KOREAN AIR FORCE TACTICS, TECHNIQUES & PROCEDURES 3-3

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BASIC EMPLOYMENT MANUAL F-16C

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TACTICS, TECHNIQUES AND PROCEDURES 3-3

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BASIC EMPLOYMENT MANUAL

PURPOSE: The Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3 series publications are the primary aircraft fundamental reference document for the USAF. This special version of AFTTP 3-3 was prepared specifically for the Korean Air Force and is based on the most current version of USAF fundamental employment procedures and techniques. This series provides a comprehensive, single-source document containing fundamental employment procedures and techniques necessary to accomplish the various missions. The procedures and techniques are presented solely for consideration in planning and are not for regulatory purposes. Other procedures and techniques may be used if they are safe and effective; the fundamentals presented are solely for employment and planning considerations.

SCOPE: This manual addresses basic flying tasks and planning considerations for the air-to-air (A/A) and air-to-surface (A/S) arena. It presents a solid foundation on which effective tactics can be developed. This manual is not a step-by-step checklist of how to successfully employ aircraft, but rather it provides information and guidelines on basic procedures and techniques.

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CHAPTER 1

INTRODUCTION

1.1 Overview. War in the aerospace environment is currently in a period of fast-paced evolution. Since the beginning of aerial combat, technological development has driven, and been driven by, progress in building more efficient and effective aircraft and weapons. Nevertheless, the very basic principles of aerial combat remain virtually unchanged. As technology advances, mutual support and situation awareness (SA) are still critical to effective employment of airborne weapons. Current data link systems and situation displays will not replace core competence in basic skills. These fundamentals, or standards, are only part of training for combat, and provide the building blocks for effective tactical employment. Discussions on formation flying, air-to-air (A/A), air-to-surface (A/S), and night operations in the F-16 are designed to aid in building a strong foundation of tactical skills. The maneuvers addressed are a means to an end, a starting point for pilots to study and explore first hand; describing the methods used to achieve desired results in air combat.

1.2 Purpose. This volume is designed to supplement training programs; and when used in conjunction with, provides F-16 pilots the information needed to make the right decisions during any phase of a tactical mission. This volume is not directive in nature, and provides no authority to depart from established training procedures, regulations, or directives.

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CHAPTER 2

PREPARATION

2.1 Introduction. Mission preparation is absolutely essential for successful fighter operations. A common understanding of what is expected during all phases of mission employment allows all fighters to concentrate on mission objectives. It provides the foundation for performance enhancing knowledge and skills, encompassing situation awareness (SA), flight integrity, effective communication, task and risk management, mission planning, and debriefing. Each aspect is part of a professional, disciplined approach to increase flight safety and maximize combat capability.

2.2 Preparation.

2.2.1 Psychological Considerations. Fighter missions demand total involvement. This requires mental preparation prior to every mission. As tasking increases, whether in actual combat or daily training, increased attention to human limits must be applied. Mental preparation includes managing stresses and distractions, allowing for total concentration on the mission. Habit patterns cannot be turned on and off at will, although in-flight distractions will interrupt them. The same skills and techniques developed during continuation training will be the ones used in combat. Avoid turning them into "rote" habit patterns—distractions then become killers. Professionalism and discipline are qualities common to all fighter pilots and the basis for the fighter pilot attitude. This ensures a proper blend of pride, desire, aggressiveness, and knowledge.

2.2.1.1 Situation Awareness. The cornerstone to formation success is SA. SA is the continuous perception of self and aircraft in relation to the dynamic environment of flight, threats, and mission, and the ability to forecast, then execute tasks based on that perception. It is gained through assimilating information obtained through:

- On-board sensors.
- Visual cueing and perceptions.
- Flight members.
- Ground-controlled intercept (GCI)/airborne warning and control systems (AWACS).
- Support assets.

NOTE: The one most important aid in maintaining SA is a common understanding of the briefed plan. Overlaying current fight conditions to arrive at an overall picture of what is happening and what will happen defines SA.

2.2.1.2 Human Performance. Honest awareness of your capabilities as a human (mental and physical) and as a fighter pilot (proficiency and currency) in conjunction with thorough preflight preparation ensures:

- Use of superior knowledge versus superior skill.
- Faster reaction time to events with less probability of error.
- Reduced possibility of unanticipated events and uncertainty.
- Reduced need for in-flight planning.

NOTE: Analysis of these factors reduces the risk of distraction, channelized attention, task saturation, or procedural errors that will, in the end, increase attention requirements. In addition, building mission objectives based on current abilities and limitations prevents mishaps.

2.2.2 Physiological Considerations.

2.2.2.1 The High-G Environment. Modern fighter aircraft can exceed pilot tolerance for sustained high Gs. This capability often allows pilots to apply more Gs than their body can tolerate, and after several seconds oxygen available to the brain is depleted and consciousness lost. Pilots must anticipate the G, control the G-onset rate, and perform the G-straining maneuver early. This requires mental discipline and practice to master. Failure to do so can spell disaster. G-induced loss of consciousness (GLOC) has two serious aspects: First, it is more dangerous than other pilot stresses because it is not possible for the pilot to accurately and reliably know how close they are to the GLOC threshold. Second, since amnesia (of the incident) is a characteristic of GLOC, the pilot may never recognize a loss of consciousness and may not be cognizant of any “close calls.” The best solution to the GLOC problem is keyed to pilot awareness. The pilot has ultimate control over G-stress factors. Here are some factors to consider:

2.2.2.1.1 Flight Factors. High-onset rates and long periods of sustained high G bring the pilot's body to the brink of exhaustion more quickly than at lower G-levels. High-onset rates can bypass the normal stages of reduced vision resulting in near-instant unconsciousness.

2.2.2.1.2 Diet, Conditioning, and Rest. The result of good diet, proper physical conditioning, and adequate rest is a fighter pilot who is mentally and physically prepared to meet demanding mission tasks. The lack of respect for any one of these factors could be fatal in a high-G environment. There is also a synergistic effect when more than one of these factors is below standard. Be prepared, mentally and physically, for high-G stress. Proper physical conditioning involving anaerobic training (free weights, Nautilus, and Universal Gym) and aerobic training (running, cycling, and swimming) play an important role in improved G-tolerance. Critical to G-tolerance is hydration, where dehydration can reduce G-tolerance by 50 percent or more. Proper mission planning begins with good physical and mental preparedness.

2.2.2.1.3 Currency, Anxiety, and Aggressiveness. G-tolerance is increased by adapting to repetitive exposure. Layoffs such as a long leave, duty not involving flying (DNIF), or even just coming out of a low-G flying phase require a build-up of G-tolerance. Anxiety in new situations or other pressures can mask objectivity in assessing tolerance. Aggressiveness, if not properly controlled, can lead to overconfidence and inattention to, or disregard for, the warning signs of fatigue and stress. Pilots need to be aware of these factors and be on guard for signs of G-stress limits. An individual's G-tolerance and warning signs can vary significantly from day-to-day. Fatigue, tunnel vision, or gray-out are critical warning signs that the pilot is already at his limit. Do not attempt to maneuver the aircraft up to these limits; there is no buffer or reliable safety margin. Expect G-tolerance to vary at different times even on the same flight, based on all the factors discussed above. When a pilot suspects effectiveness is being reduced,

appropriate actions must be taken. In combat, it may mean separation if able; in training, it means a knock-it-off (KIO) and a less demanding alternate mission. Here are guidelines to follow:

- Identify high-G situations and maneuvers in the briefing for each mission and the proper techniques for avoiding GLOC.
- Tailor the mission accordingly if high-G sorties have not been recently flown.
- Do not forget proper G-suit fit and straining maneuver techniques. By far the most important factor in improving G-tolerance is the performance of a good, well-timed, and coordinated G-straining maneuver.
- Perform a good G-awareness exercise.
- Anticipate the onset of G. Strain early.
- Make G-awareness part of SA in flight. Avoid "snatch pulls" to high G. Make all G-inputs smooth, with controlled buildup, and within personal limits.
- Exercise strong flight lead control and seriously consider coming home early if any flight member feels fatigued.
- Although COMBAT EDGE-equipped aircraft decrease the effects of G-fatigue, do not become complacent. Always perform a correct G-straining maneuver.
- Do not sacrifice good training, but be sensitive to the dangers of GLOC through all engagements. Loss of consciousness is a serious problem, but it can be controlled. Your approach to the entire problem is the key to its solution. Take GLOC seriously; the consequences can be fatal. You will make the difference.

2.2.2.2 Night Operations. With the introduction of new weapons and weapons systems, fighters are flying more at night than in the past. Thus, it is important for pilots to understand the physiological effects of night operations. Areas of primary concern affecting performance at night are circadian rhythm, sleep, and fatigue.

2.2.2.2.1 Circadian Rhythm. Circadian rhythm is defined as the "biological clock," meaning our physiological, psychological, and behavioral functions are subject to periodic daytime-dependent oscillations. Biological desynchronization and performance suffers when a pilot's circadian rhythm cycle is disrupted. The most common way to disrupt this cycle is through shift work. This can occur with an occasional night flight, 1 or 2 weeks of night flying, or a permanent shift in the flying schedule. Other ways to disrupt the cycle are to withdraw normal daylight and darkness cues, and through transmeridian flights such as on long deployments, causing jet lag. The ability to sustain performance is important to fighter pilots. Alertness is the major determinant of sustained performance and is influenced not only by man's inherent circadian rhythm, but also by the need for sleep.

2.2.2.2.2 Sleep. While partial sleep loss for any one night might impair performance, repeated partial sleep loss will have a definite impact on performance. Total sleep loss is the absence of sleep for at least 24 hours. This impairs the learning of new information and the recall of newly learned material. Susceptibility to disorientation may increase, scanning ability is reduced, and chart reading ability is affected. Most impor-

tantly, judgment and mood are impaired. Irregularity of work and rest over several days also results in decreased levels of performance. Combined with recent or cumulated sleep loss, irregular schedules can be especially fatiguing. Duty day length and irregular schedules can further degrade performance. As with partial sleep loss, irregular schedules increase susceptibility to the same factors resulting from total sleep loss.

2.2.2.2.3 Fatigue. Fatigue is tiredness, or exhaustion, from physical and/or mental exertion, and is categorized as three types:

- Acute fatigue—how you feel at the end of a physically/mentally demanding flight.
- Cumulative fatigue—the tiredness you feel after extended periods of inadequate sleep.
- Circadian fatigue—the tiredness you feel from having your routine biological clock disrupted.

2.2.2.2.4 Consequences of Fatigue. The consequences of fatigue are degraded performance and efficiency. Research has determined that sleep loss and fatigue can lead to complacency, computational and navigational errors, and communication errors:

- Complacency is a sense of well being, often while unaware of potential danger.
- Mathematical and abstraction abilities crucial to accurate navigation, SA, and mission accomplishment are impaired.
- Communication errors occur by misinterpreting or not perceiving what is actually stated.

2.2.2.2.5 Compensation/Prevention. There are preventive measures to prepare for night operations and reduce the inherent risk: adjust sleep schedule, prepare specifically for the particular night mission, and make good use of the simulator. Cancel the sortie if not physiologically ready; it is the individual pilot's responsibility to determine preparedness for night operations.

2.2.3 Teamwork. Due to the complex and diverse nature of F-16 operations, preparation ensures the element works as a team with emphasis on effective communication as well as defined roles and responsibilities of lead and wingmen.

2.2.3.1 Task Management. Establishing a flexible task management plan allows for proper task prioritization, recognition of task saturation, and effective use of automated systems and all available resources in a dynamic environment.

2.2.3.2 Flight Leadership. Flight leaders have the general responsibility for planning and organizing the mission, leading the flight, delegating tasks within the flight, and ensuring mission accomplishment. They are in charge of the resources entrusted to them. They must know the capabilities and limitations of each flight member. Once airborne, the flight leader has the final responsibility and controlling authority for establishing the formations, maximizing the flight's effectiveness, and leading the flight successfully to and from the target.

2.2.3.3 Establishing Priorities. It is an acknowledged fact that during the heat of any mission, there are occasions when you cannot do everything in the time available. This

requires assigning priorities (task prioritization). At the top of the list are things you have to do—do them first. Lower on the list are things you would like to do—do them later when they do not interfere with the have-to-do things. The list of have-to-do tasks should be established long before getting near an aircraft.

2.2.3.3.1 Critical Tasks. Those tasks that can never be ignored without catastrophic consequences. If any non-critical task becomes a higher priority, a terminate or KIO may be appropriate. As a minimum, immediately re-prioritize any critical task above the mis-prioritized task. Critical tasks fall in these general categories:

- Terrain avoidance (almost 100 percent probability of kill [P_k]).
- Element deconfliction during formation, system updates, targeting with FCR, TGP, or any other heads down time. Flight path deconfliction (avoid other aircraft and training rule [TR] adherence). Transmit “callsign unable” when task saturated and performing terrain avoidance, visual, or formation duties
- Mid-Air avoidance of other flight members/flights, to include block adherence inside 10 miles with limited SA.
- Mid-Air avoidance
- Maintain aircraft control (helps in avoiding the first two).
- Monitor, manage, and maintain sufficient fuel.
- Threat awareness/detection/defense (the lowest priority CRITICAL task).

2.2.3.3.2 Prioritizing Non-Critical Tasks. Lower priority tasks fall into two general categories: formation tasks and mission tasks. Formation tasks range from answering fuel checks on the radio to proper execution of tactical turns. Critical tasks can never be disregarded, but other tasks will require monitoring and management. For example, at 20,000 feet in close formation in the weather, formation tasks (staying in formation, radio awareness, and instrument cross-check) should be prioritized above mission tasks (radar work and weapons management). Although mission success is usually measured by how well mission tasks are accomplished, keep overall mission success in perspective. ***Remember, if you do not get yourself and your aircraft home, you have failed to accomplish the mission.*** If formation tasks become secondary to mission tasks, as a general rule mission success will suffer. Letting nice-to-do things take priority over have-to-do things will jeopardize yourself and those around you. If the rare occasion comes up where aircraft malfunction/emergencies make it impossible for you to perform your top priority tasks, it may be time to eject (extreme).

2.2.3.3.3 Mis-Prioritization. Mis-prioritization can have disastrous results. Many of the revisions in this volume are the result of accidents that occurred because of mis-prioritization. Search for situations that are most critical and mentally address what would happen in the cockpit: instrument cross-check, changing switches, checking six, checking mates' six, checking gas, or practicing a critical emergency. Stress basic SA. Fighter pilots are not born with it; SA must be developed and kept “current.” Mentally engaging a MiG simply is not enough. “Look” at the fuel gauge and comprehend what it tells you: “JOKER FUEL” (i.e., snap shot, separate, expend flares [channelize the

MiG driver's attention]), run, where's lead?" Get the "big picture"—strive for "no surprises."

2.2.3.4 Wingman Responsibilities. Wingmen have critical responsibilities of helping the leader plan and organize the mission. They have visual lookout and radar responsibilities, perform backup navigation tasks, and are essential to target destruction objectives. Wingmen engage as briefed or when directed by the leader and support when the leader engages. Wingmen must understand briefed responsibilities and execute their contracts with discipline. Discipline is the most important quality a fighter pilot can possess and leads to success in the aerial arena. Discipline is executing self-control, maturity, and judgment in a high-stress, emotionally charged environment. Teamwork is the foundation of the fighting element. If all flight members know and perform their respective duties, they work together as a team. Experience and realistic training leads to solid and professional air discipline.

2.2.3.5 Effective Communications. Communication ties the mission together. From the beginning of mission planning through the lessons learned in the debrief, communication is the basic determinant of both mission accomplishment and success. The mission commander must effectively translate the plan and objectives to each flight lead so assets can be directed to achieve the goals. The flight leads must communicate thoroughly during planning to produce the correct flight products for their mission. In the briefing, they must address the flight's execution plan and major contingencies that can be expected during flight and the planned reactions. Standards must be established to cover those contingencies that are not briefed. Briefings must be complete and understood so that contingencies can be executed in the air using concise radio communications. Visual signals must be understood and used correctly to be effective. Preparation to ensure effective in-flight communication includes the following:

- Know and adhere to accepted and standard terminology (squadron standards, Mission Planning Manual [MPM] and ATC).
- Brief anticipated communication flow.
- Zero tolerance for complacent, sloppy, or ambiguous radio calls (in flight and during debrief).
- Establish an appropriate assertion level; ensure two-way communication.
- Do not assume.
- State concerns and intentions and get an acknowledgment/decision.

2.3 Mission Flow. Whether a basic student upgrade sortie or a complex combat mission, successful accomplishment demands thorough preparation. This mission preparation consists of two phases: mission planning and mission briefing. Incomplete preparation in either area degrades mission accomplishment.

2.3.1 Preparation. The flight leader establishes priorities for mission planning and delegates them to flight members to ensure all planning considerations are addressed while precluding any duplication of effort. **Chapter 4**, "Air-to-Air," and **Chapter 5**, "Air-to-Surface," contain additional information specific to these roles. The depth of planning detail is dictated by the

mission and flight experience level, but all necessary mission planning must be completed in time to conduct a concise, comprehensive briefing. The two main factors which determine the direction of mission preparation are the role of the F-16 for the particular mission (e.g., offensive counterair [OCA], interdiction, or defensive counterair [DCA]) and the overall mission objective (e.g., student training syllabus objectives, continuation training profile, visual bombing qualification, or wartime target destruction).

2.3.1.1 Planning Considerations. Additional factors, determined by the role and overall objective, which must be addressed during mission preparation include higher headquarters (HHQ) guidance, flight composition and size, support forces, communications and data link, routing contingencies, weather, fallout, and threats.

2.3.1.1.1 Higher Headquarters (HHQ) Guidance:

- Syllabus.
- Air tasking order (ATO).
- Rules of engagement (ROE).
- Special instructions (SPINS).
- Special interest items (SII).
- Flight crew information file (FCIF).

2.3.1.1.2 Flight Composition and Size:

- Experience level of flight members.
- Weapons delivery options.
- Aircraft configuration.
- Fuel tanks.
- Navigation and targeting pods.
- Weapons loads.
- Electronic countermeasures (ECM) pod.
- Air-to-air missiles.

2.3.1.1.3 Support Forces:

- Controlling agencies.
- Escort, suppression of enemy air defense (SEAD), and ECM support.

2.3.1.1.4 Communications and Data Link.

2.3.1.1.5 Routing.

- Fuel considerations/refueling.
- Egress and safe passage procedures.

2.3.1.1.6 Contingencies.

2.3.1.1.6.1 Weather.

2.3.1.1.6.2 Fallout.

2.3.1.1.6.3 Threats:

- Cockpit indications.
- Capabilities.
- Numbers and locations.
- Electronic identification (EID) requirements.
- Visual identification (VID) requirements.

2.3.1.2 Mission Objectives.

2.3.1.2.1 Preparation. Preparation for any given mission is based on mission objectives tailored to the lowest common denominator. The objectives are performance standards to measure individual and team success during any mission, and should give the "big picture" of what is happening. A valid objective has three parts: performance, conditions, and standards.

2.3.1.2.2 Performance. Performance is what each pilot or the flight is required to do during the mission. It describes the action and is not vague. Use action verbs such as: demonstrate, employ, or practice.

2.3.1.2.3 Conditions. Conditions is where it is happening, the environment. Examples include Line Abreast formation or outside the bandit's turn circle.

2.3.1.2.4 Standards. Standards state how well the performance must be done and are categorized by time limits, accuracy, and/or quality. Time-on-target (TOT) within ±30 seconds, hits within 10 meters, or ranging within ±500 feet are examples.

2.3.1.2.5 Objectives. Defining objectives also depends on contingencies and other planning considerations: weather, sun angles, day or night, the threat, or the ATO are a few. Incorporating well-defined objectives based on the mission requirements and the particular mission's lowest common denominator (e.g., weather and wingman experience) pays benefits in terms of risk management.

2.3.1.3 Risk Management. Part of mission planning is assessing and managing the risks inherent in fighter operations with respect to individual limitations and vulnerabilities. Review the mission and clearly define what is to be accomplished. Then focus on critical phases throughout the flight, keep in mind many mishaps occur during takeoff, en route, rejoins, and landing, not just during tactical operations in the military operating area (MOA). Attempt to assess all possible risks during these flight phases by building a mental picture of the sequence of events—look for the obvious risk factors, then ask yourself: if something goes wrong how do I adapt? In addition, critically assess each of these areas:

- Pilot—proficiency/currency issues; physical and mental health, skill level, and experience.
- Environment—weather, time-of-day (TOD), terrain, altitude, Gs, and temperature.
- Aircraft—configuration limitations, cockpit setup, and potential distractions.
- Supervision—personality conflicts, discipline, supervisory, and peer pressures.

2.3.2 Mission Briefing. The briefing sets the tone for the entire mission. Establish goals and tailor the plan to achieve them. Write the mission objectives on the board and establish a standard that measures successful performance. Standard briefing items including start, taxi, takeoff, and recovery, and relevant special subjects should be covered in an efficient manner. As computerized briefing outlines become available, squadron standards can be integrated into automatic presentations. Elements of the mission, which are standard, should be briefed as "standard." Spend most of the time describing the "what" and "how to" of the mission. If adversaries, friendly players, intelligence (intel), or other mission support personnel are present, brief them first on only pertinent information and the mission. GCI/AWACS controllers, however, should receive the entire tactical briefing and must fully understand the game plan to include ROE review, identification procedures, and the communications plan. Alternate missions should be less complex than the original mission but also have specific objectives. The flight lead must control the brief and be dynamic, credible, and enthusiastic. The flight lead motivates and challenges the flight to perform to planned expectations, asking questions to involve flight members and determine briefing effectiveness.

The objective of the debrief is to determine if the desired mission objectives were achieved, identify lessons learned, and define aspects of training needing improvement. The end result should be all participants gaining solid direction after the debrief on how to do it better next time. An effective debrief includes three main areas: preparation, reconstruction, and analysis.

2.3.2.1 Preparation. This step will make the difference between an effective and efficient debrief and a 6-hour mess. Flight leads should have a specific mission-debriefing guide aligned with the mission-briefing guide—this will ensure a logical structure and flow. All participants should know (from the briefing) what will be required from the flight lead during the debrief, and sufficient time between arriving in the debrief area and starting the actual debrief should be allowed to gather that information (normally 20 to 30 minutes).

2.3.2.2 Reconstruction. The "what happened" during the mission occupies most of the debriefing. Correct preparation by all participants will greatly streamline this phase. For telephonic debriefing, use of faxes will greatly help during flight reconstruction. At the beginning of the debrief establish guidelines, so all participants know when to interrupt, provide information, and make corrections. During reconstruction, assign roles to each participant to focus attention and keep them involved. Typical assignments are as follows:

- Objectives/execution monitor (Number One).
- Training rules monitor (Number Two).
- Communications monitor (Number Three).
- Weapons validation monitor (Number Four).

NOTE: Flight leads must be aware of all participants' debriefing limitations. These may range from tight turn times to the next days sortie; follow-on simulators or academic training; or personal commitments. Tailor the reconstruction so that essential errors are identified while considering these limitations. Sometimes debriefs will be required to be slipped to the next day. Here are ten reconstruction tips to consider:

- Preflight the room (tape players and pens).
- Annotate bullseye on the board with 5 NM tics down fight axis.

- Double-check the initial picture (have a correct start point).
- Do not draw inner group pictures until it is important to know it.
- Show spike status with color codes and direction.
- Keep arrows synched (equal numbers for all players/groups) and in scale.
- Mark all shots, include from and to whom, type, and outcome.
- Show countermeasure (CM) use when expended.
- Tag all groups with altitude and annotate changes.
- Put notes on board for discussion items during analysis (probably the most important).

2.3.2.3 Analysis. This phase brings out the actual “what to do better or different” focus from the flight. It is essential to derive accurate lessons learned; not simply the execution errors that occur in every sortie. Primary consideration should be toward gaining insight into how the pilot has performed versus the mission objectives. Get the small items out of the way first (i.e., debrief the motherhood). Discuss significant departures from the briefed flow or established procedures without belaboring the items. Review the mission objectives and provide a general impression of mission success.

2.3.2.4 Final Summary. Choose only the significant events that impact the objectives of the flight. Use the notes on the board identified during reconstruction. Identify execution errors, and draw from them lessons learned, if appropriate. The final summary includes an assessment of strong and weak points and the required corrections for next time.

CHAPTER 3

TRANSITION

3.1 Ground Operations. Prior to step, the flight lead should confirm configuration to ensure the aircraft/pilot combinations are optimized. Fuel tanks, model, weapons configurations, and takeoff type are some of the most obvious factors to be considered. Ensure takeoff and landing data (TOLD) is available for each expected configuration and takeoff type. Each pilot should make a quick study of the aircraft historical data for any system peculiarities. Before takeoff, a thorough check of all aircraft systems should be completed IAW the Dash 1 and Dash 34 checklists, and the flight lead informed of any problems. Initial check-ins should confirm operation of all radios and radio modes expected to be used in flight. Sufficient time should be allowed to have radios re-keyed after check-in prior to taxi.

3.1.1 Aircraft Preflight. Immediately upon arrival, verify the correct configuration. Always take time to perform a thorough inspection of the AFTO Form 781, the aircraft, and armament. Just as in pilot training, confirm the aircraft has been properly released for flight. Talk to the crew chief and brief him on starting procedures if required. Have the Dash 1 and Dash 34 checklists available for the preflight. Inspect the work area around the aircraft and the taxi path. If the configuration or status is questionable, contact the maintenance superintendent, IP, or squadron operations.

3.1.2 Interior Checks. Preflight the seat carefully—it may save your life. Check the condition of the canopy and cockpit area. A dirty canopy or loose material in the cockpit can impair vision and affect performance in flight. Although the crew chief generally offers assistance, you are ultimately responsible for ensuring you are properly strapped in. This includes connections to the ejection seat, G-suit, and life support systems. Stow personal gear carefully to avoid damage to the canopy and preclude in-flight problems. Use the expanded checklist to initially set up the cockpit. Always complete the Dash-1 VERIFY checklist prior to starting the engine. Learn these checklists during initial simulator and cockpit familiarization missions before the first flying sortie. Complete required checklist items, install the data transfer cartridge (DTC), and monitor the backup UHF radio 1 minute prior to start on the squadron frequency. Select ground control for engine start, so crash/rescue assistance is required, an immediate request can be made.

3.1.3 Engine Start. Initially, the engine start sequence will seem to occur within a very short time span; therefore have a thorough knowledge of normal, abnormal, and emergency procedures. Prior to engine start, review appropriate emergency procedures such as HOT/HUNG START or ENGINE FIRE/OVERHEAT. Remember, the fire warning light is not functional until the standby generator comes on line. Do not rest your feet on the rudder pedals after battery power is applied as this can deplete the jet fuel starter (JFS) accumulators and prevent a successful engine start. During hot weather, it is acceptable to start the engine with the canopy open. Ensure loose items (map light, etc.) are stowed to prevent engine or canopy FOD. Temperature permitting close the canopy prior to engine start. In any case, ensure the canopy is cleared, closed, and locked immediately after engine start. Be careful—flight control surfaces can be moved while the JFS is turning the engine with battery power applied.

3.1.4 After Start/Before Taxi Checks. Follow the checklist. Remember to coordinate the secondary engine control (SEC), emergency power unit (EPU), flight control, speedbrake, and wheel brake checks with the crew chief. Accomplish the SEC and EPU checks in the chocks, or as directed. Always ensure the areas fore and aft of the aircraft are clear prior to increasing power for the SEC and EPU checks. Prior to clearing the crew chief to pull the EPU pin, turn the EPU switch off and ensure the EPU GEN and EPU PMG lights are not illuminated.

NOTE: Only raise the aft portion of the red-guarded switch when moving the EPU switch to OFF. Once the EPU pin is pulled, go back to NORM and complete the EPU check. Obtain clearance IAW local procedures. Ensure the clearance contains the appropriate departure instructions and active runway. During formation flights, all flight members should acknowledge the flight clearance. Leave the canopy closed unless condensation on the outer surface limits vision. Defog will not remove exterior moisture due to the thickness of the canopy. Always check your inertial navigation system (INS) alignment status prior to taxi.

3.1.5 Taxi Checks. Do not taxi unless all aircraft systems are operating normally. It is much easier to work a red ball on the ramp versus the arming area. Normally, power slightly above idle is necessary to clear the chocks. Check nosewheel steering (NWS) and brakes (lightly) as the aircraft pulls out. Do not continue taxiing with any NWS or brake malfunctions. Reduce the throttle to IDLE prior to making turns to avoid engine blast to personnel and equipment. The nose gear is located slightly behind the front seat, requiring a different turning point of reference than most aircraft. Normal taxi in the F-16 has you “sitting” on the yellow taxi line during turns. Taxi speed in clear areas should not exceed 25 knots. To reduce tire wear, slow to 10 knots when making sharp turns. Do not ride the brakes. Correct braking technique allows taxi speed to increase to approximately 25 knots, and then apply moderate braking to slow to 15 knots. Release the brakes, allow the speed to increase back to 25 knots and repeat the process. Ground speed is available on the INS page (List 6). Keep alert for conflicting traffic or other hazards to safe operation. Do not be distracted by superfluous cockpit avionics.

3.1.6 Quick Check/Arming/De-Arm. Keep your hands in sight while end of runway (EOR) personnel are under the aircraft. This includes not accomplishing upfront control (UFC) and head-up display (HUD) actions. Ensure personnel are clear before completing the EPU check (if not previously accomplished). After the ground crew finishes their inspection and arming process, complete the BEFORE TAKEOFF checklist and any desired INS enhancements (Block 25/30/50/52 RLG). Use the same procedures for de-arming.

3.1.7 Ground Aborts/Problems. Notify squadron operations for any red ball requirement, and your flight lead for expected delays. Remember, with the engine shutdown, the VHF radio is inoperative. Squadron Top Three must approve any spare decision. When starting a spare aircraft behind schedule, do not rush to the point where checklist procedures may be omitted. Follow hot weather procedures when the temperature is greater than 100 degrees Fahrenheit, or the fighter index of thermal stress (FITS) is in the caution or danger zone.

3.1.8 Taking the Active. Always acknowledge the tower clearance (e.g., “on to hold” or “cleared for takeoff”). Perform before takeoff checks (SLIPER-speedbrake, landing light, IFF, probe heat, ejection seat, and radar). Monitor the base turn and final approach areas for landing traffic. Prepare for a takeoff abort by reviewing procedures and TOLD data. Once in position,

apply brakes and complete the engine check. Do not use the parking brake during the run-up check since advancing the throttle will release it.

3.2 Takeoff. The flight lead will direct the appropriate runway line up based on winds and runway width.

3.2.1 Lineup. The correct line up will allow visual signals to be passed and engines simultaneously run up without putting any aircraft in aircraft exhaust. Care should be taken during lineup to maintain taxi spacing and ensure aircraft do not come in contact.

3.2.1.1 Two-Ship Lineup. Wingmen should line up ensuring wing tip clearance (runway width permitting) and just slightly forward of the normal in-flight reference (line up the main landing gear wheels). If runway width is not a factor, wingmen should line up with 3- to 5-foot wing tip spacing.

3.2.1.2 Four-Ship Lineup. **Figure 3.1**, Four-Ship Runway Lineups, depicts the three options that are normally used:

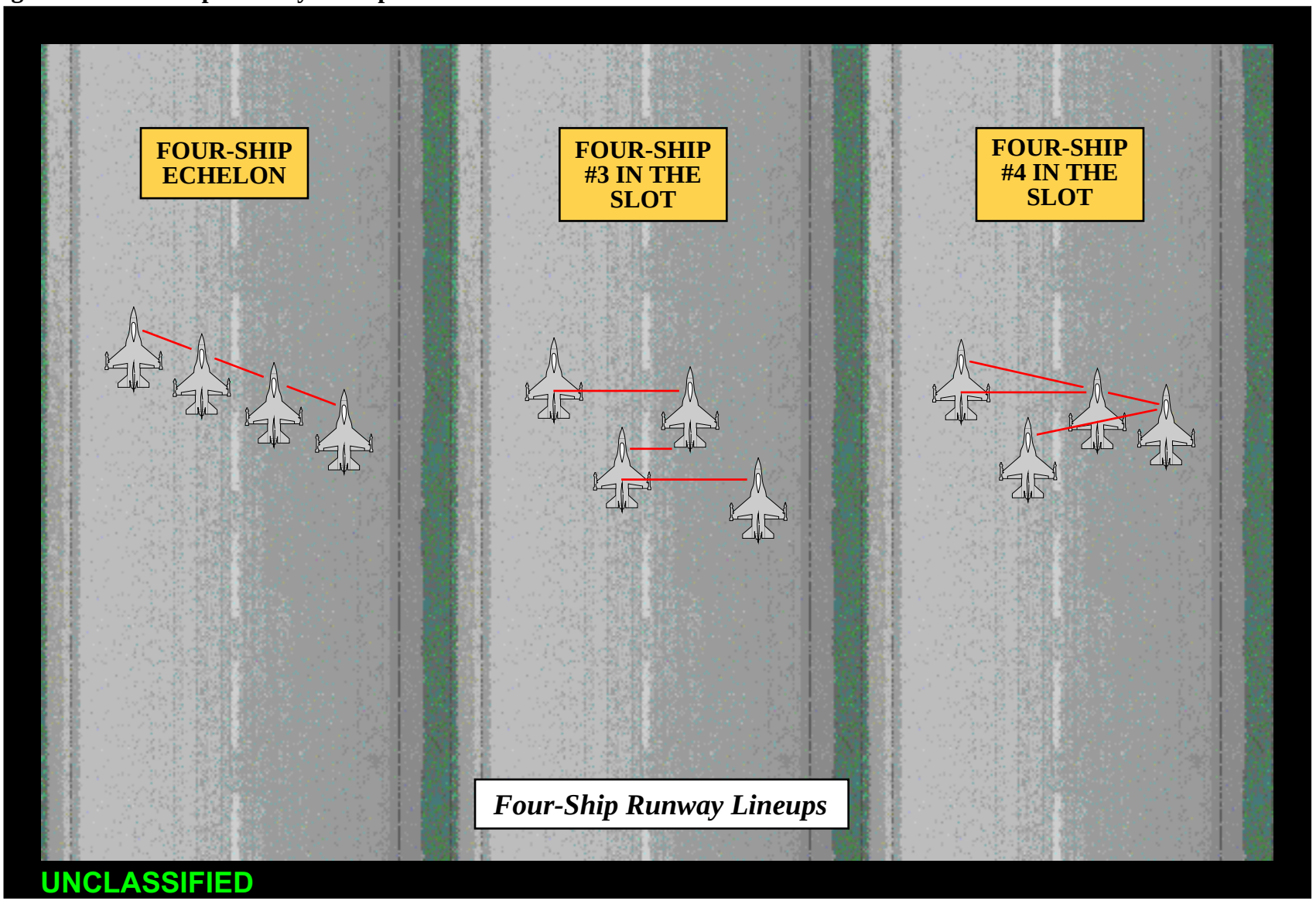
3.2.1.2.1 Four-Ship Echelon Lineup. Number One should take the downwind side of the runway with Number Two in the normal 3- to 5-foot wing tip spacing. Number Three and Number Four should align helmets of preceding flight members.

3.2.1.2.2 Three-in-the-Slot. Number One should take the downwind side of the runway with Number Two putting the missile rail (nearest lead) on the centerline. Number Three should split the distance between Number One and Number Two and pull forward until lining up Number Two's afterburner (AB). Number Four should line up on Number Three with the same spacing that Number One and Number Two have.

3.2.1.2.3 Four-in-the-Slot. Similar to three-in-the slot, except Number Three pulls forward to normal echelon position on Number Two and Number Four pulls forward so that Number Three's helmet is visible in front of Number Two's tail (over the spine).

3.2.2 Military Power Takeoff. Advance power to the appropriate rpm and accomplish the run-up check. Release brakes, advance power to Mil power, and check for proper engine operation. Fan turbine inlet temperature (FTIT) and rpm vary with temperature and pressure altitude, but should stabilize within 5 to 15 seconds. Normal engine operation is indicated by a closed nozzle position IAW Dash 1 limits. The rudder becomes effective at about 70 knots. Normally disengage NWS at this speed. Check speed at the appropriate acceleration check distance, normally 2,000 feet. When airspeed is approximately 10 knots below computed takeoff speed, smoothly apply aft stick pressure to establish a takeoff attitude between 8 and 12 degrees. Set the gun cross at approximately 10-degree nose high using the pitch bars. In a clean configuration, rotation and liftoff occur almost simultaneously. The aircraft may settle or skip if you initiate rotation early. Once safely airborne with a positive climb, retract the gear. Ensure the gear are up and locked before exceeding 300 KCAS. The trailing edge flaps retract when the gear is retracted and the leading edge flaps schedule automatically. For Mil power takeoffs at high-density altitudes or when heavyweight, delay gear retraction until airspeed and altitude are sufficient to offset the loss of lift, which occurs as the trailing edge flaps retract.

Figure 3.1 Four-Ship Runway Lineups.



3.2.3 Afterburner Takeoff. Acceleration to takeoff speed is rapid, and takeoff distance in the clean configuration is very short. After accomplishing the run-up check, release brakes, smoothly advance the throttle to full AB, and check for proper engine operation. Monitor the nozzle indicator for movement toward the open position to indicate AB ignition. Disengage NWS as in a Mil power takeoff. When airspeed is approximately 15 knots below computed takeoff speed, smoothly apply aft stick pressure to establish a takeoff attitude between 8 and 12 degrees, and fly the aircraft off the runway. Less time is available to ensure gear and flap retraction. If making a normal departure, retard the throttle to Mil power at 300 KCAS, and accelerate to the normal departure airspeed of 350 KCAS.

3.2.4 Takeoff Emergencies. The variety of possible takeoff emergencies prevents a "cut and dried" approach to handling them. The three basic rules governing all emergencies apply. Always consider the nature of the problem, airspeed, gross weight, and runway remaining. Most engine-related takeoff emergencies require critical action procedures (CAP).

3.2.4.1 Initiating an Abort. Perform the CAPs and other checklist items, but remember that aircraft control is primary. If aborting at or above 100 KCAS, lower the hook. When aborting above 120 KCAS or anytime hot brakes are suspected, declare a ground emergency, taxi to the hot brake area, and follow hot brake procedures.

3.2.4.2 Takeoff Continued. Obtaining altitude and airspeed is your primary goal. Execute CAPs and continue straight ahead until within ejection parameters. Once assured of the ability to climb and/or accelerate, use shallow turns and reduce gross weight as much as practical. Be prepared to eject if the situation deteriorates beyond your capability to prevent a sink rate from developing.

3.2.5 Formation Takeoff. Following takeoff clearance, a visual channel change to departure and a "run-up" signal (spinning vertical index finger) will be passed from the flight lead and copied down the flight. After all aircraft have indicated "ready," the flight lead will check-in and signal for takeoff. During daytime, the flight lead will signal for brake release with a single head nod. The wingman should simultaneously select MIL or MAX as briefed while maintaining wing tip clearance. The flight lead should select a power setting below that of the wingman (not less than the computed formation takeoff fan turbine inlet temperature [FTIT]). This is normally one-half to one knob-width below the briefed takeoff setting. Wingman should reduce power slightly to maintain position. The best technique is to concentrate on flying formation after brake release, then to rotate with lead as the nose strut extends. When safely airborne, the leader will pass a gear up (reverse head-nod) and AB out signal (forward to aft fist movement), if appropriate. If the visual gear signal is missed, raise the gear when the lead's gear starts to move. Confirm gear is up and locked prior to exceeding 300 knots. Move smoothly into Fingertip while checking lead's aircraft from front to back to detect open panels, open gear doors, and fuel or hydraulic leaks.

3.2.6 Wingman Actions. The wingman will maintain wing tip clearance throughout the takeoff roll. Ask lead for a power adjustment if unable to maintain position (e.g., "VIPER 1, PUSH IT UP/PULL IT BACK"). The flight lead will then select the maximum briefed power setting or the minimum FTIT. If still overrunning the leader ensure wing tip clearance and make a separate takeoff. If still falling back, recheck engine gauges and takeoff in trail with the flight lead. If either member of the element must abort, the other member should continue the takeoff. In

either case, directional control (staying on your side of the runway) is essential to prevent collision.

3.3 Departure. Follow the departure IAW local procedures. Adhere strictly to assigned altitudes. Lead level-off altitudes by approximately 10 percent of the vertical velocity. If the vertical velocity indicator (VVI) is pegged (greater than 6,000 fpm), cut the pitch in half 2,000 feet below your desired level-off altitude. Then use 10 percent of the VVI to finish the level off. If assigned an intermediate altitude (less than 10,000 feet MSL), a climb at less than Mil power (usually 850 degrees FTIT PW, 750 degrees FTIT GE) will keep the vertical velocity to a manageable value. Maintain a constant lookout for other traffic. Departure airspeed is typically 350 KCAS.

3.3.1 Trail Departures. A trail departure is normally used to get a flight of two or more airborne when conditions will not permit a formation takeoff. Wet runways, crosswind limits, weapons loads, configuration differences, and low ceilings or poor visibility are normally deciding factors. The two types of trail departures are visual departure and rejoin (below the weather) and radar trail departures (aircraft separated by 2 NM). For prolonged IMC flight, radar trail is preferred because close formation increases wingman workload and can induce spatial disorientation. Also, the required departure altitudes combined with high terrain and weather will require special consideration by the flight lead. Altitude deconfliction between all flight members must be available in the event of radar failure or no radar contact.

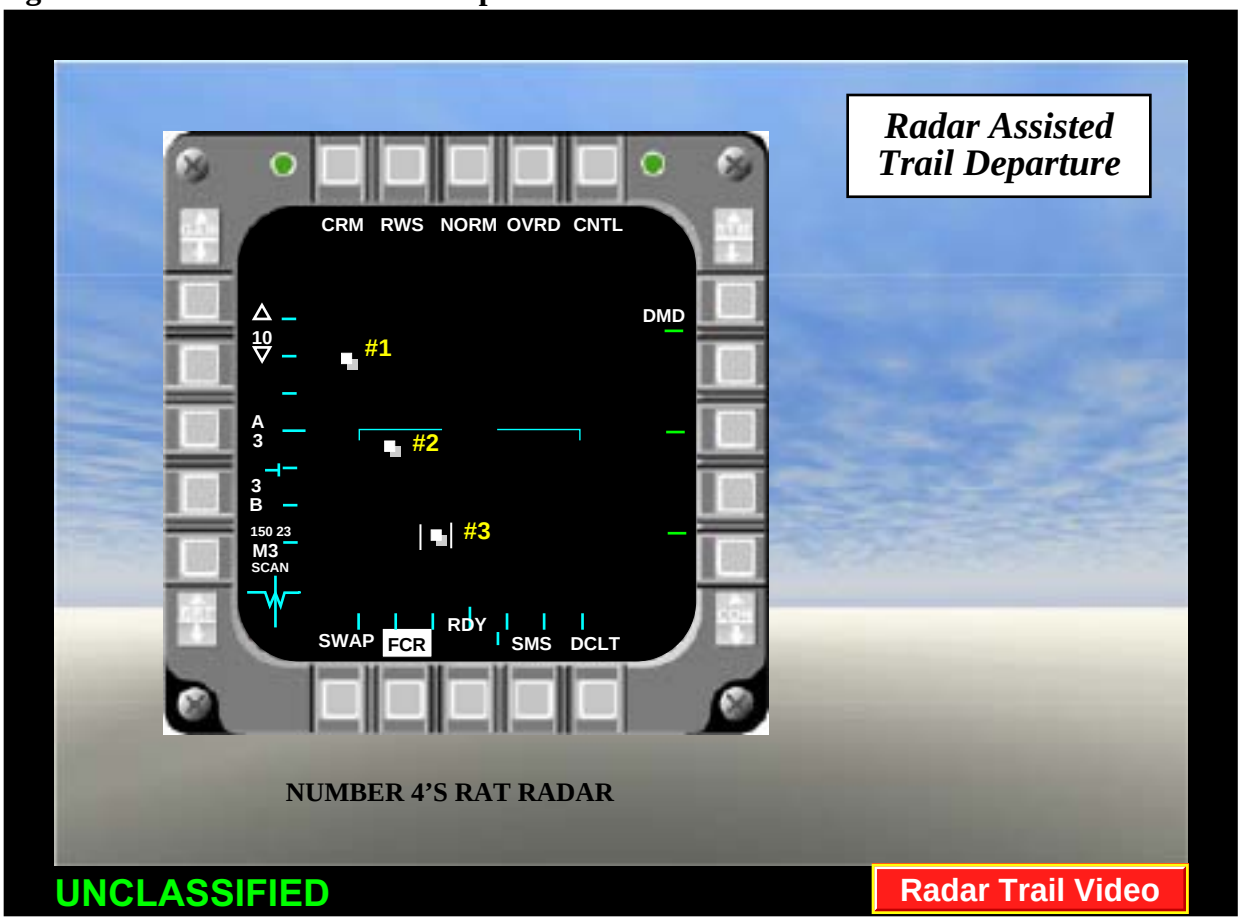
3.3.1.1 Preparation and Execution. Prior to takeoff, review the departure and set up navigation aids appropriately. All flight members must acknowledge the clearance, and prepare for non-standard or unpublished restrictions. For radar trail departures setup the radar to 10 or 20 NM scope and set the elevation (el strobe), to look slightly high (+5 degrees).

3.3.1.2 Visual Departure and Rejoin. The primary consideration during this maneuver is to maintain sight with the rest of the flight while rejoining to the briefed formation. Unless otherwise briefed, rejoins after departure will be to route formation (see **paragraph 3.6.2**, Route Formation). The radar should be utilized to clear for other aircraft, but may be used to aid in maintaining visual and controlling closure. Normal radar lock technique is to use boresight to accurately select the correct flight member to rejoin on. Standard rejoin techniques (see **paragraph 3.6.7**, Rejoins) should be used, while complying with any departure restrictions. The flight lead must adhere to briefed airspeeds and power settings until joined to reduce overshoot potential and allow for expeditious rejoins. If Number Four rejoins on Number Three prior to rejoin with the front element, Number Four will rejoin IAW Number Two's contract (left/inside). A cross under may then be required prior to rejoin with the front element and will be directed by Number Three. In the event of an overshoot by any flight member, primary consideration must be to regain nose-tail clearance while deconflicting flight paths. In the event of an overshoot by Number Two, Number Three must utilize extra care.

3.3.1.3 Radar-Assisted Trail (RAT) Departure. In the event a trail departure is required to be flown and an immediate rejoin is not feasible (weather, ATC, and departure restrictions), a RAT will be flown. Critical tasks (instrument flying and departure adherence) must be accomplished prior to other tasking (radar work and radio calls) during this maneuver. All flight members must have an in-depth knowledge and adhere to the departure and forma-

tion contracts for airspeed, bank angles, and power settings. (See **Figure 3.2**, Radar-Assisted Trail Departure.)

Figure 3.2 Radar-Assisted Trail Departure.



3.3.1.3.1 Standard Radar Setup. This setup provides for multi-ship departures and allows trailing aircraft to sort the other flight members. Air combat mode (ACM) is not used because scan volumes are insufficient and locks to the wrong flight member are likely. ACM is only useful when able to visually verify and have a lock on the correct aircraft prior to weather penetration. Track-while-scan (TWS) has many of the same limitations, especially in AUTO. TWS may be useful after sorting is complete and the flight is relatively predictable.

- Range while search (RWS) or normal air mode (NAM).
- Scan: 10 NM or 20 NM scope, ±60 degrees sweep, elevation slightly above detent.
- MTR-LOW, target history 2 or 3, channel/subset/agility as briefed.

3.3.1.3.2 Takeoff/Transition to Instruments. During the takeoff, maintain aircraft control by making a timely transition to instruments as outside visual cues deteriorate. The overriding priority must be flying the aircraft, not operating the radar. Get the aircraft safely airborne, gear retracted, and establish a safe climb at departure airspeed. Do not

transition from the basic instrument cross-check until these tasks are completed and you are able to precisely fly the departure.

3.3.1.3.3 Climb Out. During the climb out, maintain the briefed power setting and airspeed (FTIT: PW-850 degrees, GE-750 degrees, 350 KCAS if unbriefed). Listen to the radio for instructions and information. Accurate flying of the departure, not the radar, ensures clearance from terrain and the rest of the flight. Unless restricted by a standard instrument departure (SID) or controller instructions, begin all climbs at the same time as the leader (usually when lead acknowledges the altitude change).

3.3.1.3.4 Using the Radar. After safely taking off (see **paragraph 3.3.1.3.2**, Takeoff/Transition to Instruments), start bringing the radar into the cross-check. The preceding flight member should be displayed as histories approximately 2 NM in front of you. If not, check the search elevation and confirm the correct radar setup. ***Do not sacrifice basic instrument execution to accomplish radar work!*** More than one wingman has been without radar contact, 2 NM behind and below lead, due to incorrect antenna elevation positioning. A mistake of this nature can be disastrous if combined with weak instrument flying. Expect each set of histories to be superimposed or extremely close together when other flight members are at or near the same airspeed. If there are numerous contacts, concentrate on those, which are at a range and azimuth on the scope consistent with the departure ground track. Again, do not allow your attention to be channelized on the radar if you are having trouble gaining contact. At the first indication of task saturation or disorientation, immediately concentrate on flying instruments. Flying the aircraft is always the first priority.

3.3.1.3.5 Contact Established. Wingmen report “TIED” when they have radar contact on the correct flight member and can maintain radar SA until “VISUAL.” Ensure the cursor is precisely placed over the correct aircraft prior to commanding lock. Typically, Number Three and Number Four lock using the situation awareness mode (SAM) so all flight members are displayed (be aware the short lock range could drive the radar into pseudo-SAM). ACM mode to gain a lock in the weather is not desired. If, for example, you are Number Three and do not realize that the ACM lock is on lead instead of Number Two, the result could be a midair collision since both you and Number Two are trying to fly the same position behind lead. No matter the method, all locks should be verified by ensuring the target is at the correct range, azimuth and altitude, and is flying the proper ground track at the briefed airspeed. If there is a doubt, immediately return to a search mode to regain and ensure SA.

3.3.1.3.6 After Tied. Fly radar trail by thorough reference of the radar display/MFD and the HUD. While all data is available on the radar display, azimuth, and range information is not as precise as that shown in the HUD. With a radar lock, reference the target designator (TD) box (or target locator line [TLL]) for azimuth, and the target range and closure rate displays for separation. While a printout of the target's elevation is not available in the HUD, compare the TD box (or TLL) elevation in the HUD to get a fairly good estimate. Use of horizontal situation display (HSD) and data link systems can greatly increase SA at this point if operating correctly.

3.3.1.3.7 Radio Calls. Lead calls passing every 5,000 feet mean sea level (MSL) increment, and all turns off the briefed departure until all flight members have reported "TIED."

3.3.1.3.8 Maintaining Formation. For turns using 30 degrees of bank, allow the preceding aircraft to drift 5 degrees from the center of the multifunction display (MFD) for each mile of separation or delay approximately 20 seconds from the "Turning" call without radar contact. For example, to maintain a 2 NM trail position, allow the preceding aircraft to drift 10 degrees before initiating the turn; to maintain a 3 NM trail position, allow the aircraft to drift 15 degrees before starting the turn (20 seconds delay is a good tradeoff when not tied).

3.3.1.3.9 Adjusting Formation. If spacing is greater than desired, initiate the turn prior to the standard lead point to establish cutoff and decrease separation. One technique is to keep the target at 0 degrees azimuth during a turn. This "pure pursuit" technique establishes an easily controllable amount of cutoff. As the desired separation is attained, roll out of some bank and let the aircraft drift to the appropriate azimuth. If spacing is less than briefed, allow the preceding aircraft to drift beyond the normal lead point before initiating the turn and separation will increase. As a technique, letting the target drift no more than 10 degrees colder than the azimuth required to maintain spacing works well. At the desired separation, increase the bank angle slightly to bring the target to the correct azimuth.

3.3.1.3.10 Visual Transition. After regaining visual meteorological conditions (VMC) and maintaining visual with the preceding aircraft call "VIPER 2, VISUAL." After all flight members have called visual, expect the flight lead to direct a rejoin to the briefed en route formation.

3.3.2 Prioritization. Constantly reevaluate current conditions during the departure. Remember, the bottom line is to maintain aircraft control and fly instruments. Watch out for task saturation, channelized attention, and disorientation. Radar work takes a back seat when prioritizing tasks. A detailed discussion of task management is in **paragraph 2.2.3.1**, Task Management. Successful trail departures have been flown for decades without the use of a radar.

3.4 Cruise. Keep the HUD flight path marker (FPM) on the 0 degree pitch line to maintain current altitude. To use the autopilot, place the FPM on the 0 degree line, ensure vertical velocity is zero, and engage PITCH ALT HOLD (if using HDG SELECT, ensure the "captain's bars" are set to your current heading before engaging the autopilot). When you adjust and set the throttle, rpm continues to change 1 to 2 percent in the direction you moved the throttle with a corresponding change in fuel flow. This is due to fan response and engine control system refinements. One technique for setting cruise airspeed is to set the throttle at the approximate fuel flow, allow the engine to trim itself, and then use small throttle movements to refine the desired settings. If you want to use the autopilot for steering, rotate the horizontal situation indicator (HSI) "Captain's bars" to the current heading under the lubber line, then select ROLL HDG SEL. This prevents the autopilot from suddenly banking the aircraft to seek a heading different than your current one. To use the roll attitude hold function, ensure the aircraft is wings-level and engage ROLL ATT HOLD. This prevents a constant heading change due to a small bank angle. Using pitch altitude or attitude hold

during decelerating flight can produce a descent from the referenced altitude if AOA increases above a certain value. (Reference applicable Dash 1, Section VI autopilot discussion.)

3.5 G-Awareness. G-induced loss of consciousness (GLOC) is a serious problem. Contributing to the severity of this problem is the inability to accurately and reliably assess pilot G-tolerance and G-endurance.

3.5.1 G-Tolerance. G-tolerance can be thought of as the ultimate G-level that can be maintained over a short period of time that still allows the pilot to employ the aircraft safely and effectively. However, if action is not taken to either improve the anti-G straining maneuver (AGSM) or reduce the G-load, rapid progression to GLOC will occur. G-tolerance is highly variable and dependent upon numerous additive factors.

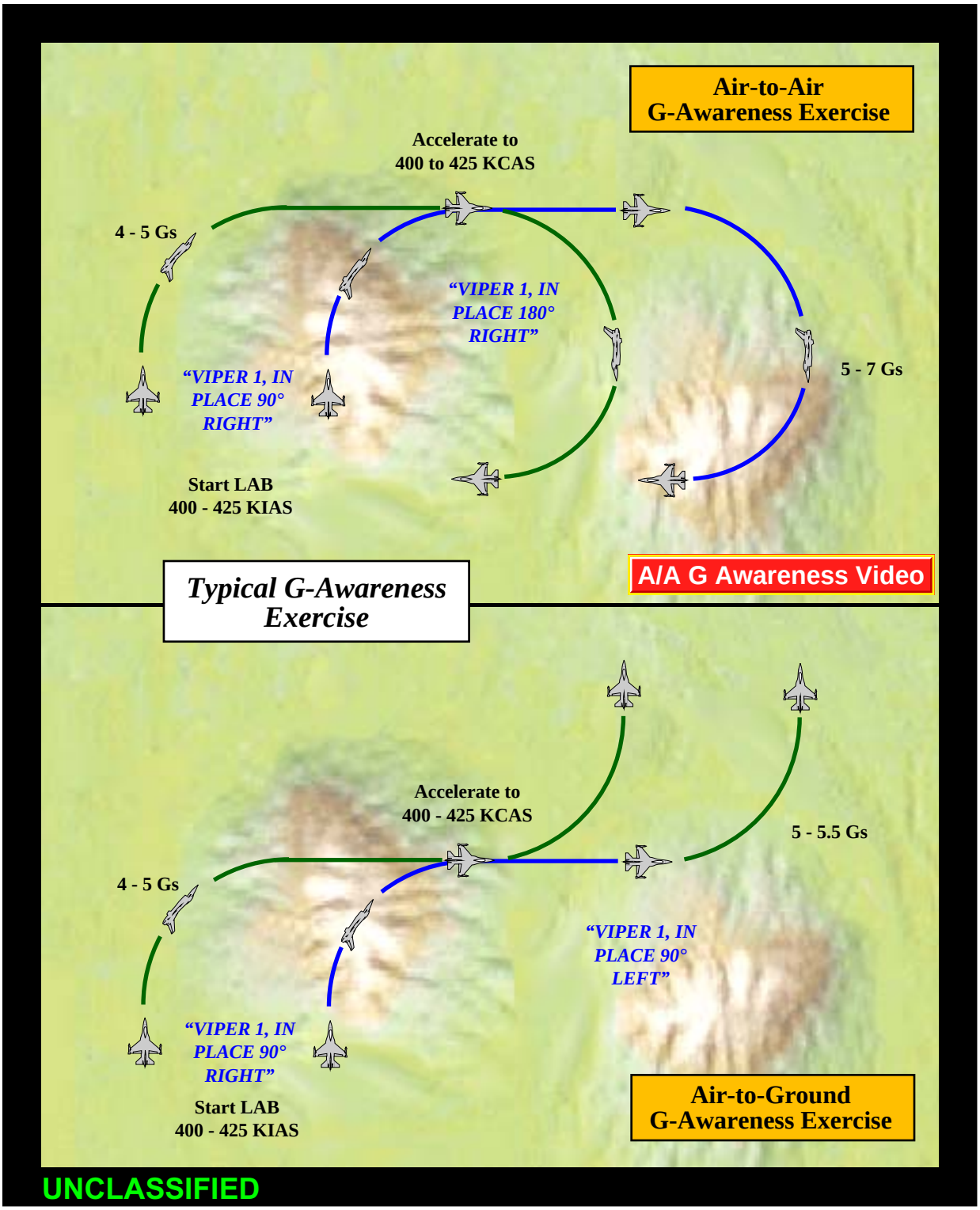
3.5.2 G-Endurance. G-endurance, the maximum G-level that can be maintained over a longer period of time, is perhaps more important; especially considering the F-16's capability to sustain high G. G-endurance is highly dependent upon physical conditioning and "G-currency." Centrifuge studies have shown that layoffs of even a few weeks will result in significantly reduced G-endurance even though G-tolerance remains essentially unchanged. It is easy to see how this increased gap between G-tolerance and G-endurance could set a pilot up for GLOC.

3.5.3 G-Awareness Exercise. A dedicated G-awareness exercise should be conducted when required. **Figure 3.3**, Typical G-Awareness Exercise, is an example of the exercise. The key to GLOC avoidance is pilot awareness; the pilot alone has the ultimate control over G-stress factors. For this reason, the G-awareness exercise is designed to heighten pilot awareness of the man-machine interface and the G-stresses of the mission at hand. As a minimum, the G-awareness exercise should be flown as follows:

- Establish an appropriate formation (i.e., line abreast, spread, etc.) that ensures adequate separation (greater than 6,000 feet) and airspeed to allow tactical maneuvering.
- Self-test the G-suit system for proper inflation, mindful of proper connections and leaks in the system.
- Film the exercise in head-up display (HUD) and in HOT MIC.
- With a smooth application of G (as in a tactical turn), perform a 4- to 5-G turn for 90 degrees (level to climbing). Use this opportunity to ensure proper operation of the G-suit and practice the timing and coordination of AGSM.
- Re-establish airspeed and perform another 90-degree (air-to-ground)/180 degree (air-to-air) turn. Turn initially with 5 to 7 Gs and then let off to a minimum of 3 to 4 Gs during the last 90 degrees as energy bleeds off. Again use this opportunity to establish awareness for operating in the increased-G environment while practicing the AGSM.
- If aircraft limits or energy limits preclude completing the above at the prescribed G, then turns should be performed so as not to exceed aircraft limits.
- It is imperative that all flight members fly the briefed contracts (formation, airspeed, and G-loading). If during the maneuver, the briefed formation contracts cannot be maintained, especially lateral separation and/or deconfliction, flight members should call

"TERMINATE/KNOCK-IT-OFF," as appropriate. Establish briefed parameters or ensure adequate separation prior to the next G-awareness turn.

Figure 3.3 Typical G-Awareness Exercise.



3.5.4 G-Awareness Summary. The G-awareness exercise is not, nor is it meant to be, an assessment for G-tolerance or G-endurance. This exercise cannot protect you from GLOC. It can only afford the opportunity to test equipment, practice the AGSM, and bring the G-environment to the forefront of your mind. G-awareness is a mindset, not a set of exercises to be done and forgotten. G-awareness must be practiced and observed throughout the mission. Remember GLOC incidents typically do not occur during canned "G-awareness exercises" when aircrews are physically and mentally prepared for the onset of Gs. They occur when pilots channelize their attention on some other facet of the mission, such as threat reactions, and place themselves in the high-G environment without preparing their bodies to do so.

3.5.5 Anti-G Straining Maneuver. The AGSM is the best G-defense measure available to aircrew members. Equipment measures (anti-G suit, and reclined seat) were never meant to replace the AGSM, only aid it. Pilots must properly perform the AGSM in order to gain maximum benefit. It is imperative to realize the AGSM should be performed under all G-loading, only the intensity of the AGSM should be varied to match the particular G-load. The intent is to ingrain into the subconscious the ability to automatically apply the proper AGSM anytime G-loading is applied or anticipated. This will build the instinctive reaction required by your body to ensure you do not get caught behind the G-loading and become a GLOC statistic. Additionally, an instinctive, properly executed AGSM will serve to benefit you with increased combat capability as it allows you to maximum perform the aircraft in the combat arena. It is also the best defense against fatigue that will degrade the performance and make you even more susceptible to GLOC on your next engagement.

3.5.5.1 Performing the AGSM. The AGSM consists of two components: muscle tensing and a cyclic breathing technique that must be performed in the proper sequence. Performing one without the other may significantly reduce the effectiveness of the strain. The following are the sequential steps required to properly perform an effective AGSM:

- Anticipate the G.
- Tense all lower body muscles including the gluteus (butt) and abdominals.
- Take a deep breath, hold against a closed glottis (throat), and bear down to generate chest pressure.
- Hold the chest pressure against the glottis until on top of the "G."
- Take a very short, quick breath every 2.5 to 3.5 seconds (the duration and volume of air exchanged is roughly equivalent to the amount you could exhale and inhale through a "soda straw" in 0.5 to 1 second).
- Minimize communication and do not relax until the aircraft is really unloaded.
- Muscle tensing increases usable blood volume and return of blood to the heart. The harder the muscles contract, the greater the reduction in the tendency for blood to pool. Tensing of all skeletal muscles, especially lower body and abdominal, help to "push" blood back to the heart.
- It is important to maintain muscle tension throughout the G-load. The muscle strain intensity may be varied depending on the G-load, but tension must continue as long as the G-load is maintained. The muscle strain must be maintained continuously, even when breathing.

- An effective AGSM increases heart output pressure. The greater the pressure generated in the chest, the greater the resultant blood pressure to the eyes and brain.

3.5.5.2 Common Errors in Performing the AGSM.

- Failure to translate proper AGSM knowledge into a skill that is integrated into other flying skills. The AGSM must be consciously practiced correctly in the aircraft until its performance becomes automatic and correct. This takes a lot of discipline and practice.
- Developing good chest pressure but failing to tense the lower body musculature or relaxing the lower body muscles while still under G. The blood will immediately pool in the extremities making it very difficult for blood to return to the chest even at moderate G and may result in almost instantaneous GLOC or severe visual loss at best, depending on the G.
- Failure to anticipate the G. Performance of the AGSM should begin, ideally, just before the aircraft is loaded. Failure to do so will result in the aircrew member either trying to catch up on the AGSM (a very dangerous practice) or having to unload in order to buy time to catch up.
- Failure to maintain chest pressure (loss of air). Occurs while talking or whenever the strain is audible. As air is lost from the chest the amount of pressure generated falls. This directly reduces blood pressure to the brain. If air loss is heavy, as might occur with speech, the subsequent loss of blood pressure in the brain may result in GLOC without the prior warning of visual loss. Other causes of air loss are “groaning” (letting the air escape slowly) and trying to hold the chest pressure by sealing the lips rather than with the throat.
- Holding your breath less than the required 2.5 to 3.5 seconds results in lower average blood pressure in the brain than would be obtained otherwise (G-tolerance is reduced) and fatigue is accelerated.
- Holding your breath longer than 3.5 seconds. The increased chest pressure impedes return of blood to the chest where it is available to the heart. If blood return to the chest is blocked for 4 to 5 seconds, the heart may have insufficient blood to pump. This can be especially dangerous when wearing COMBAT EDGE.
- Exhaling too much air or taking too long to complete the exhalation and inhalation cycle while under G, particularly common during rapid onset. Results in a reduced ability to develop chest pressure and may significantly shorten the breath-holding time.
- Performing a strain with the intensity necessary to stay awake at 9 Gs while actual G-load is much lower. This will result in early fatigue and increased potential for GLOC in subsequent engagements. The intensity of the AGSM may be graduated in relation to the level of G. It is always safe to overestimate the intensity of the strain, it is always unsafe to underestimate the intensity required. Ideally, the intensity of the straining maneuver will match the G-level.

3.5.5.3 AGSM Assessment. Assess the AGSM effectiveness during mission debriefings. This assessment should not be limited to the G-awareness exercise. It is imperative to eval-

uate the AGSM after the pilot has had time to fatigue, as this is usually when the AGSM breaks down and GLOC occurs.

3.5.5.3.1 Fly the tactical portion of all basic missions (basic fighter maneuvers [BFM], surface attack, and air combat maneuvering [ACM]) in HOT MIC to enable assessment of the AGSM. Intercom volumes should be set at a level which is comfortable for the aircrew, but still allows assessment of breathing and AGSM technique in the debrief. For high task sorties dissimilar air combat tactics (DACT), composite force, and opposed surface attack tactics (SAT) it is highly desirable for aircrews to fly in HOT MIC. The purpose is to identify breakdowns in the AGSM that commonly occur during high task portions of a mission.

- HUD should be selected with camera "ON" (if applicable).
- Listen for a preparatory inhalation just before or as the G is loaded. If it is not there, the pilot may already be behind the G.
- Listen for exhalation sounds or talking during the G-onset. This signifies loss of air from the chest and reduced efficiency of the strain and G-tolerance. Additionally, the pilot is likely to be behind the G and will have trouble catching up. This may cause the pilot to either unload some of the G or sharply increase the intensity of the strain (usually audible). The latter may be a result of recognition of vision loss. Ideally, the first breath should be held until the desired G-level is reached or 3 seconds, whichever occurs first.
- Listen for the first exhalation. It should be short and immediately followed by a quick inhalation. The end of the inhalation may be noted by a sudden grunt sound or a sudden absence of breathing sounds. Total time for the breath ideally should be 0.5 second, but in no case should be longer than 1 second.
- If breath intervals are greater than 3.5 seconds, return of blood to the chest may be impeded reducing G-tolerance. If breath intervals are 4 seconds or longer, there is an increased risk of GLOC.

3.5.5.3.2 Ideally, after the inhalation, breath sounds should not be heard for 2.5 to 3.5 seconds. If breath sounds are more rapid, average chest pressure is lower and G-tolerance is negatively affected. As G-tolerance is negatively affected, the pilot will have to work harder at any given G-load. Fatigue during the engagement, or especially in subsequent engagements, will most likely become apparent. This may be evidenced by even more rapid breathing or breathless, gasping sounds. Observation of the G-load at these times may provide evidence that the pilot is apparently working too hard for the G or is unable to maintain the G necessary for the tactical situation.

3.5.5.3.3 Talking at G may be hazardous depending on the individual and the G-load. If talking is required, it should be in very short bursts accomplished during the breathing phase of the AGSM. However, the need to talk should be weighed carefully against the need to stay awake.

3.5.5.4 AGSM Summary. Remember, the same AGSM should be performed anytime G is applied, only the intensity of the maneuver is varied. Therefore, the AGSM should also be assessed under relatively low-intensity G such as air-to-surface sorties.

3.6 Formations and References. A complete understanding of formation references and limits is essential to flying superior formation. Wingmen should be completely familiar with all the formations referenced in this chapter.

3.6.1 Fingertip (Close) Formation. Fingertip is flown in a position that aligns the front portion of the wing tip missile launcher rail (or forward missile fins) with a point halfway between the environmental control system (ECS) duct and the leading edge of the intake fairing. Fly to align the trailing edges of the exhaust nozzle. Turns by the flight lead do not adjust the formation "picture." (See **Figure 3.4**, Fingertip Position References.)

Figure 3.4 Fingertip Position References.

3.6.2 Route Formation. Route formation is flown as a modified Fingertip formation. Spacing is two-ship widths to 500 feet. When turned away from, the wingman will stack level with the leader. When turned into, the wingman will only stack down enough to keep lead in sight and avoid the maneuvering aircraft.

3.6.3 Echelon. Echelon formation can be flown in either Route or Fingertip. If in Fingertip, turns will only be made away from the Echelon. If a turn into the Echelon is unavoidable, in Fingertip, use minimum bank. If in Route formation, and a turn is made into the Echelon, each aircraft will only stack down enough to keep the rest of the formation in sight and avoid their maneuvering plane. Lead should avoid excessive bank angles. On turns away from the Echelon, all aircraft will maintain the same horizontal plane and the same formation spacing.

3.6.4 Trail Formations.

3.6.4.1 Close Trail. This position is defined as one to two-ship lengths behind the lead aircraft and below the jet wash.

3.6.4.2 Trail. This formation is flown in a cone 30 to 60 degrees aft of lead at a range briefed by the flight lead to accomplish specific requirements. Avoid flying at lead's high 6 o'clock and use caution not to lose sight of lead under the nose.

3.6.4.3 Chase Formation. Chase formation is used during high tasking situations to monitor and assist the lead aircraft in accomplishing required checks. The chase aircraft must not be a flight conflict to the lead aircraft. The lead aircraft may not provide any visual support to the chase. The chase aircraft is responsible for all flight path deconfliction, while performing the monitor duties above.

3.6.4.3.1 Safety Chase. Safety chase is flown in a maneuvering cone 30 to 60 degrees aft of the lead aircraft, from 300 to 1,000 feet back. Provide assistance as directed. As a minimum provide altitude awareness calls, refer to the checklist if the situation dictates, and advise the lead aircraft of any unusual events (smoke, visible leaks, and lack of gear prior to landing). Do not close inside 300 feet unless directed by the lead aircraft for weather penetration or visual checks. Match the lead aircraft’s configuration as soon as changes are apparent.

3.6.4.3.2 Evaluation Chase. Instructors may fly chase formation from a much closer range than during safety chase. Evaluation Chase uses the same maneuvering cone, but allows flight all the way into fingertip position. Normally, do not fly inside that range required to effectively monitor lead aircraft performance (about two-ship widths). Increased care must be used so that midair collision potential is minimized. A normal technique is to beat the lead aircraft to any configuration change (lowering the gear or opening the speedbrakes) to maintain a power or drag advantage.

3.6.5 Show Formations.

3.6.5.1 Diamond: Wingmen fly normal Fingertip formation. The slot pilot flies a close trail position maintaining nose-tail clearance. Current restrictions may not allow this formation.

3.6.5.2 Missing Man: Normal four-ship Fingertip formation. On command from the leader, the Number Three aircraft pulls up and out of the formation. The Number Four aircraft holds position, maintaining relative spacing from the leader.

3.6.6 Cross Unders. A cross under is either directed on the radio or by a slight wing dip toward the wing you are directing the affected aircraft/element to go to.

3.6.6.1 Two-Ship. Number Two drops below and behind Number One and moves to the directed wing. No part of Number Two's aircraft passes below the lead's aircraft. Wingman should strive to pass less than one-half ship-length behind the lead. Number Two should then assume the formation departed on the new wing.

3.6.6.2 Multiship. When the Number Two aircraft is required to cross under in a flight of three or more, Number Three (or the element) will move out to allow Number Two sufficient spacing to move into position. Number Two performs a normal cross under. Number

Three will then move in on Number Two's wing. When an element is required to cross under, the element will drop below and behind the lead (element) maintaining nose-tail and vertical clearance, cross to the opposite side, and then move up into position. Number Four performs a cross under on Number Three after the flight has achieved nose-tail separation.

3.6.7 Rejoins. Any rejoin requires an accurate appraisal of position and closure. The low-drag nature of the F-16 and relative ineffectiveness of small throttle changes in slowing down requires some anticipation for power reduction. The speedbrakes are effective in reducing overtake at normal flying airspeeds (300 knots and above).

3.6.7.1 Turning Rejoins. In this maneuver, the lead will maintain 350 knots and 30 to 45 degrees of bank. Flight members maintain approximately 400 knots. Number Two rejoins to Fingertip on the inside wing and Number Three and Number Four join to the outside. If the rejoin subsequently becomes straight-ahead (lead rolls out), continue to the wing originally maneuvering toward (do not reset to the straight-ahead contract).

3.6.7.1.1 Visual Reference. A visual reference for a normal turning rejoin line is to obscure the far wing tip with the top of the vertical tail; you may be forward (slower) or aft (faster) of this line depending on relative airspeeds. (See **Figure 3.5**, Turning Rejoin Sight Picture.) Keeping the lead aircraft slightly above the horizon and comfortably visible will avoid an endgame vector into lead, while allowing for a controllable overshoot.

3.6.7.1.2 Radar Lock-On. A radar lock-on may be used during the rejoin to provide range and overtake information.

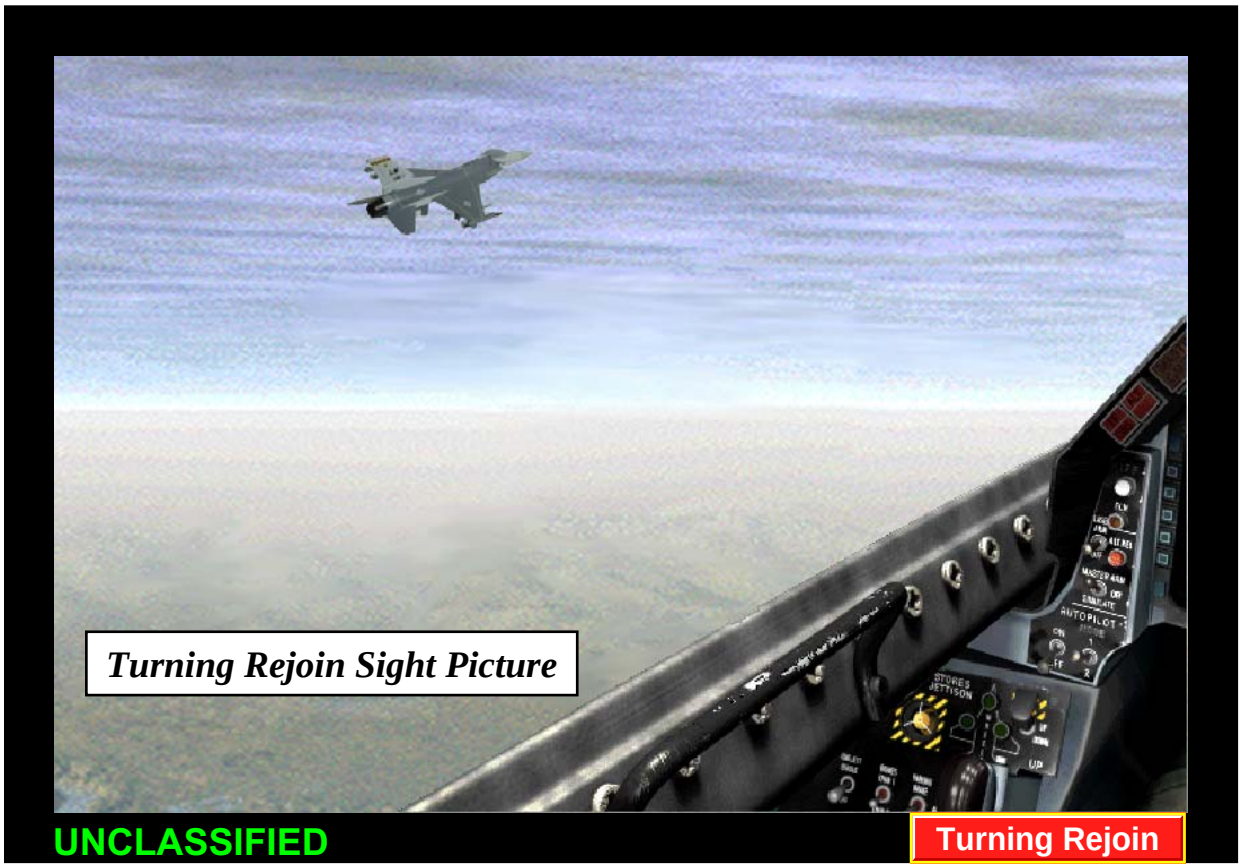
3.6.7.1.3 Position. If you are Number Three or Number Four, ensure that you are locked to the leader and stay visual with Number Two.

3.6.7.1.4 Speed Reduction. As separation decreases to approximately 3,000 feet, reduce power smoothly to control overtake. At approximately 1,500 feet, overtake should be about 50 knots. Consider using the speedbrakes if overtake is excessive. Stabilize momentarily in route and then smoothly move into the Fingertip position. If overtake is excessive approaching the extended Fingertip position, initiate a controlled overshoot early enough to allow nose-tail separation.

3.6.7.2 Straight-Ahead Rejoin. Lead should maintain 350 knots unless otherwise briefed. Number Two rejoins to the left wing, Number Three, and Number Four to the right. Wingmen should strive for a radar lock due to the reduced closure cues at 0 degrees aspect. Flight members should maintain approximately 75 to 100 knots of closure until inside 3,000 feet. At this point make a slight turn to arrive at about 200 feet lateral spacing from lead, while reducing closure to less than 50 knots by 1,500 feet. Stabilize in route and then move in to Fingertip.

3.6.7.3 Overshoots. If the overtake is excessive and cannot be controlled with power and speedbrakes, initiate an overshoot: turning and straight-ahead.

Figure 3.5 Turning Rejoin Sight Picture.



3.6.7.3.1 Turning. If turning, reduce bank and slide to the outside of the turn. Ensure nose-tail separation and pass behind and below the flight lead. Once line of sight (LOS) begins moving forward, perform a normal cross under to the inside wing. Stabilize in route and then move into Fingertip.

3.6.7.3.2 Straight-Ahead. If straight-ahead, check away from the lead and stay slightly low on the formation. Keep lead in sight, stabilize, and move back to route and then into Fingertip.

3.6.8 Lead Changes. Lead changes require an unmistakable transfer of responsibilities from one flight member to another. Lead changes may be initiated and acknowledged with either a radio call or visual signal. Visual contact with the new lead is required prior to initiating a lead change. The flight member who assumes the lead will be no further aft than the normal Route/ Fingertip position prior to initiating or acknowledging the lead change. The lead change is effective upon acknowledgment. All flight members must continue to ensure aircraft separation as positions are changed. The new leader must continue to monitor the new wingman's position until the leader is established in front with the wingman looking at lead. If the radio is used for the lead changes, use call signs and be specific. The wingman assuming the lead will so state in his acknowledgment. Lead changes using visual signals are preferred since it guarantees that the flight members are looking at each other. Whether done visually or using radio calls, all flight members must monitor aircraft separation until the new positions are established.

3.6.9 Operations Checks. The flight leader will initiate operations checks. This is the time to confirm proper fuel state, fuel transfer, engine operation, and operation of life support equipment. It is each pilot's responsibility to continually check these items without prompting by the flight leader.

3.6.10 Weather. Formation in the weather may require some adjustment in formation procedures. The aircraft is very responsive to pilot inputs; therefore, a smooth, steady hand, and a light grip are essential.

3.6.10.1 Flight Leads. When flying formation in IMC, or transitioning from VMC to IMC, monitor attitude and altitude so as not to exceed 30 degrees of bank or enter an excessive descent rate.

3.6.10.2 Wingmen. When flying close in turbulent conditions, do not attempt to rapidly counteract every gust with control inputs. Remember, the leader is flying in the same patch of air, and both aircraft will react the same way to rough air. Use smooth corrections and avoid rapid erratic control inputs. Lost wingman procedures should be used if you lose sufficient visual formation reference.

3.6.11 Leaving Formation.

3.6.11.1 It is the duty of the wingman to leave the formation:

- When visual is lost. Change altitude to deconflict from lead’s last known altitude by at least 1,000 feet.
- Any time when feeling that his presence in the formation constitutes a hazard.
- When directed to do so.
- When unable to join-up or to stay in formation without crossing over, under, or in front of the aircraft ahead.

3.6.11.2 The wingman should clear the flight path in the direction of the turn and notify lead. If the wingman loses sight, he must comply with the appropriate lost wingman procedures. The wingman will rejoin only when directed to do so by the flight lead.

3.6.12 Lost Wingman Procedures. When executing lost wingman, first transition to instruments. Execute the appropriate lost wingman procedures in a prompt but controlled manner while making a radio call to inform lead. Smooth application of control inputs is imperative to minimize the effects of spatial disorientation. A common error is to overreact by putting in more bank than is required. Concentrate on the instrument references and stabilize the aircraft. Once the procedure is initiated, carry it through until confirming flight path deconfliction (visual, radio, and ATC). Do not attempt to rejoin without clearance from the flight lead.

3.6.13 No Operative Radio/Emergencies. Comply with briefed procedures. The flight lead will usually brief no operative radio (NORDO) rendezvous point and escort requirements during the mission briefing.

3.6.14 Formation Landing.

3.6.14.1 Lead Procedures. The flight lead must fly the best approach and landing while giving the wingman consideration for differences in configuration.

- Establish an approach speed consistent with the heavier aircraft.

- Position the wingman on the upwind side if the crosswind component exceeds 5 knots.
- Plan to land near the center of your half of the runway to ensure enough runway is available for the wingman.
- Ensure touchdown of the heavier aircraft is no slower than 13 degrees AOA.
- Do not touchdown long and fast.

3.6.14.2 Wing Procedures. The wingman must fly precise formation and match leads aircraft configuration and airspeed. During the transition to landing:

- Maintain a minimum of 10-foot lateral wing tip spacing and stack level with the lead aircraft inside the final approach fix (FAF) and visual with the runway, or as briefed by the flight lead when VMC and configured on final.
- Cross-check the runway and ensure sufficient runway is available.
- Go around or execute a missed approach if sufficient runway or aircraft clearance is not available.

3.6.14.3 Roll-Out Procedures:

- Prior to aerobraking, the leader should maintain the landing attitude until nose-tail separation is assured.
- The wingman should smoothly aerobrake to 11 to 13 degrees AOA, avoiding abrupt aft stick inputs.
- Each pilot will maintain their landing side of the runway until slowed to normal taxi speed.
- After assuring clearance, move to the turnoff/cold side of the runway. Wingmen may clear the leader to the cold side after their aircraft is under control.
- If the wingman overruns the leader, accept the overrun, maintain the appropriate side of the runway, and do not attempt to reposition behind the leader. The most important consideration is wing tip clearance. Although a verbal lead change is desired (e.g., “VIPER 2, YOU HAVE THE LEAD” “VIPER 2, HAS THE LEAD”), it is not required.

3.7 Tactical Formation. Varying factors of the tactical arena (weather, visibility, background, terrain, and threat), will determine the position and responsibilities for the individual flight members. Central to all maneuvering must be a capability to communicate intent, role, and threat information. Definitions of pilot responsibilities and emphasis on air discipline will help ensure success in a restricted communications environment. The formations described in this chapter are applicable for both air-to-air (A/A) and air-to-surface (A/S) operations. The guidelines given have proven to be the most universally applicable. As the tactical situation changes, the numbers given here may change. For a more detailed discussion on how and why various factors affect formation decisions, refer to MPM and AEM. Remember, flying a given formation is not an end in itself; it facilitates proper task prioritization, lookout, and offensive and defensive considerations. If you cannot perform your responsibility in a formation listed, get into one which does permit you to carry out

your formation responsibilities. The flight briefing should cover, as much as possible, any changes that may be necessary.

3.7.1 Mutual Support. A vital subset of SA is mutual support. Mutual support is a contract within a flight of two or more aircraft that supports the flight's mission objectives. An effective mutual support contract will enable a flight to maintain the offensive, while enhancing its survival in a hostile environment. Mutual support in the modern combat arena is more directly related to SA than ever before. It demands position awareness of other flight members and the threat as well as an understanding of the flight's and the threat's weapons capability. Flight leads must carefully assess the experience and proficiency level of their flight members when developing the flight's mutual support contract. A sound mutual support contract should provide the following:

- Position awareness of other flight members.
- Early position awareness of the threat and the attack axis.
- Communication of offensive and defensive information to the flight.
- Targeting and weapons employment prior to threat attack.
- The ability to prosecute the attack and/or disengage.

3.7.2 Formations. Visual formations can provide for all of the elements of a sound mutual support contract. Additionally, visual contact with other element members is critical in a visual fight. A visual formation is a common choice because you cannot assume the enemy is beyond visual range (BVR). Visual formations are easy to fly, provide a common and reliable reference for communication and targeting, mass of firepower, and most importantly provide immediate position awareness of supporting fighters. (See **Figure 3.6**, F-16 Canopy Codes.)

3.7.3 Visual Lookout. Visual lookout is a priority task for all flight members, flight leads as well as wingmen. Historically, 90 percent of all A/A losses were due to undetected attacks. Visual formations evolved throughout the years in an attempt to visually clear and deny the enemy an unseen entry. In addition to visual detection, survivability increases when each flight member has a potential for timely assistance by using the radio or weapons. The amount of time spent maintaining visual contact, or formation position, influences the ability to detect a threat visually or by other means (radar and ground-controlled intercept [GCI]). In addition, the dynamics of ACM often drive you to a position where providing timely assistance is difficult. Examples of this can be found in **Figure 3.7**, Six O'clock Visual Coverage, and **Figure 3.8**, Aircraft References for 6 O'clock Look Angles.

3.7.4 Formation Selection. The basic combat formation employed by tactical fighters is the four-ship flight. The two-ship element is the basic fighting unit. The wingman's primary duty is to fly formation on his leader and to support the lead at all times. The wingman is to clear the area and perform his portion of the briefed mission. A four-ship flight consists of two elements directed by the four-ship flight lead, increasing the mutual support of all. Considering the variety of air and surface threats, terrain, weather, target arrays, and mission objectives that will be encountered in carrying out a wide range of wartime taskings, there is a need for both Line Abreast and Trail formations. Each of these types of tactical formations has unique strengths and weaknesses.

3.7.4.1 Line Abreast Considerations. Where the major threat is from enemy fighters, line abreast provides optimum visual cross coverage and good position for rapid maneuvering and mutual support for counterattack. Also, it diminishes the opportunity for a ground threat to be alerted by the leader's overflight and carry out a successful engagement on the wingman. (At ingress airspeeds AAA gunners have an additional 2 to 4 seconds reaction time on a wedge wingman.) Line abreast makes it easy for the leader to check on the position and status of all wingmen. It also lends itself well to simultaneous attacks by the leader and wingmen against known enemy targets with distance deconfliction and turning room. On the other hand, line abreast formations have certain disadvantages. It is not practical to fly at extremely low altitude with random maneuvering. Moreover, when line abreast, it is difficult for wingmen to achieve spacing on the leader for a sequenced attack, particularly where target location is not precisely known.

3.7.4.2 Trail Considerations. Trail formations provide less 6 o'clock threat look-out coverage and have less flexibility in initial maneuvering to counter A/A attacks behind the 3/9 line. On the strength side, Trail formations can be flown successfully at lower altitude, especially in mountainous terrain, because the wingman can keep both the leader in sight and adequately scan approaching terrain. In certain threat scenarios, extremely low-altitude flight can be a critically important advantage. Trail formations also allow for good offensive air capability against a forward quarter threat and good maneuvering potential. Trail also provides much greater maneuvering flexibility as wingmen can handle turns of any magnitude by delayed maneuvers. Such maneuvering may be required to pinpoint targets at the last minute and also to evade pop-up ground threats such as automatic weapons fire. Finally, Trail formations also have advantages for multiple attacks against the same target or target array (not all threat scenarios call for single pass tactics).

Figure 3.6 F-16 Canopy Codes.

Figure 3.7 Six O'clock Visual Coverage.

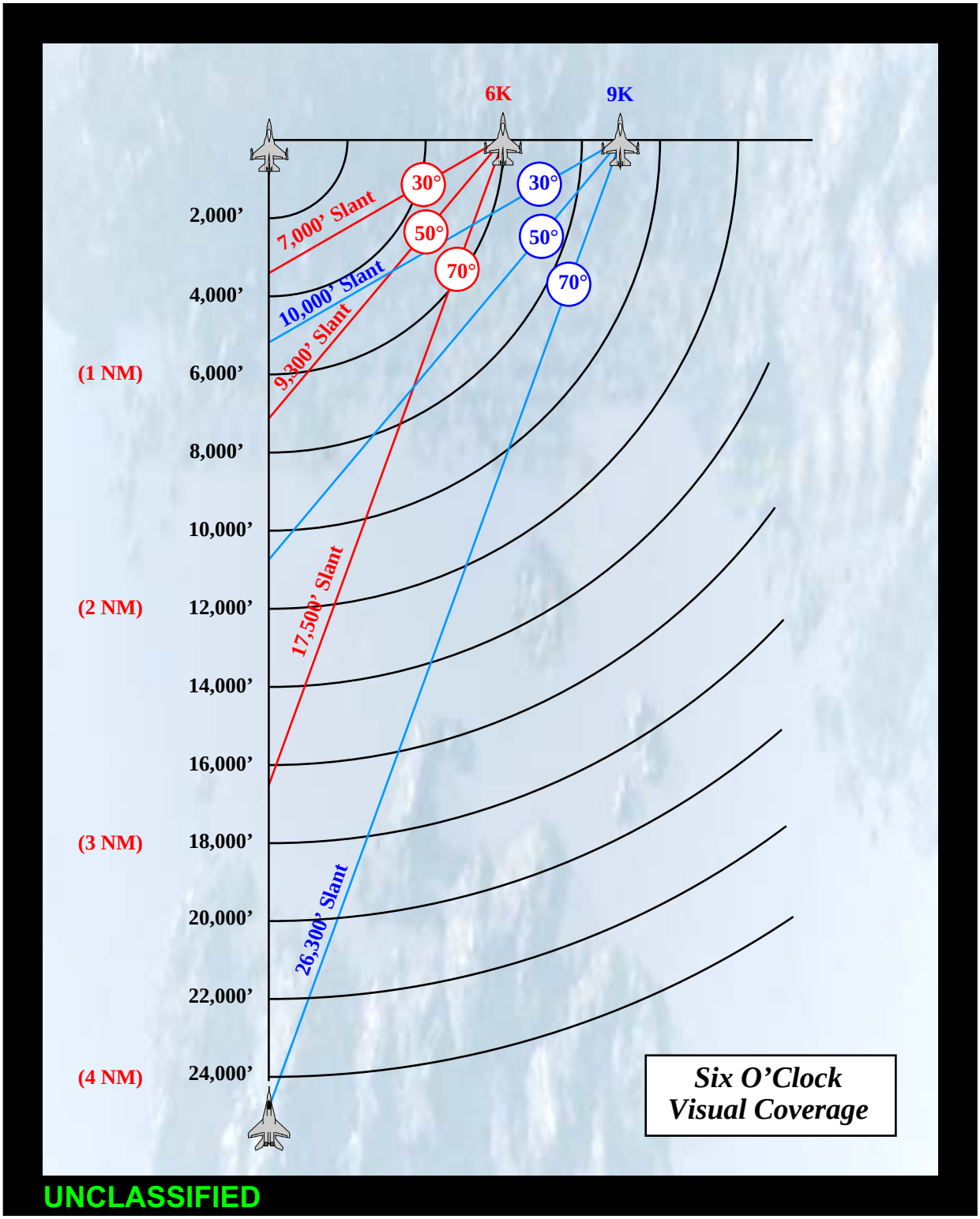
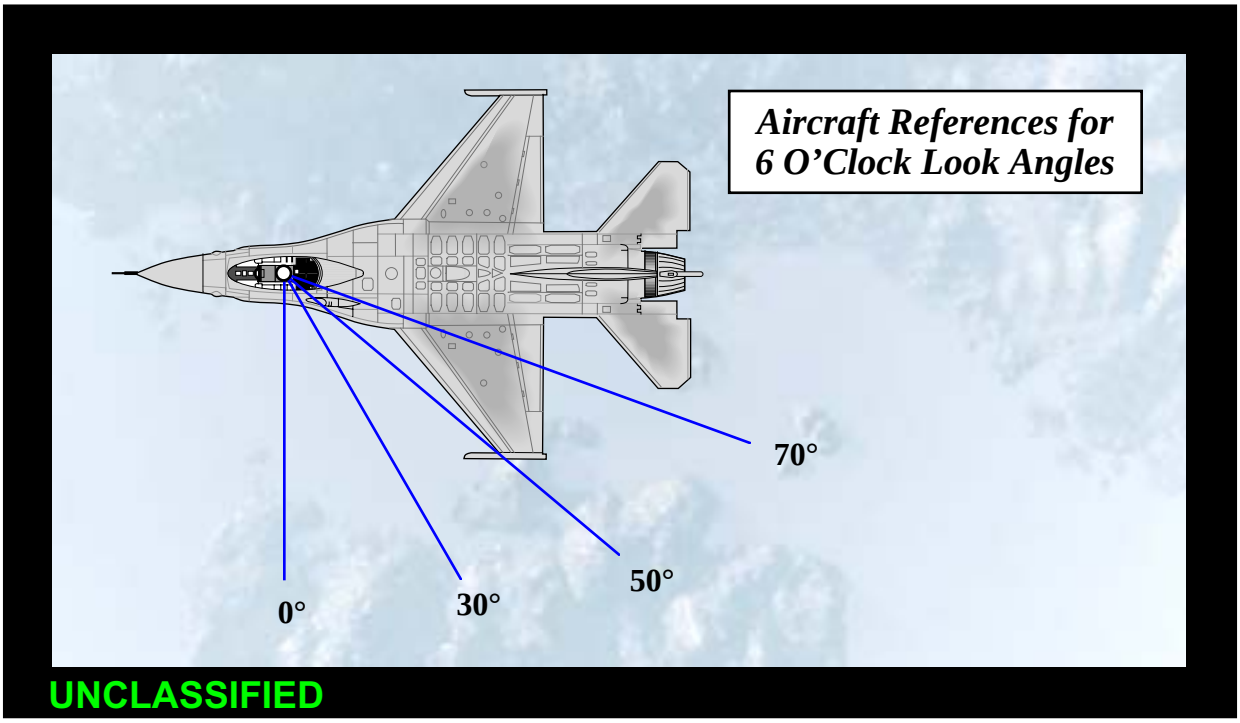


Figure 3.8 Aircraft References for 6 O'clock Look Angles.



3.7.5 Formation Responsibilities. The flight lead assigns responsibilities for each flight member. Dividing responsibilities ensures each pilot has a manageable number of tasks to perform. Flight member normal responsibilities are as follows:

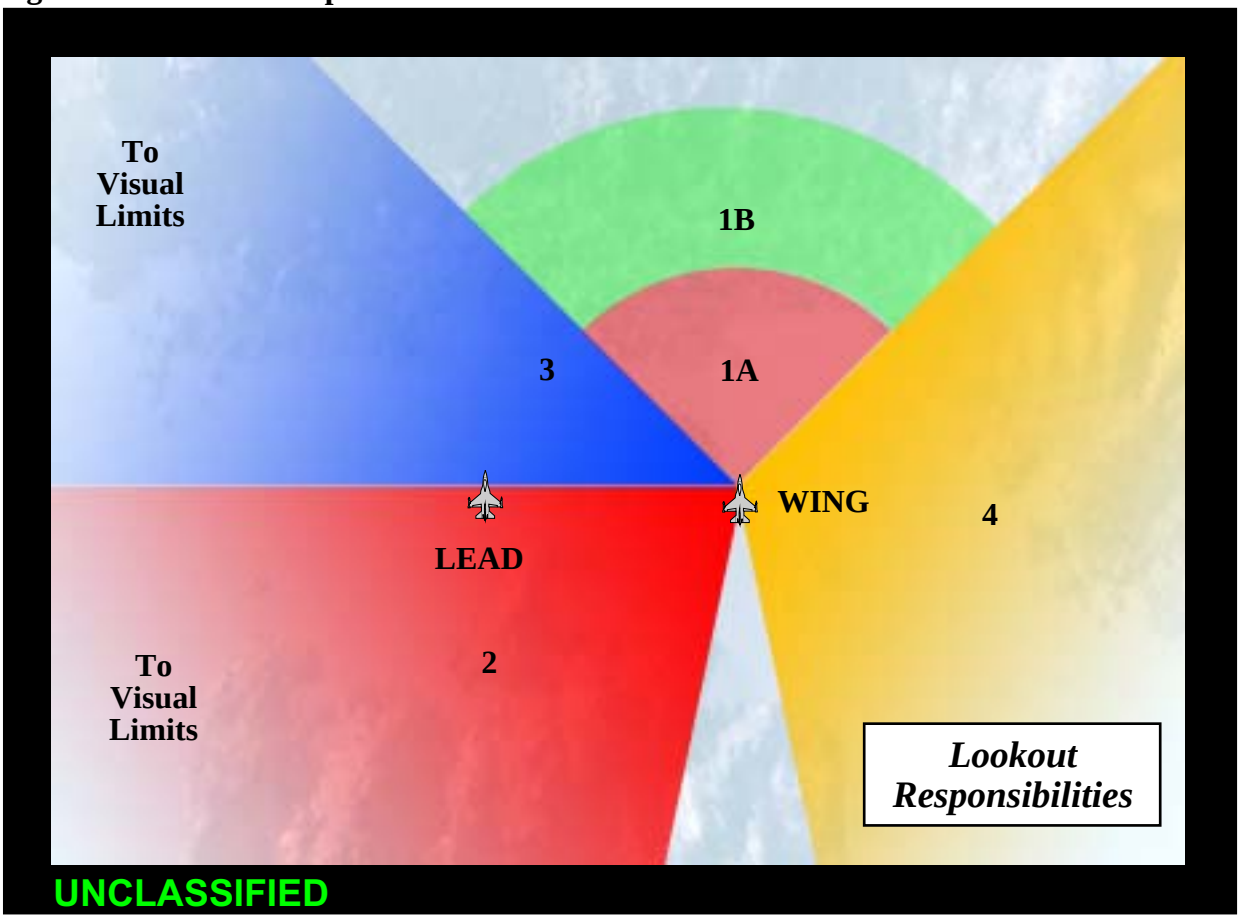
- Number One: Primary planner and decision-maker, primary navigation and radar lookout, visual look out as other responsibilities allow, and primary engaged fighter, if practical.
- Number Two: Maintain formation position and visual lookout. Radar awareness and navigation position awareness, as other responsibilities allow.
- Number Three: Maintain formation on the lead element, secondary navigation and radar monitor, and visual lookout as other responsibilities allow.
- Number Four: Same as Number Two.

3.7.6 Time-Sharing. The goal on every low-level training mission should be to improve the development of the time-sharing cross-check. Practice and discipline are essential to maximizing visual mutual support. On each mission, pilots must start with the basic NEAR ROCKS, FAR ROCKS, LEAD, CHECK SIX pattern and build up the visual search arena as allowed by task saturation, threat, and flight conditions. When encountering extremely rough terrain, defensive reactions and navigation turns drop the lowest priority sectors in order. There will be times, such as hard turns, when only NEAR ROCKS can be cross-checked. The key is to quickly re-establish the cross-check one sector at a time as tasks permit.

3.7.7 Lookout Responsibilities. Although the pilot has a myriad of responsibilities, one task can be performed at a time. Therefore, a time-sharing plan must be employed to quickly and efficiently accomplish many tasks. The following is an example of a time-share plan for lookout responsibilities. The airspace around the aircraft is divided into sectors and each sector is

assigned a priority based on lookout responsibilities. (See **Figure 3.9**, Lookout Responsibilities.) This plan is developed from a perspective of Number Two in a four-ship, but the principles apply to all positions in the flight.

Figure 3.9 Lookout Responsibilities.



- Sector 1: This is the hub of the cross-check. It is divided into two parts. Sector 1 is NEAR ROCKS, the rocks that will affect the flight path in the next 10 to 15 seconds. This sector is the highest priority sector and is the center of the cross-check. NEAR ROCKS are the ones that present an immediate threat. Sector 1A is FAR ROCKS, the terrain that will affect future maneuvering. Pilots that look ahead at the FAR ROCKS are smooth in their maneuvering to maintain position or navigate because they see the mountain peaks and valleys in time to make small corrections.
- Sector 2: Besides avoiding the ground, the next most important area for lookout space is inside the flight's 6 o'clock. Sector 2 allows Number Two to monitor formation position and check lead's 6 o'clock. Sectors 1, 1A, and 2 make up the basic cross-check NEAR ROCKS, FAR ROCKS, LEAD, and CHECK SIX.
- Sector 3: Once these responsibilities are completed, other areas can be brought into the cross-check. The next sector is inside the flight ahead of the 3/9 line. Searching this area can detect bandits converting, as well as surface-to-air missiles (SAM) that may be fired from the front quadrant. Sector 3 is lower priority than Sectors 1, 1A, and 2; therefore, it

should be searched less frequently. NEAR ROCKS and FAR ROCKS must be checked during each search cycle. The frequency of search is dependent on pilot task saturation.

- Sector 4: When proficient enough, expand the search to a 360-degree lookout by picking up Sector 4. Sector 4 is outside the flight, ahead or behind the 3/9 line. This sector is the lowest priority; the wingman owes it to the flight lead to provide inside-the-flight lookout before dedicating time to this sector.

3.7.8 Sensor Integration and Cockpit Tasks. A complete understanding of **paragraph 3.7.7**, Lookout Responsibilities, will answer the question "Where does the sensor usage fit into the cross-check?" Flight position will determine where to incorporate sensor search. As lead or Number Three, it should be part of Sector 3. As Number Two or Number Four, the radar should be after Sector 4. Performing cockpit tasks is the next problem. The best plan is to accomplish as many tasks as possible prior to entering the low-altitude regime. Switch errors are often made in the heat of battle. When switch changes are required, substitute them for a cross-check sector search. For pacing, do one task, then reference the flight path before moving to another task.

3.8 Two-Ship Formations.

3.8.1 Line Abreast. Line Abreast formation is a position 0 to 20 degrees aft; 4,000 to 12,000 feet spacing; with altitude separation. (See **Figure 3.10**, Two-Ship Line Abreast Formation.) At low altitude, the wingman should fly no lower than lead.

3.8.1.1 Wingmen will fly from 6,000 to 9,000 feet and strive for the 0-degree line, unless further defined by the flight lead. The 6,000 to 9,000 feet position provides optimum visual and firepower mutual support for threats from the beam and 6 o'clock positions.

3.8.1.2 The flight lead may tailor the parameters of this formation to meet particular situations or requirements. For example, in poor visibility conditions at low altitude, the wingman may be briefed to fly 4,000 to 6,000 feet lateral spacing. For certain A/A scenarios, the briefed lateral spacing may be 9,000 to 12,000 feet to enhance 6 o'clock visual coverage while complicating the enemy's visual acquisition of all aircraft in the formation. Wingmen need to maintain a formation position, that allows performance of other responsibilities and does not require them to concentrate 100 percent of their attention on flying formation.

3.8.1.3 Each pilot must be in a position to detect an adversary converting on the wingman's stern prior to that adversary reaching firing parameters. Against an all-aspect, all-weather adversary this may not be possible. F-16 rearward visibility field of view (FOV) is not a limiting factor, as it is in most other aircraft.

3.8.1.4 This formation allows element members to be in position to quickly bring ordnance to bear when a threat is detected. A vertical stack of 2,000 to 5,000 feet, when applicable, minimizes the chance of simultaneous detection by a bandit.

3.8.2 Wedge. Wedge positions the wingman 30 to 60 degrees aft of the leader's 3/9 line, 3,000 to 6,000 feet back. The flight lead may extend the formation spacing out to 12,000 feet to meet particular situations or requirements. (See **Figure 3.11**, Two-Ship Wedge.)

Figure 3.10 Two-Ship Line Abreast Formation.

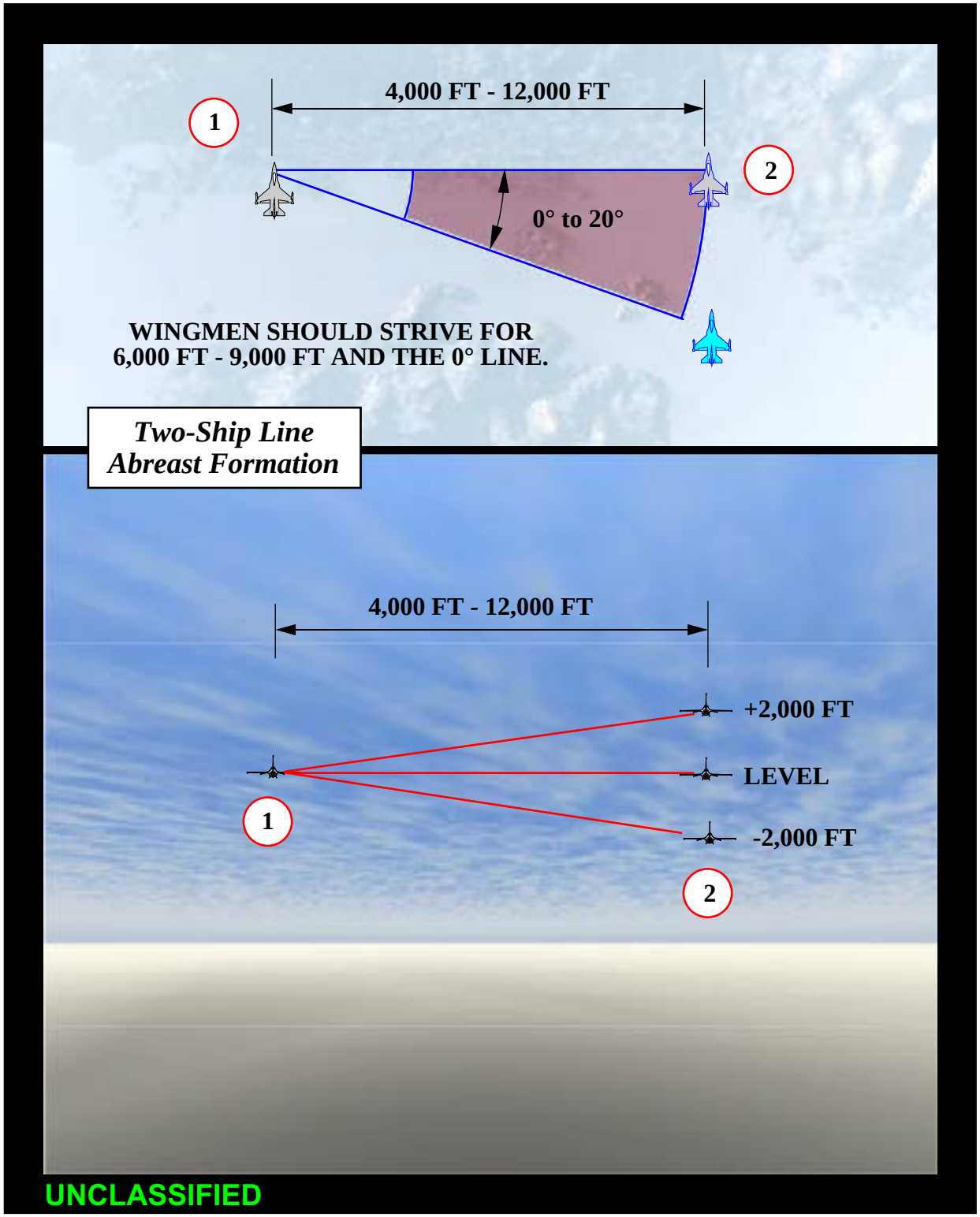
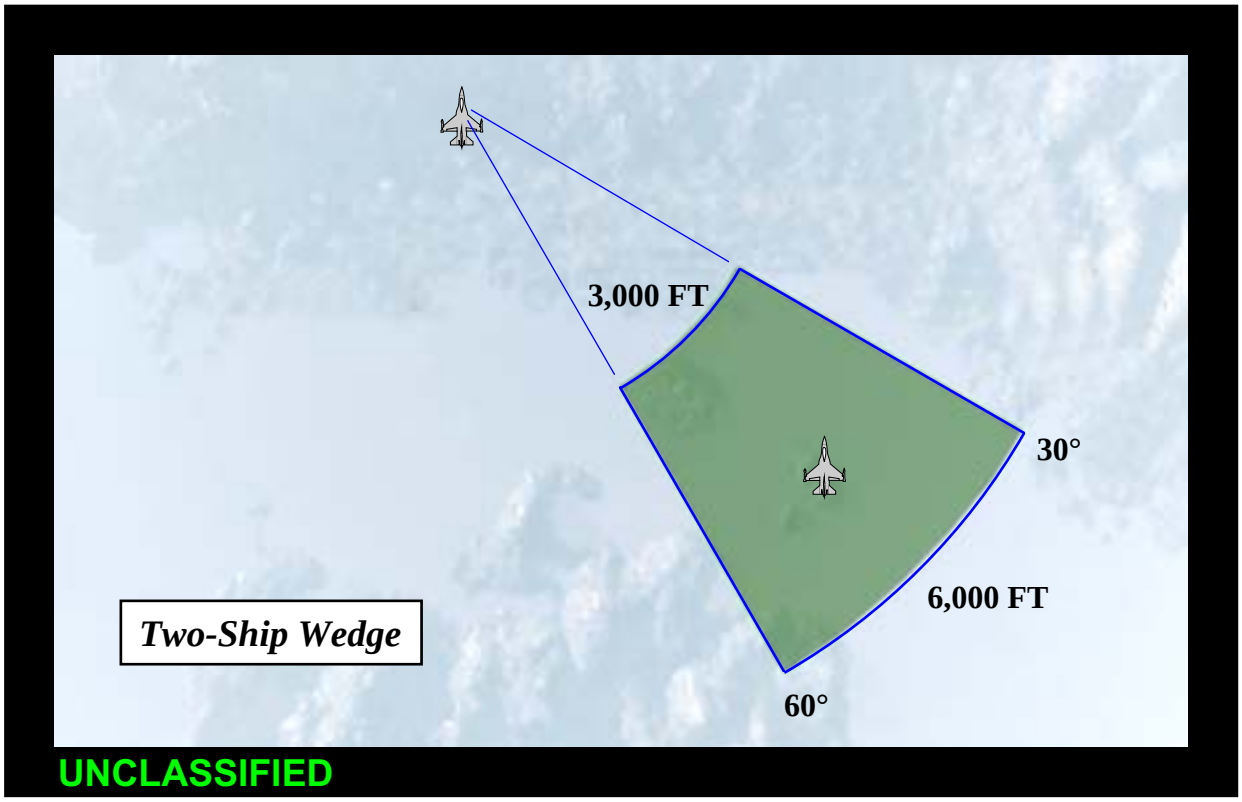


Figure 3.11 Two-Ship Wedge.

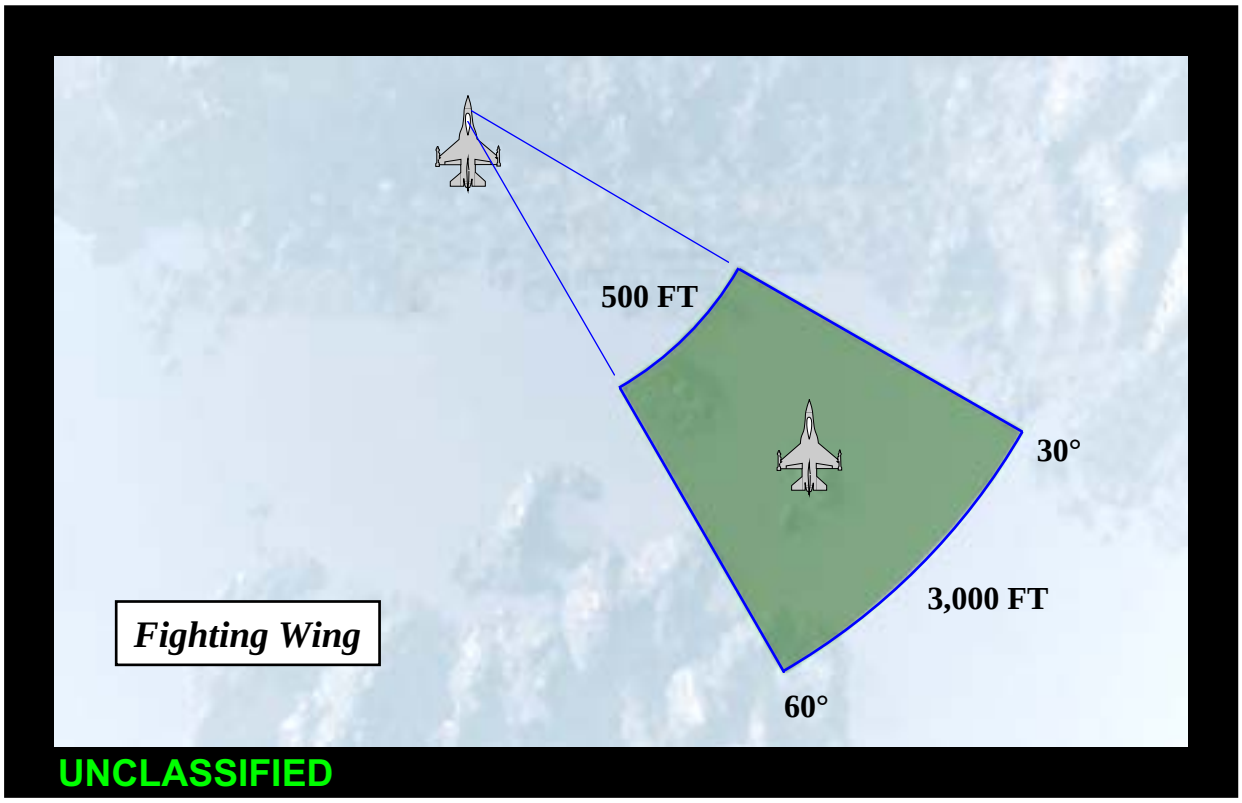


3.8.2.1 The advantages of wedge are that the leader is well protected in the 6 o'clock area and is free to maneuver aggressively. The wingman may switch sides as required during turns. The wingman may also switch sides as required to avoid terrain, obstacles, or weather but must return to the original side unless cleared by the leader.

3.8.2.2 The most significant disadvantage of the wedge is that it provides little to no 6 o'clock protection for the wingman. Lead changes, if required, are difficult to execute.

3.8.3 Fighting Wing. This formation, flown as a two-ship, gives the wingman a maneuvering cone from 30 to 60 degrees aft of line abreast and lateral spacing between 500 to 3,000 feet. Number Two maneuvers off lead and uses cutoff as necessary to maintain position. This formation is employed in situations where maximum maneuvering potential is desired. Arenas for use include holding in a tactical environment or maneuvering around obstacles or clouds. (See **Figure 3.12**, Fighting Wing Formation.)

Figure 3.12 Fighting Wing Formation.



3.8.3.1 Advantages:

- The formation allows the element to maintain flight integrity under marginal weather conditions or in rough terrain.
- Allows for cockpit heads-down time for administrative functions when in a low-threat arena where hard maneuvering is not required.

3.8.3.2 Disadvantages:

- Poor to nonexistent 6 o'clock coverage.
- Easy detection of formation by single threat.

3.9 Four-Ship Formations. The four-ship is under the control of one flight lead and is employed as a single entity until such time as it is forced to separate into two elements. At no time should an element sacrifice element integrity attempting to maintain the four-ship formation. Each two-ship element should have its own radar and visual plan so that no changes will be required if the four-ship is split into two-ships.

3.9.1 Box/Offset Box. In Box formation, elements use the line abreast maneuvering and look-out principles. The trailing element takes 1.5 to 3 NM separation, depending on terrain and weather. The objective of the spacing is to give separation to avoid easy visual detection of the whole formation, while positioning the rear element in a good position to immediately engage an enemy converting on the lead element. Because the F-16 is difficult to see from a direct trail position, a slight offset will facilitate keeping sight of the lead element. Use of A/A

tactical air navigation (TACAN) between the elements, and the radar in the rear element, will help keep the proper spacing. Element leaders initiate formation maneuvers. Number Three maneuvers to achieve pre-briefed spacing on the lead element (based on threat, mission, and weather). Flight leads may modify wingmen position to Wedge or Fighting Wing if desired. (See **Figure 3.13**, Four-Ship Offset Box.)

NOTE: In an ATC environment, if standard formation is required, the trailing element should fly closer than 1 NM and wingmen from 4,000 to 6,000 feet.

3.9.1.1 Advantages:

- The formation provides excellent mutual support and lookout.
- The rear element is positioned to engage an adversary making a stern conversion on the lead element.
- It is difficult to visually acquire the entire flight.
- Element spacing for an attack is built into the formation.

3.9.1.2 Disadvantages:

- The formation is difficult to fly in poor visibility and rugged terrain.
- Depending on position, the trailing element may be momentarily mistaken as a threat, especially if staggered too much off to one side.

3.9.2 Fluid Four. Element leads fly line abreast, with wingmen in Fighting Wing or Wedge (as briefed) on the outside of the formation. Number Three maneuvers off Number One. Number Two and Number Four maneuver off their element leaders to maintain the outside of the formation. Element leads are responsible for deconfliction of elements when crossing the opposing element's 6 o'clock. At medium altitude, wingmen should stack away from the other element when turning. (See **Figure 3.14**, Fluid Four Formation.)

3.9.2.1 Advantages:

- Inexperienced wingmen are kept close for ease of maneuvering.
- Four-ship maneuverability is good.
- Good NVG formation when wingmen fly the Wedge position.
- Formation provides concentration of force.
- Easily converts to three-ship when one aircraft falls out.

3.9.2.2 Disadvantages:

- Adversary can acquire all four aircraft.
- Defensive maneuvering produces deconfliction challenges due to the proximity of aircraft.
- Cumbersome to maneuver at low altitude in rough terrain.

3.9.3 Spread Four. Element leads maintain line abreast, wingmen position themselves 0 to 30 degrees back from their element leads and 6,000 to 9,000 feet spread. Each element uses fluid maneuvering. Number Three flies off Number One (similar to Fluid Four). The elements

are not always required to be line abreast. On some occasions they may be briefly in trail. (See **Figure 3.15**, Spread Four Formation.)

Figure 3.13 Four-Ship Offset Box.

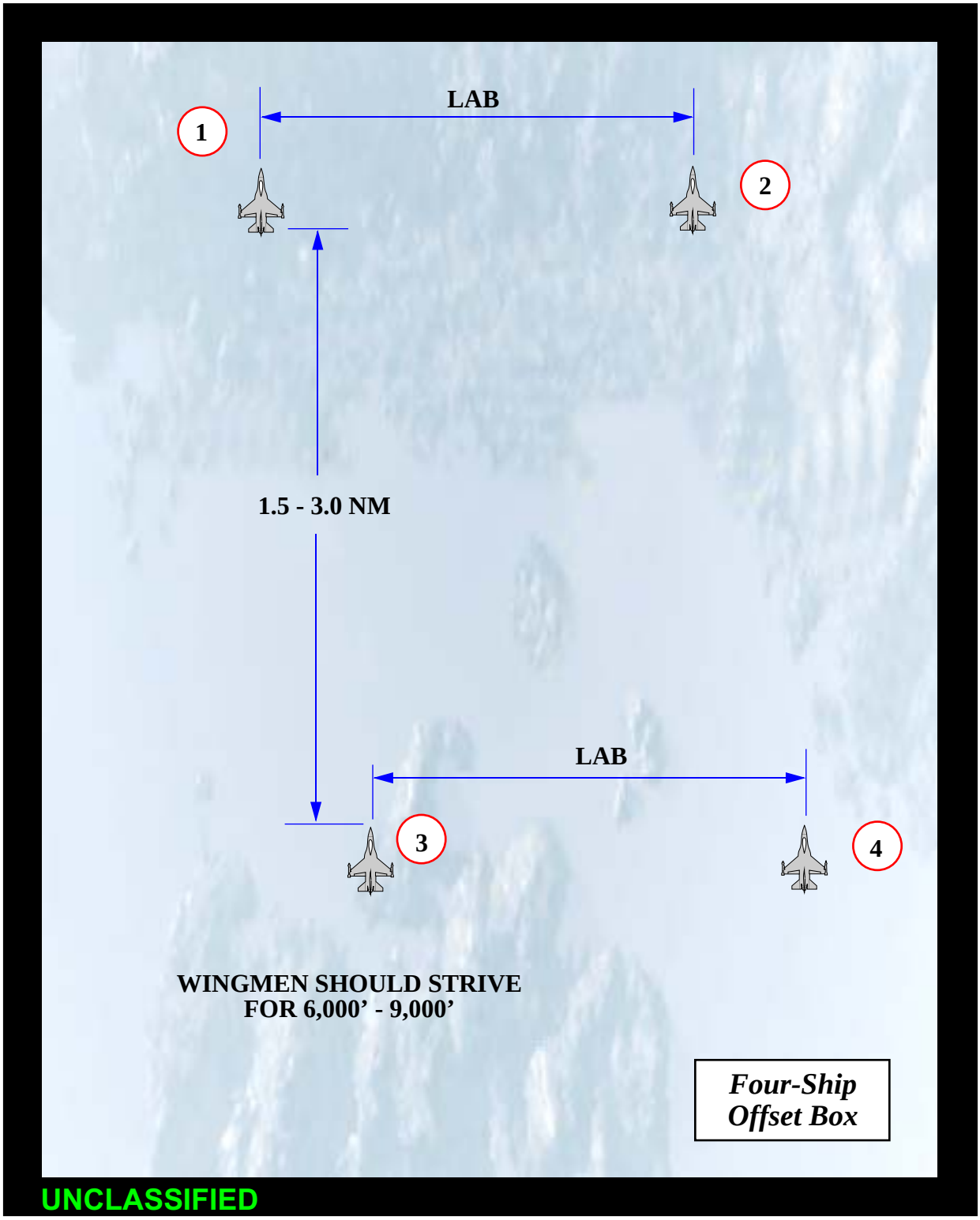


Figure 3.14 Fluid Four Formation.

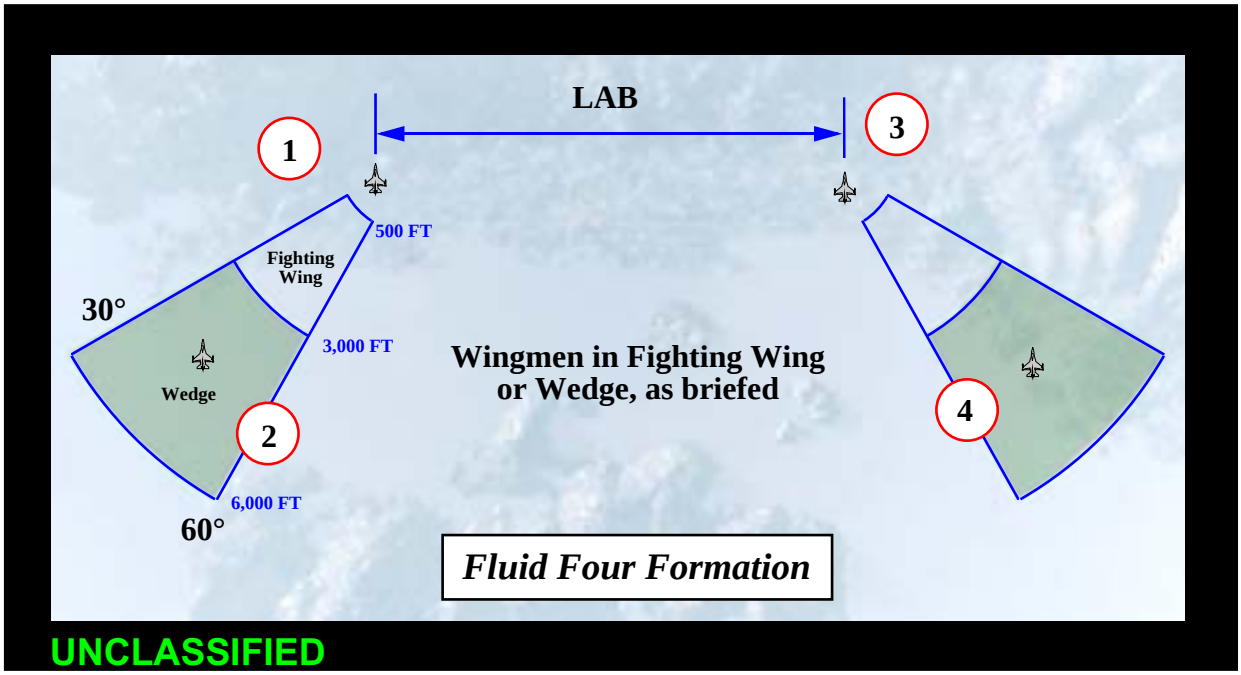
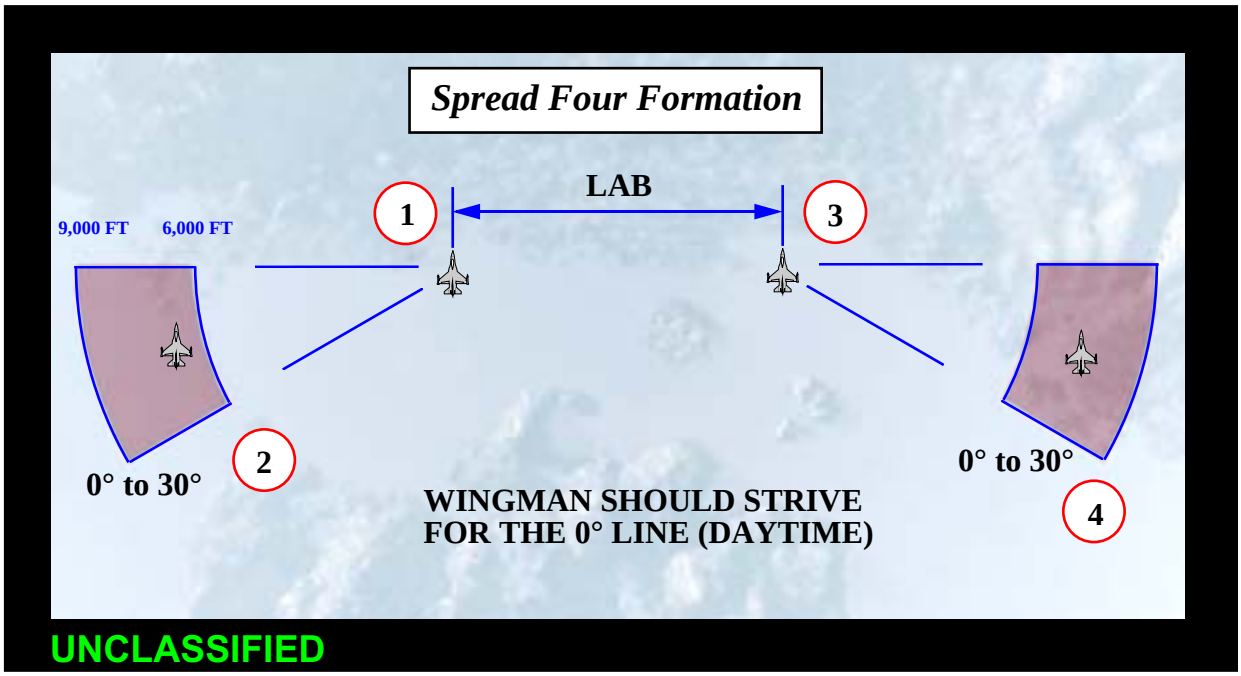


Figure 3.15 Spread Four Formation.



3.9.3.1 Advantages:

- Spread Four formation makes it difficult for an adversary to visually acquire the entire flight at once.
- Firepower is maximized for BVR weapons employment.

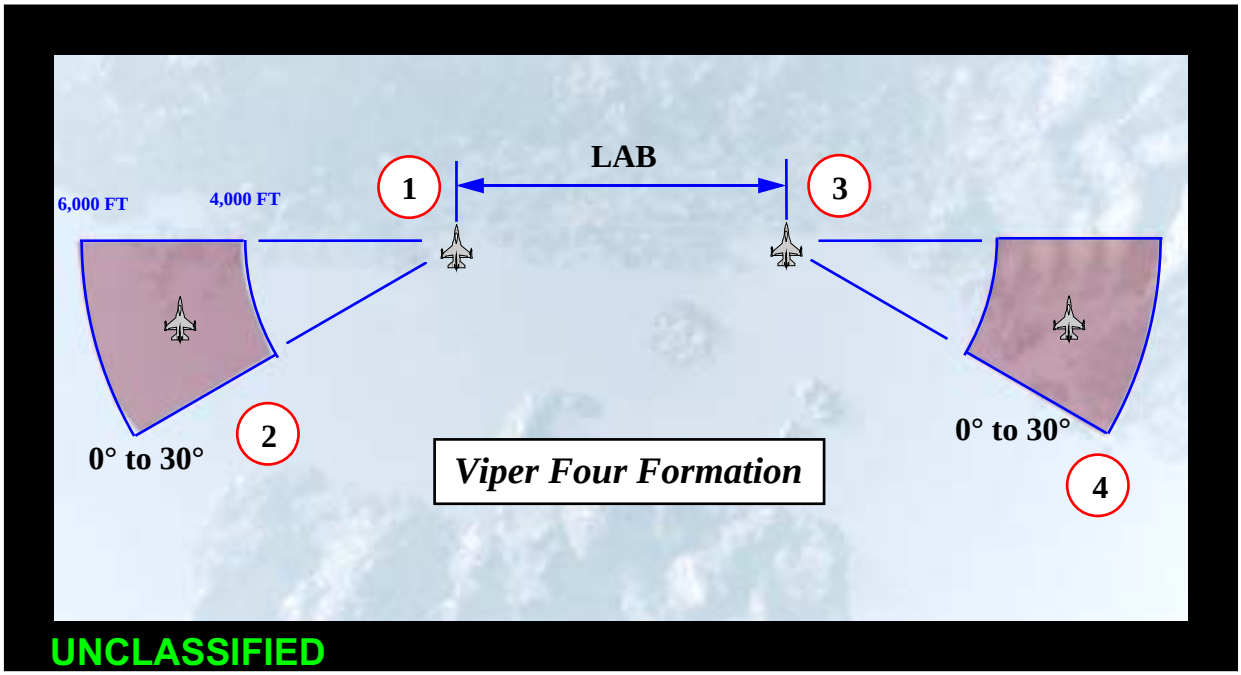
3.9.3.2 Disadvantages:

- Maneuvering is difficult if the line abreast position is maintained.
- Very difficult for wingmen to fly at low altitude.

3.9.4 Viper Four. Element leads maintain line abreast, wingmen position themselves 0 to 30 degrees back from their element leads and 4,000 to 6,000 feet spread; this is the same as Spread Four, but wingmen fly a tighter position. (See **Figure 3.16**, Viper Four Formation.)

3.10 Three-Ship Formations. There may be occasions when a priority mission requires maximum available aircraft and a three-ship is the only alternative. Mutual support requirements to ensure survivability and recovery are paramount; therefore, a three-ship contingency should be briefed on all four-ship missions. On these occasions, the following three-ship formation discussion is applicable.

Figure 3.16 Viper Four Formation.

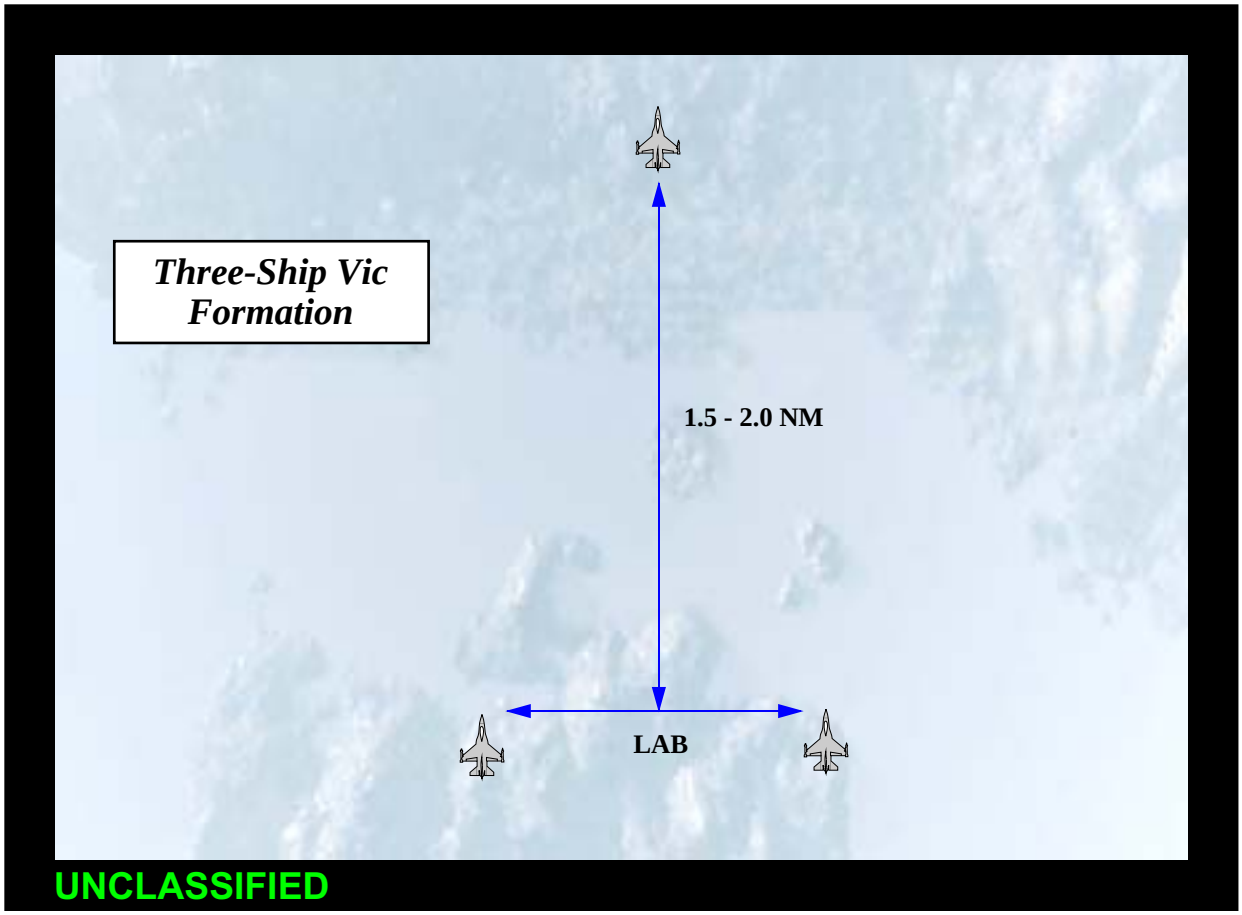


3.10.1 Vic Formation. Lead flies 1.5 to 2 NM in front of the trailing element. The lead aircraft maneuvers as desired. The trailing element uses line abreast maneuvering to follow. (See **Figure 3.17**, Three-Ship Vic Formation.)

3.10.2 Fluid Three. This is the same as Fluid Four with one aircraft missing. If the three-ship is caused by one aircraft falling out from a briefed four-ship, the following position changes should be followed: if lead falls out, Number Three assumes lead and Number Two moves to line abreast; if Number Three falls out, Number Four moves up to line abreast; if Number Two or Number Four fall out, there are no changes.

3.10.3 Spread Three. This is the same as Spread Four with one aircraft missing. Roles and responsibilities caused by fall out from a four-ship are the same as Fluid Three.

Figure 3.17 Three-Ship Vic Formation.



3.10.4 Viper Three. This is the same as Viper Four with one aircraft missing. Roles and responsibilities caused by fall out from a four-ship are the same as Fluid Three.

3.11 Tactical Turns. Turns may be communicated with either the radio or visual signals. Line Abreast formations compensate for inherent maneuvering problems with specialized pre-briefed procedures. These include the type of turns to be made, the parameters at which these turns will be made, and the method by which these turns will be initiated. The turns consist of 45- to 90-degree delayed turns, in-place turns, cross turns, weaves, and check turns. The parameters for the turns are briefed by each flight leader and usually consist of the speed, "G," and the power required in the turn. The method of turn initiation is generally by radio call, wing flash, or check turn.

3.11.1 Radar/Visual Lookout. Individual areas of visual and radar responsibility should be briefed. The Line Abreast formation, because it is very common and widely accepted, has developed two traps which must be addressed:

- Trap One. Assuming that everyone flies formations exactly the same. Do not skip the formation section of the briefing, this will leave some doubt as to one or more of the necessary parameters or responsibilities. Squadron standards will help, but a thorough briefing on all planned or potential formations is the best. Do not leave the flight briefing with unresolved questions or if unclear on formation positions and responsibilities.

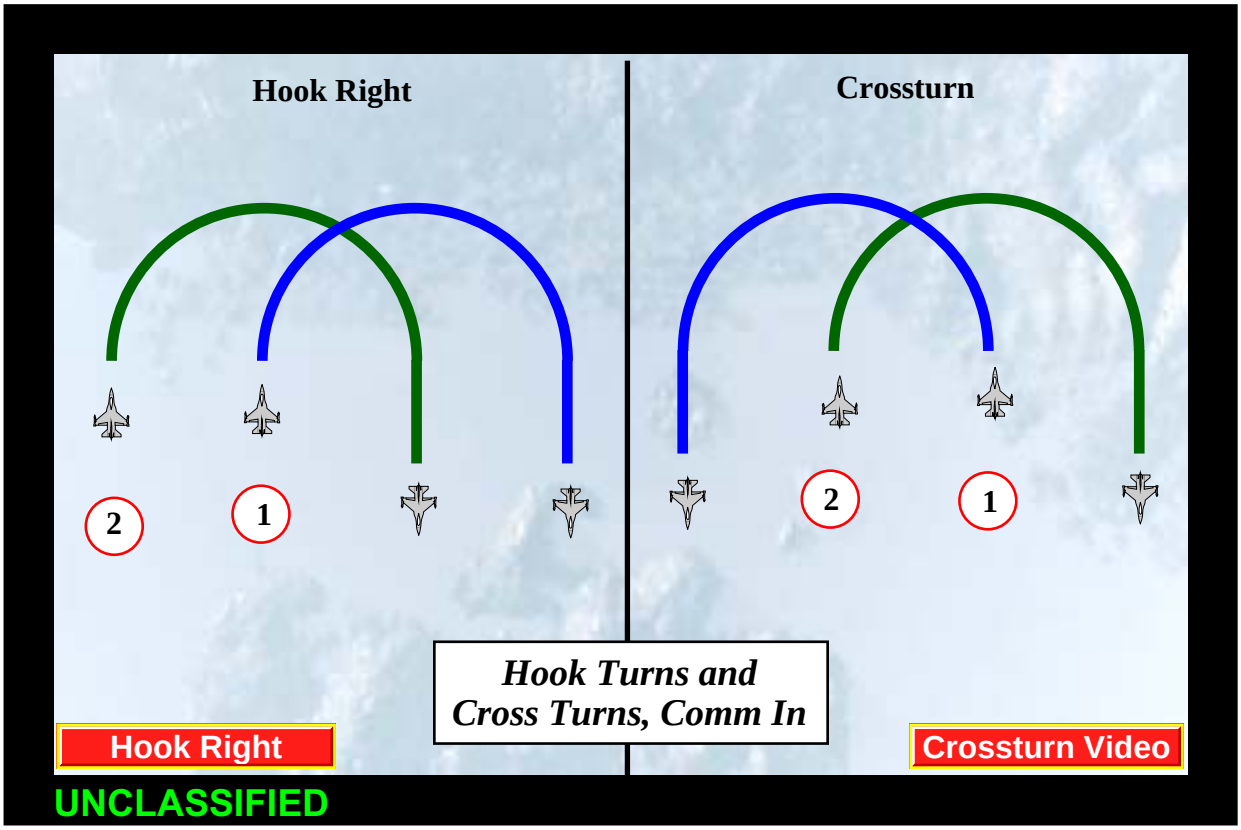
- Trap Two. Tasking levels are not compensated for, when random maneuvering is required. Specifically, when the flight lead maneuvers unexpectedly, that forces the wingman to devote more time maintaining position instead of visual/radar search. Drifting left or right off course, large variances in airspeed, or altitude, can increase basic formation tasking to the exclusion of mission tasks. A 10-degree check turn into a lagging wingman may be preferable to the time and effort required for that wingman to drive forward to the briefed position. Exact headings are not critical; however, mutual support responsibilities are vital. This is not to say a leader flies off the wingman. The flight lead can make the wingman more effective by being considerate. If the situation requires many random turns, a more maneuverable formation should be flown.

3.11.2 Maneuvering With Unrestricted Communication. When the radios are available, some flight leads will use them. Tactical turns will be initiated by the flight lead. The preparatory command for a turn is flight call sign and the command of execution is the type turn called (e.g., “VIPER 1, 90 RIGHT”). Delayed turn types are assumed, unless overridden in flight (e.g., “VIPER 1, HOOK RIGHT”, “VIPER 1 IN PLACE 90 LEFT”). **Figure 3.18**, Hook Turns and Cross Turns, Comm In.

3.11.3 Radio Silent Maneuvering. There may be times when radio silent procedures are used to maneuver the flight. Under these conditions certain variables must be held to a standard. The basic “contract” between flight members is as follows:

- The wingman will always strive for the briefed position.
- The aircraft caught in front after the turn is responsible for regaining the briefed position (Weave and Shackle).
- The wingman does not exceed 90 degrees off the leader's heading.
- Lead and wingman will use the same turns at all altitudes (normally, Mil power and G to maintain airspeed).
- Lead initiates all turns.
- Lead will signal all turns away from the wingman with a high banked 30 degree check turn.
- A turn into the wingman is signaled by lead’s turn into the wingman.
- If at low altitude, the wingman will not stack lower than the leader.
- During tactical radio silent turns at low altitude, the aircraft being turned into will do a 30-degree check turn away from the other aircraft to deconflict flight paths and/or signify acknowledgment. At medium or high altitude, this check turn may be omitted, at flight lead discretion. Flight leads are expected to specify when check turns will not be used. Also, flight members must differentiate between radio silent commands (the “big” wing flash associated with the 30 degree check turn) and belly checks, or terrain masking. (***NOTE:*** Nose rate movement may be the best way to differentiate.)
- Visual lookout responsibilities shift forward as lower altitudes are encountered. The percent of time clearing for airborne threats is reduced at low altitude.

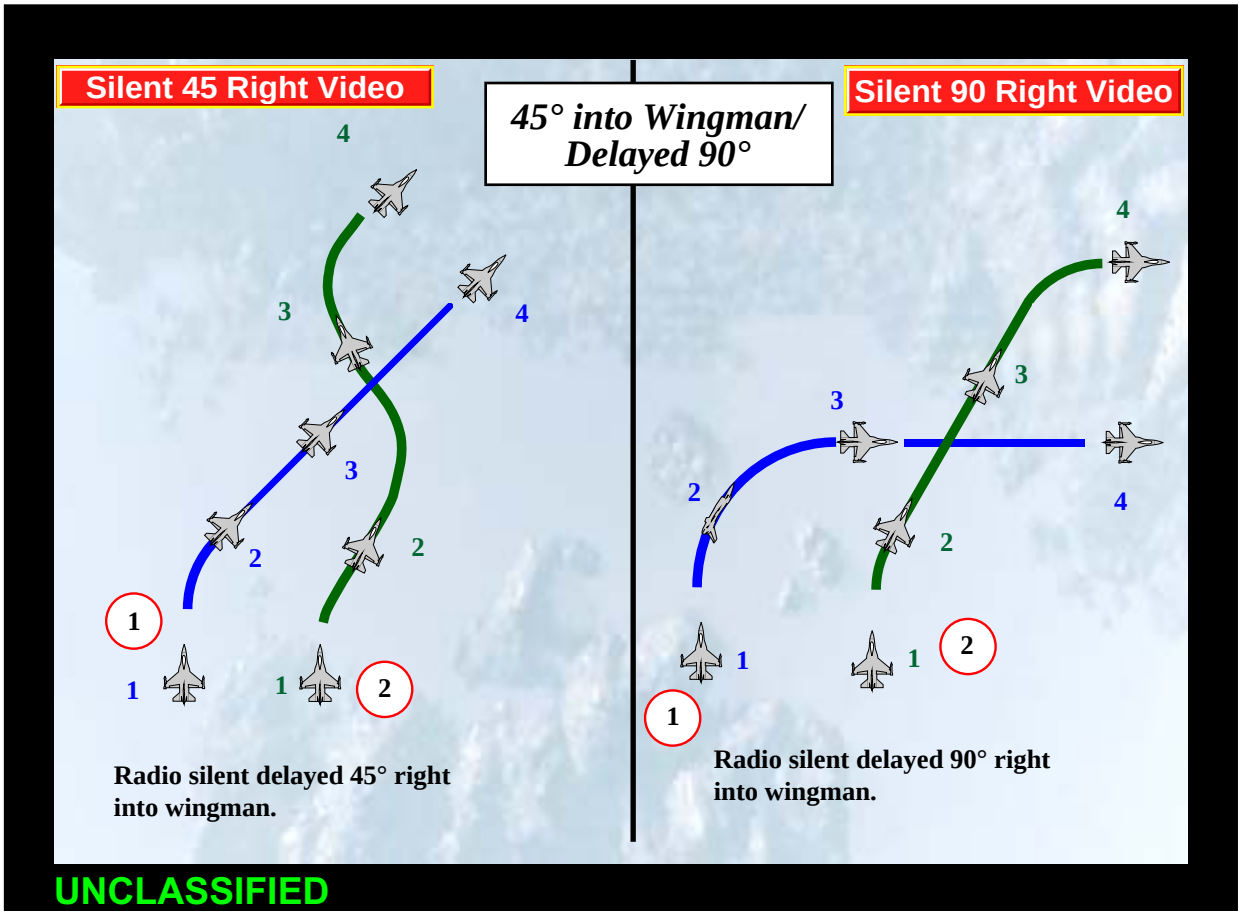
Figure 3.18 Hook Turns and Cross Turns, Comm In.



3.11.3.1 Turns Into the Wingman. (See **Figure 3.19**, 45 Into Wingman/Delayed 90.)

- Lead initiates the turn by turning into the wingman, normally at Mil power and G to maintain airspeed.
- Wingman checks away 30 degrees and searches the new six through lead.
- Flight lead checks old six during the turn and cross-checks wingman position.
- Wingman assumes a 90-degree turn and turns to regain line abreast, as lead turns through the wingman's 6 o'clock.
- If lead rolls out short of passing through the wingman's 6 o'clock (delayed 45- to 60-degree turn), wingman weaves to line abreast.
- A 180-degree turn into the wingman is accomplished in increments of two delayed 90-degree turns.

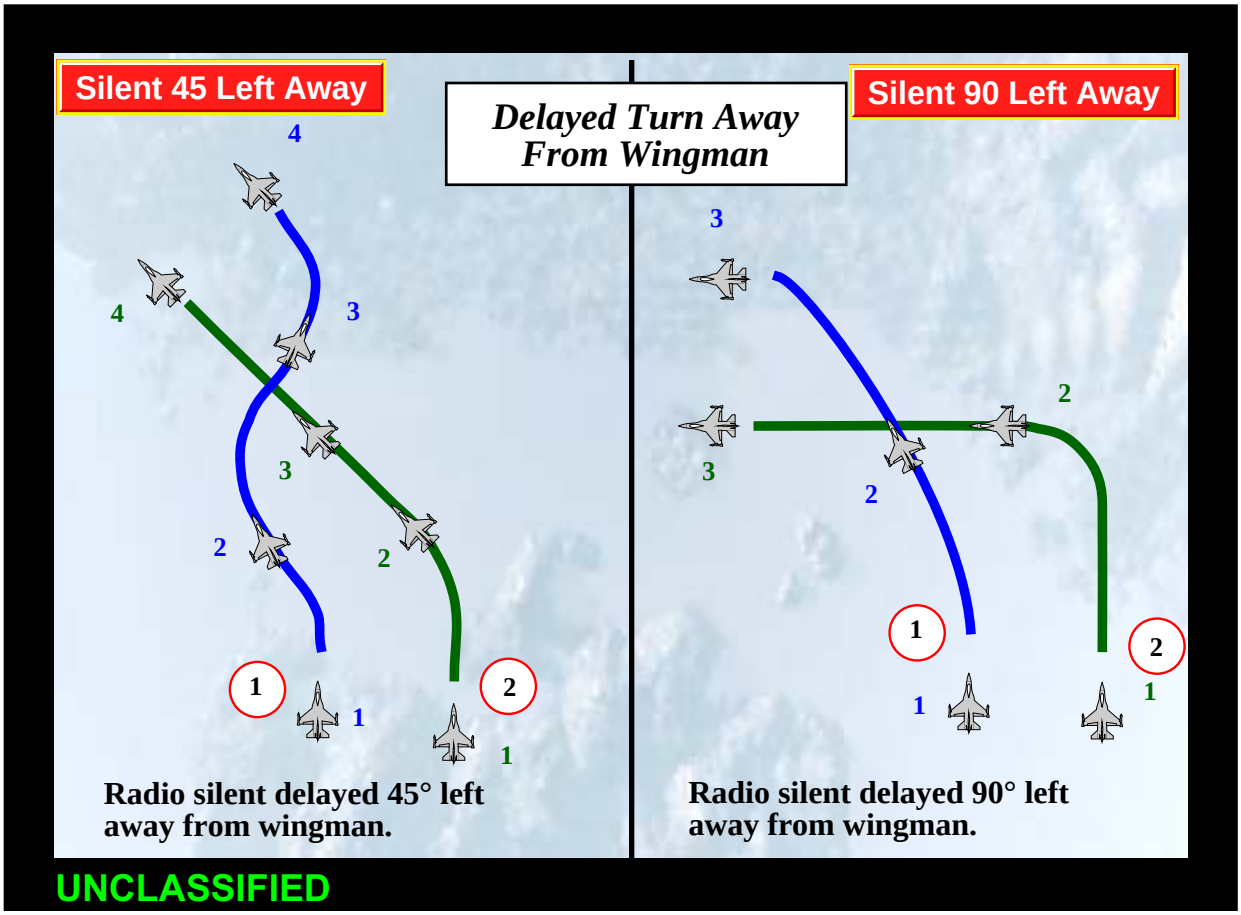
Figure 3.19 45 Into Wingman/Delayed 90.



3.11.3.2 Turns Away from the Wingman. (See **Figure 3.20**, Delayed Turn Away From Wingman.)

- Lead makes a steeply banked check turn of approximately 30 degrees to signal the turn.
- Wingman sees the flash and begins the turn into lead using the briefed G and power setting (if unbriefed, use Mil power and G to maintain airspeed).
- If lead wants a delayed 45- to 60-degree turn, lead turns into the wingman when the wingman obtains the desired heading. This is the wingman's command to roll out.
- If lead wants a delayed 90-degree turn, lead allows the wingman to continue turning through leads 6 o'clock.
- If lead wants to turn 180 degrees away, lead initiates the turn with a 30 degree check turn, and then completes the 180-degree turn as soon as lead observes the wingman beginning to turn.

Figure 3.20 Delayed Turn Away From Wingman.



3.11.3.3 Check Turns.

- Lead turns to the desired heading using a gentle (less than a 2-G) shallow-banked turn.
- Wingman sees either a divergence or convergence and strives for line abreast using an "S" turn, vertical, or power.

3.12 Communication. The primary means of communication in the Viper is through radio (ultra-high frequency [UHF], very high frequency [VHF] data), and visual signals. Flight discipline can be determined from communications, whether by radio or visual signals. Communication, to be effective, must be received and understood by every flight member. A key to clear, concise, and correct communications is the use of MPM, Attachment 1, "Operational Brevity Words, Definitions, and Counterair Communications Standards."

3.12.1 Radio Discipline. Another key to effective communications is discipline. Radio discipline requires not only clarity and brevity in the message, but limiting unnecessary transmissions as well. Never give up a chance to be quiet on the radios, BUT communicating essential information to the rest of the flight (world) is required for mission success. This is a topic that should be debriefed after every mission.

3.12.2 Radio Transmissions. The first part of any radio call should always be the "call sign." This alerts the listener that a message is coming (attention step) and specifies to whom it is directed. Failure to use the correct call sign, reliance on voice recognition, or simply not using full call sign due to flight size, builds and reinforces poor habit patterns, which are easily transferred into large packages or wartime employment. If assigned a cumbersome or difficult to pronounce call sign, request a new assignment during preflight planning.

3.12.2.1 Acknowledgments. Respond with full call sign (e.g., "VIPER 2, TARGET NORTH GROUP, BULLSEYE 210, 25, 30 THOUSAND, BOGEY"). Acknowledgment: "VIPER 2, TARGETED." Use visual signals whenever practical. No verbal response is required to visual signals if the response is visible to the directive fighter (i.e., sent to fighting wing).

3.12.2.2 Standards. Standard in-flight radio terminology is made up of three parts: "Call sign, directive transmission, and descriptive transmission." Structure calls in this format so flight members know what to expect and make sure the most important part of the transmission (the who and action desired) is received first (e.g., "VIPER 1, BREAK LEFT, BOGEY, LEFT 7, 2 MILES"). Normally, defensive-type directive calls need both volume and tone inflection to be most effective.

3.13 Aircraft Handling Exercises and Maneuvers. The following exercises and maneuvers are designed to expose the pilot to various parameters within the F-16's flight envelope. When executed correctly, they will explore the aircraft's flight envelope and reinforce awareness of aircraft performance. Minimum altitudes for the Horn Awareness Series, Confidence Maneuvers, and Advanced Handling Maneuvers are 10,000 feet AGL. Reference the applicable exercises or maneuvers for minimum and recommended entry altitudes.

3.13.1 Horn Awareness and Recovery Training Series. Horn Awareness and Recovery Training Series (HARTS 1-5) of maneuvers is flown to train recovery procedures from high-pitch attitude, slow airspeed conditions normally signaled by the horn. It is designed to be flown initially in sequence as a series. These controlled maneuvers will place you into a position in which you may unintentionally find yourself while engaged in ACM. This exposure will train you to use the proper recovery procedures should you find yourself in this situation during future flying. There are five individual maneuvers in the series. The pitch attitude for all these maneuvers should be set and maintained on the attitude direction indicator (ADI) not the flight path marker (FPM); reference to the HUD flight path results in an increasing attitude as the angle of attack (AOA) increases. The key to flying these maneuvers is to use finesse in bringing the nose to the horizon with minimum airspeed loss. If the recoveries are delayed due to slow pilot response, failure of the warning horn, or if abrupt inputs are made, a departure is possible. It should be emphasized that the roll to the horizon should be made smoothly avoiding buffet, and smoothly stopped before aft stick is applied. Smooth application of aft stick (if needed) is essential. If the nose is not moving toward the horizon, aft stick should be smoothly applied (up to full command) to get the nose moving and keep it moving. If the nose is very high and the airspeed is very slow, a rapid pitch rate downward may develop. In this case, when the nose approaches vertical downward, a good technique is to apply slight forward stick pressure to slow the pitch rate and protect against overshooting the AOA limiter. See the Dash 1 for more information.

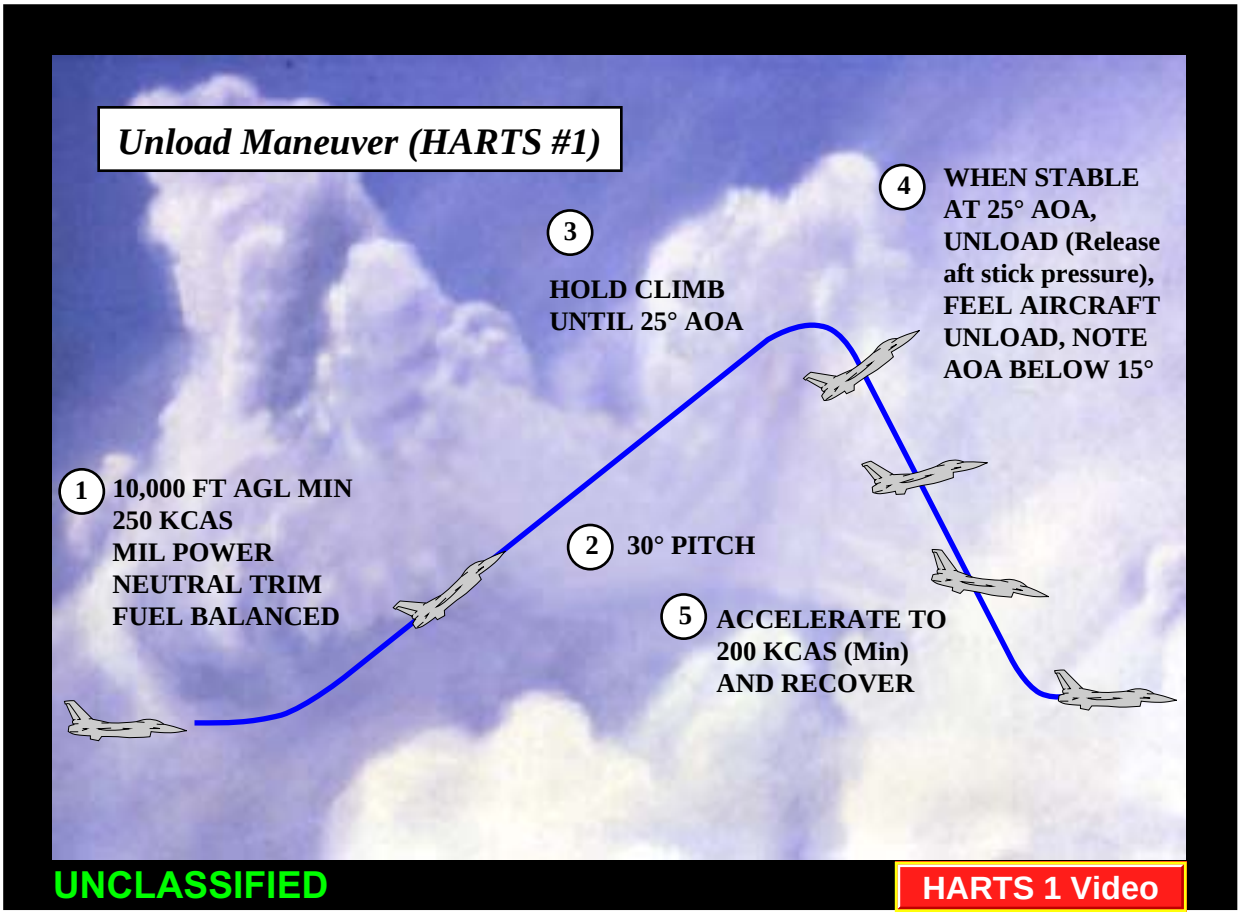
NOTE: HARTS maneuvers are to be flown by CAT I loaded aircraft only.

WARNING: For maneuvers 4 and 5, departure susceptibility significantly increases with wing tanks at entry airspeeds between 300 and 325 knots calibrated airspeed (KCAS) or in any configuration with entry bank angles less than 10 degrees.

3.13.1.1 Unload Maneuver. See **Figure 3.21**, Unload Maneuver (HARTS #1).

3.13.1.1.1 Objective. To learn the proper technique required to unload the aircraft and recognize an unloaded condition.

Figure 3.21 Unload Maneuver (HARTS #1).



3.13.1.1.2 Setup. 10,000 feet AGL or above, 250 knots calibrated airspeed (KCAS), Mil power, fuel balanced, and neutral trim (1 G).

3.13.1.1.3 Description. Pull up to 30 degrees pitch with approximately 2 to 3 Gs. Initially, slight forward pressure is required to maintain pitch attitude. At approximately 150 KCAS, aft stick is required until reaching the limiter. When the aircraft is stable at 25 degrees AOA, unload (release aft stick pressure) and note aircraft unload (check AOA, should be below 15 degrees). Hold the unload until the aircraft accelerates to 200 KCAS minimum. At 200 KCAS, initiate recovery to level flight.

3.13.1.1.4 Comments. This unload is the key to any safe recovery. This maneuver is to teach you the proper way to unload the F-16 so you can safely roll the aircraft regardless of airspeed. Because the F-16 is flown with neutral trim (set to 1 G), a release of aft stick pressure should bring the AOA to less than 15 degrees. A proper unload at slow airspeed and high AOA is to release the aft stick pressure. This unload may take 2 to 3 seconds and will make you feel light in the seat. On the first practice maneuver, look at the AOA tape, note the AOA and the unload feel. This maneuver should be practiced until the recovery can be accomplished without looking inside the cockpit.

3.13.1.2 Nose-High Recovery Maneuver. See **Figure 3.22**, Nose-High Recovery Maneuver (HARTS #2).

3.13.1.2.1 Objective. To systematically practice the unload maneuver and rolling to the nearest horizon while unloaded.

3.13.1.2.2 Setup. 10,000 feet AGL minimum, 350 KCAS, Mil power, fuel balanced, and neutral trim.

3.13.1.2.3 Description. Pull up to 60 degrees pitch with approximately 2 to 3 Gs and hold. Slight forward stick pressure is required to hold the pitch attitude. At 200 KCAS, unload (release stick pressure) and roll the aircraft inverted to the nearest horizon using positive but smooth control inputs. Stop the roll with aileron. When wings-level inverted, smoothly apply sufficient aft stick to pull the nose below the horizon. Once the nose is below the horizon, unload and accelerate to 200 KCAS. At 200 KCAS, roll upright and recover.

NOTE: IAW Dash 1 procedures, if altitude is a factor during the recovery, allow airspeed to increase to a minimum of 150 knots, unload the aircraft to less than 1 G, smoothly roll upright, and recover to level flight.

3.13.1.3 Horn Demonstration Maneuver. See **Figure 3.23**, Horn Demonstration Maneuver (HARTS #3).

3.13.1.3.1 Objective. To demonstrate and check the operation of the low-airspeed/nose-high position warning horn and to practice proper recovery procedures at the horn.

3.13.1.3.2 Setup. 10,000 feet AGL or above, 300 KCAS, Mil power, fuel balanced, and neutral trim.

3.13.1.3.3 Description. Pull up to 50 degrees of pitch with approximately 2 to 3 Gs and hold. Allow airspeed to decay until the warning horn sounds or 100 KCAS, whichever occurs first. At the horn (or 100 KCAS minimum), unload (release stick pressure) and smoothly roll inverted to the nearest horizon. Stop the roll, then smoothly apply sufficient aft stick to track the nose below the horizon. With the nose below the horizon, unload and accelerate to 200 KCAS. At 200 KCAS, roll upright and recover.

Figure 3.22 Nose-High Recovery Maneuver (HARTS #2).

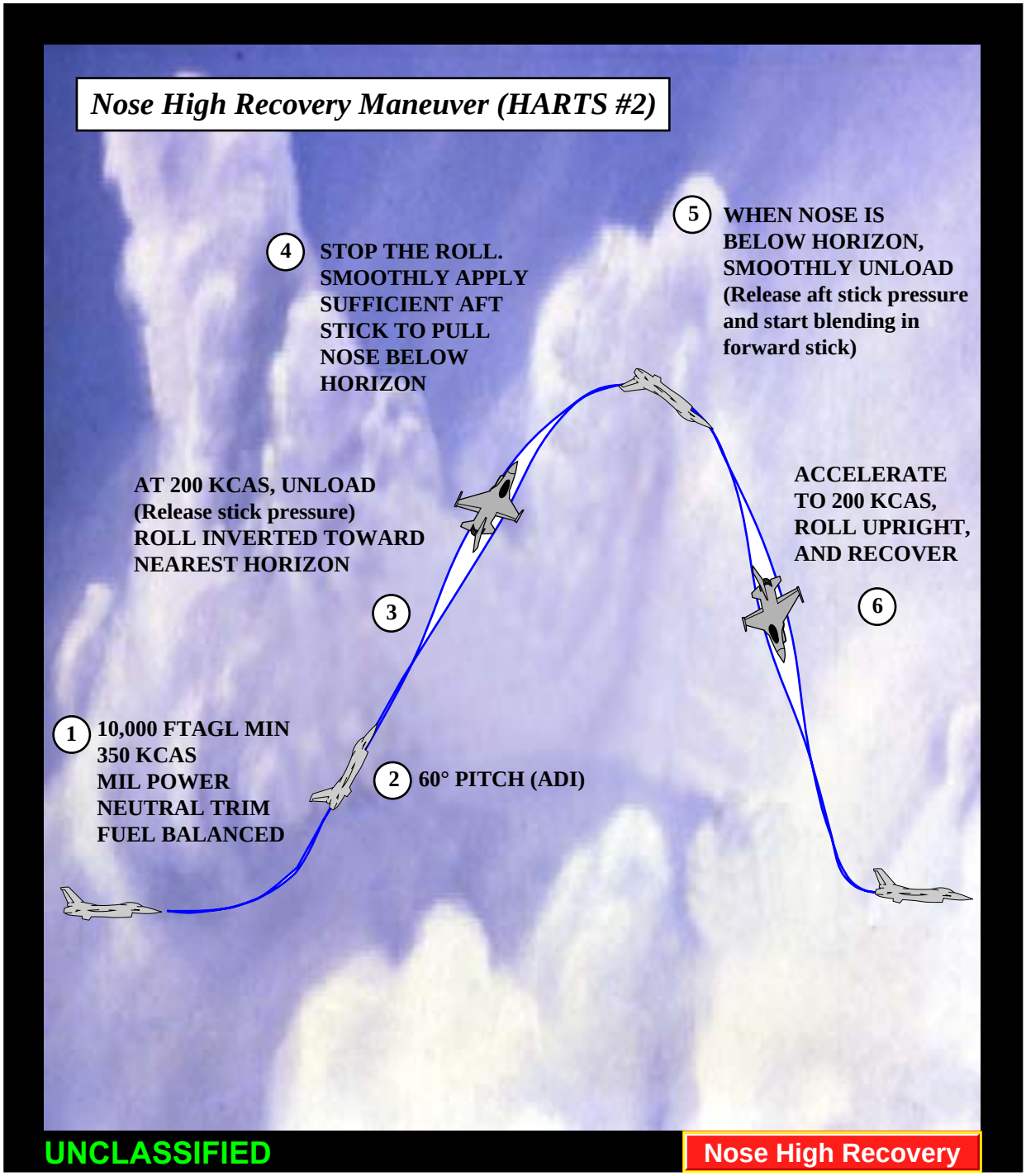
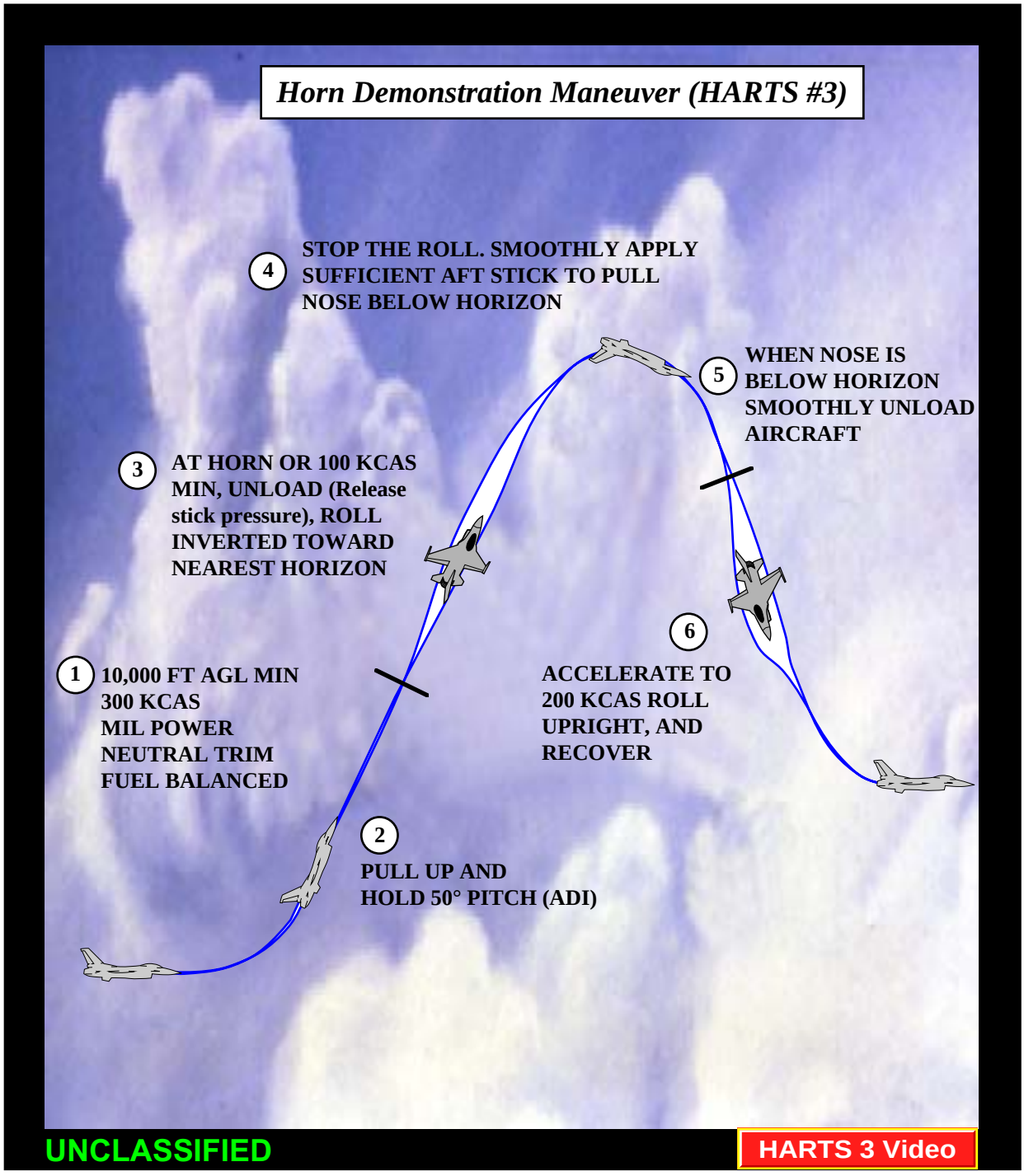


Figure 3.23 Horn Demonstration Maneuver (HARTS #3).



3.13.1.3.4 Comments. The horn should come on between 120 KCAS and 130 KCAS. A secondary objective of this maneuver is to verify that the horn works prior to flying the horn recovery maneuvers. This should be the first time you hear the horn during this series of maneuvers. If the horn does not come on prior to 100 KCAS, discontinue this series of horn recovery maneuvers and write up the horn after the flight. Smooth but positive control inputs and attention to unload cues are imperative. The aircraft

rolls smoothly while unloaded; however, the roll must be positively stopped when inverted prior to smoothly applying aft stick to avoid assaulting both flight control limiters simultaneously.

3.13.1.4 Horn Recovery Maneuver, 50 to 70 Degrees. See **Figure 3.24**, Horn Recovery Maneuver 50 to 70 Degrees (HARTS #4).

3.13.1.4.1 Objective. Practice recovery at the horn from nose high, high AOA, and low-airspeed conditions.

3.13.1.4.2 Setup. 15,000 feet AGL or above, 250 KCAS, Mil power, fuel balanced, and neutral trim.

NOTE: If flown in an F-16C/D, configured with wing tanks, entry airspeed will be 250 to 275 KCAS.

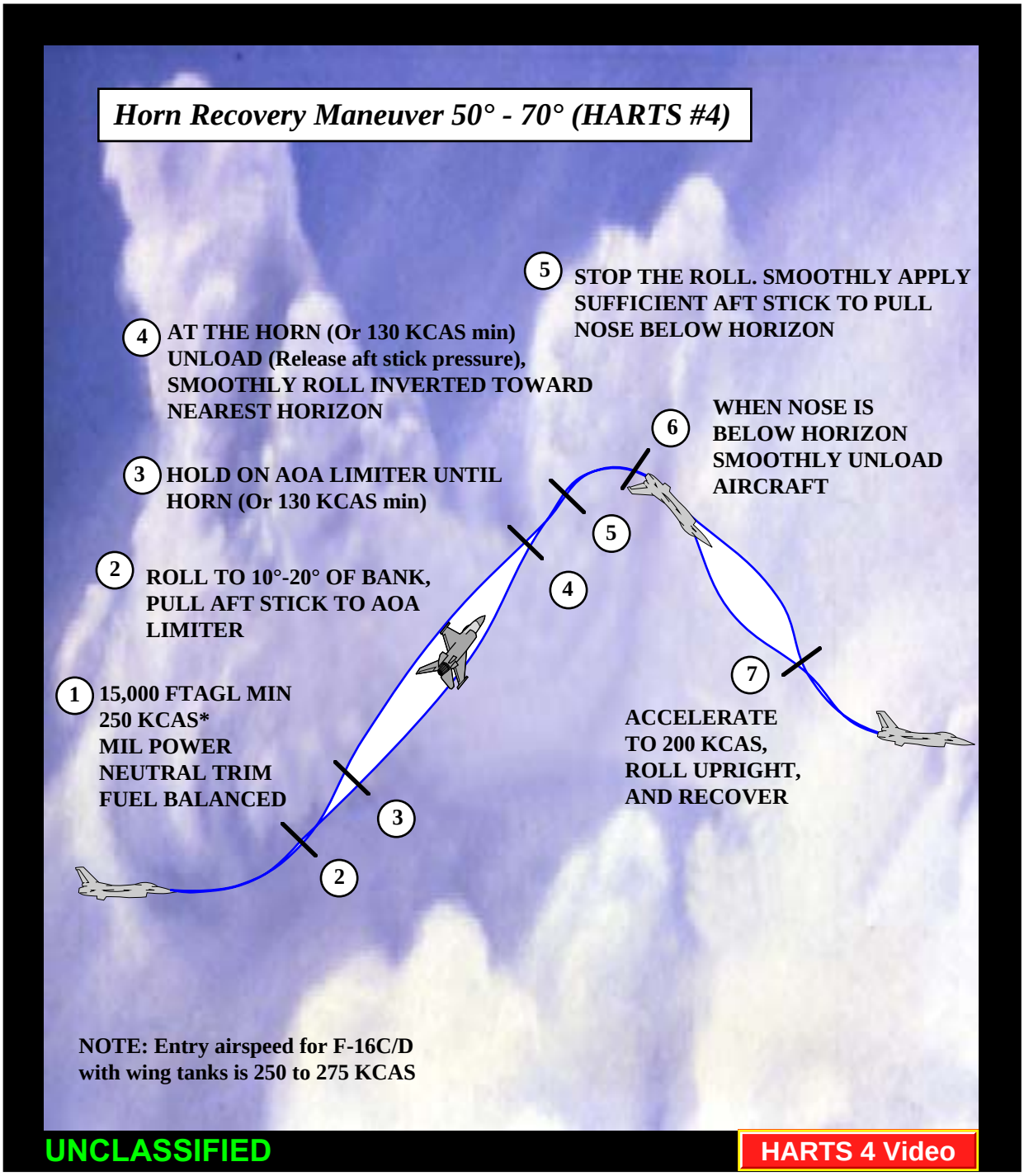
3.13.1.4.3 Description. Roll into 10 to 20 degrees bank and apply full aft stick (limiter). When the horn sounds (or 130 KCAS, whichever occurs first) unload (release aft stick pressure) and roll the aircraft inverted toward the nearest horizon. Stop the roll, then smoothly apply sufficient aft stick to track the nose below the horizon. With the nose below the horizon, unload and accelerate to 200 KCAS. At 200 KCAS, roll upright and recover.

3.13.1.4.4 Comments. The 250 KCAS entry airspeed will cause the horn airspeed to occur prior to extremely high-pitch attitudes if back stick is applied fairly quickly to the AOA limiter. Pitch attitudes of 50 to 70 degrees are typical, with the horn activating at 150 to 170 KCAS. The low initial bank angle is necessary because bank angle tends to increase as the pull-up progresses. If the pull-up is started with more than 30 degrees bank, the horn may not come on because overbanking causes insufficient pitch attitude to reach the horn envelope (45-degree nose high). Full aft stick is used to ensure the aircraft is on the limiter at the horn. This will prevent an inadvertent pitch pulse at low airspeed that could cause an AOA overshoot.

NOTE: Based on flight test experience, departure resistance and desired learning objectives should not be adversely affected with any of the following store combinations:

- One AIM-9 missile at station 1 or 9.
- Two AIM-9 missiles at stations 1 and 9.
- A centerline pylon at station 5.
- A centerline fuel tank.

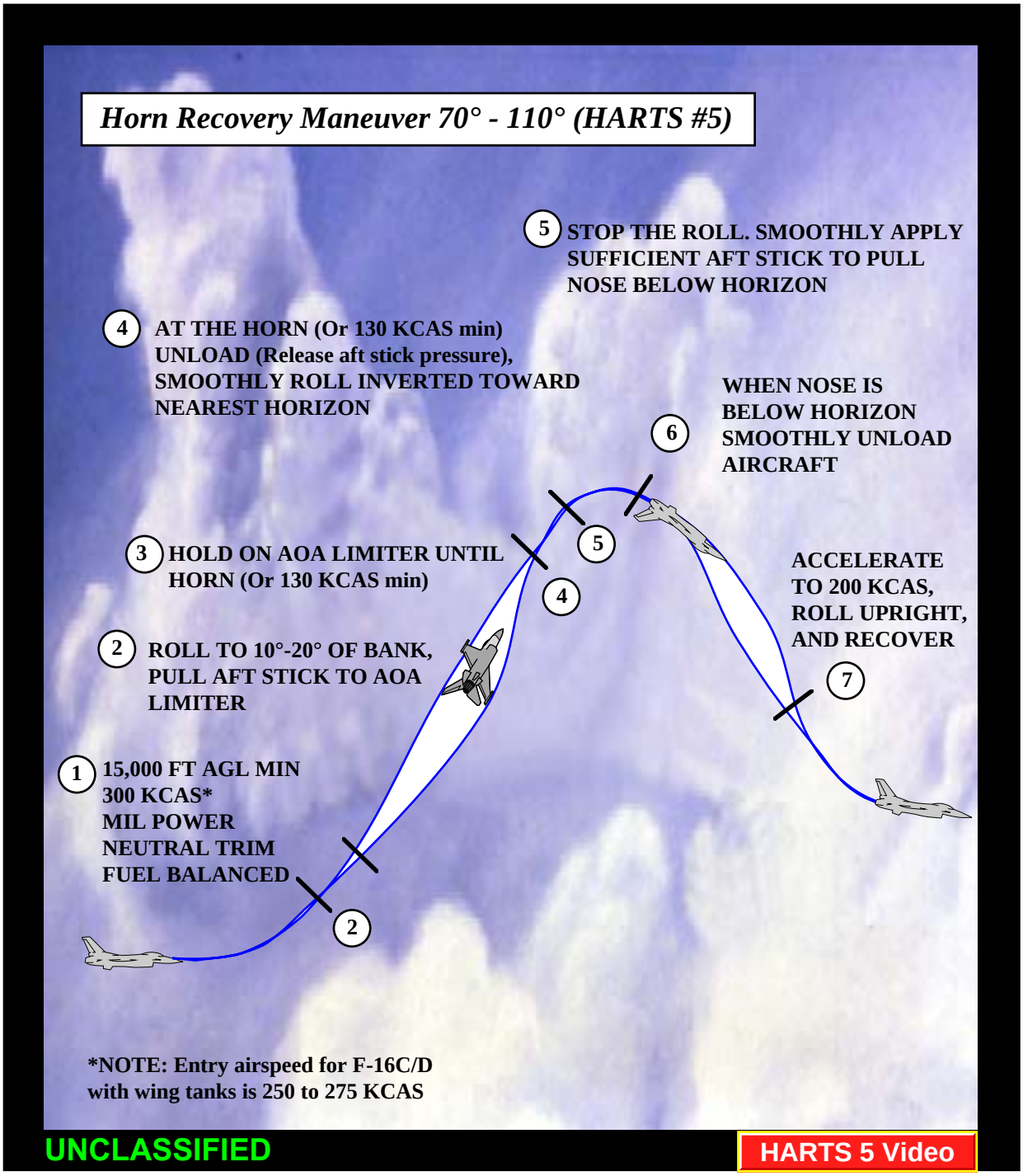
Figure 3.24 Horn Recovery Maneuver 50 to 70 Degrees (HARTS #4).



WARNING: Departure susceptibility increases significantly if airspeed and bank angle parameters are not met.

3.13.1.5 Horn Recovery Maneuver, 70 to 110 Degrees. See **Figure 3.25**, Horn Recovery Maneuver 70 to 110 Degrees (HARTS #5).

Figure 3.25 Horn Recovery Maneuver 70 to 110 Degrees (HARTS #5).



3.13.1.5.1 Objective. Practice recovery at the horn from very nose high, high AOA, and low airspeed conditions.

3.13.1.5.2 Setup. 15,000 feet AGL or above, 300 KCAS, Mil power, fuel balanced, neutral trim.

NOTE: If flown in an F-16C/D, configured with wing tanks, entry airspeed will be 250 to 275 KCAS. This may result in a lower pitch attitude than desired but is necessary due to departure tendencies when entered at higher airspeeds.

3.13.1.5.3 Description. Roll into 10 to 20 degrees of bank and apply full aft stick (limiter). When the horn sounds (or at 130 KCAS, whichever occurs first), smoothly unload (release aft stick pressure) and roll the aircraft inverted toward the nearest horizon. Stop the roll, then smoothly apply sufficient aft stick to track the nose below the horizon. With the nose below the horizon, unload and accelerate to 200 KCAS. At 200 KCAS, roll upright and recover.

3.13.1.5.4 Comments. This maneuver is identical to the previous one except for higher entry airspeed. The entry airspeed will allow the nose to rise to 70 to 110 degrees pitch before horn activation. The horn should come on in the 180 to 200 KCAS range. Unload the aircraft before any amount of roll input is made, then smoothly initiate sufficient aft stick to get the nose moving below the horizon. The rest of the recovery technique is exactly the same as for the previous maneuver.

NOTE: Based on flight test experience, departure resistance and desired learning objectives should not be adversely affected with any of the following store combinations:

- One AIM-9 missile at station 1 or 9.
- Two AIM-9 missiles at stations 1 and 9.
- A centerline pylon at station 5.
- A centerline fuel tank.

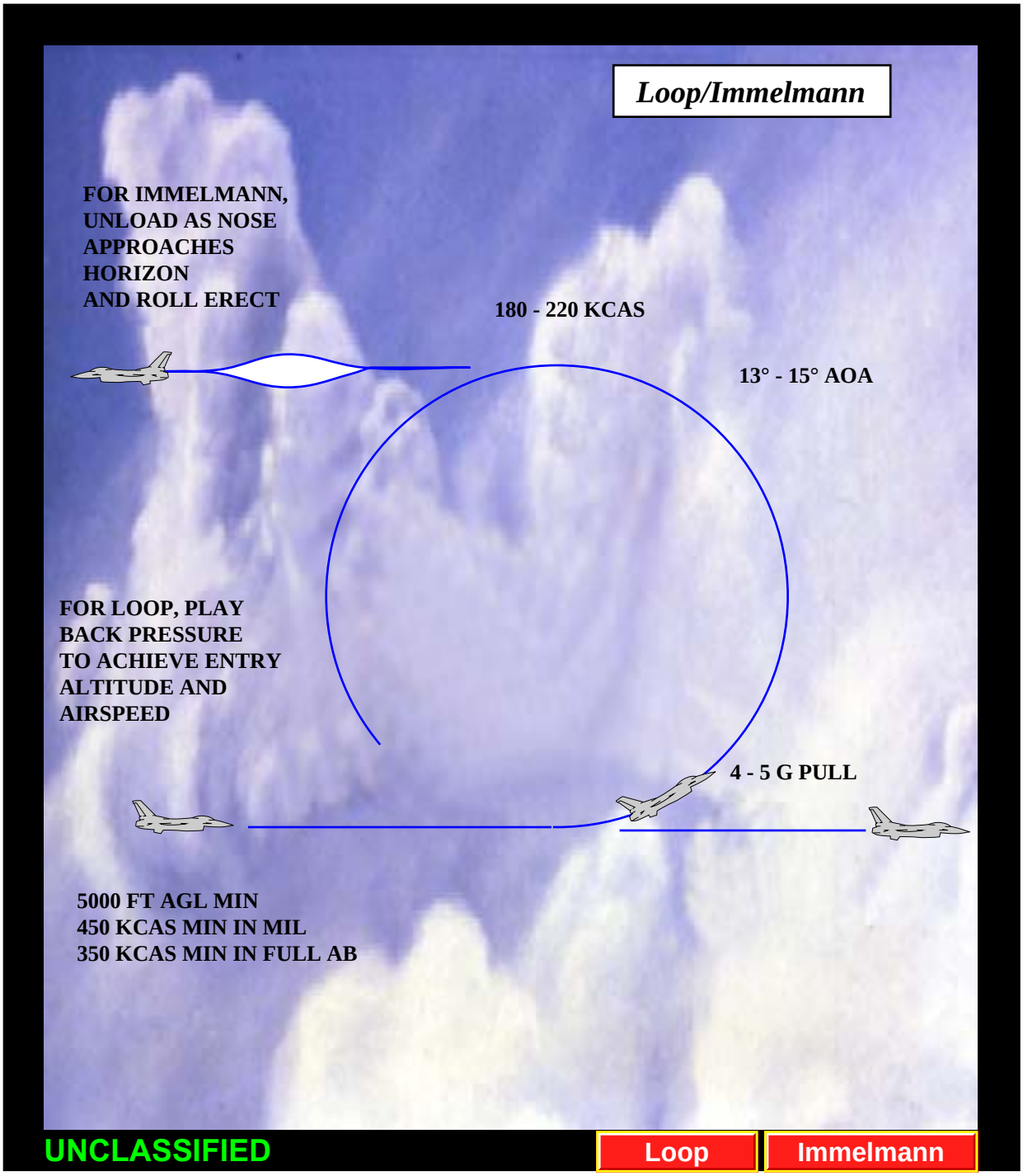
WARNING: Departure susceptibility increases significantly if airspeed and bank angle parameters are not met.

3.13.2 Aerobatics.

3.13.2.1 Loop. At 450 KCAS minimum, above 5,000 feet AGL (10,000 feet AGL recommended), with Mil power, begin a wings-level, 4- to 5-G pull. (See **Figure 3.26**, Loop/Immelmann.) As airspeed dissipates across the top, maintain smooth pitch rate. The AOA should be 13 to 15 degrees (at 14 degrees AOA you should feel light buffeting). As the nose comes back through the horizon inverted (approximately 180 to 220 KCAS) and airspeed begins to build, ease off the back pressure and play the G to arrive back in level flight near entry altitude and airspeed. In a tanked F-16B/D, expect to lose 1,000 feet or 50 knots attempting to achieve entry airspeed or altitude, respectively. If AB is used, enter at 350 KCAS minimum. Use sufficient G on the back side of the maneuver to preclude excessive airspeed buildup.

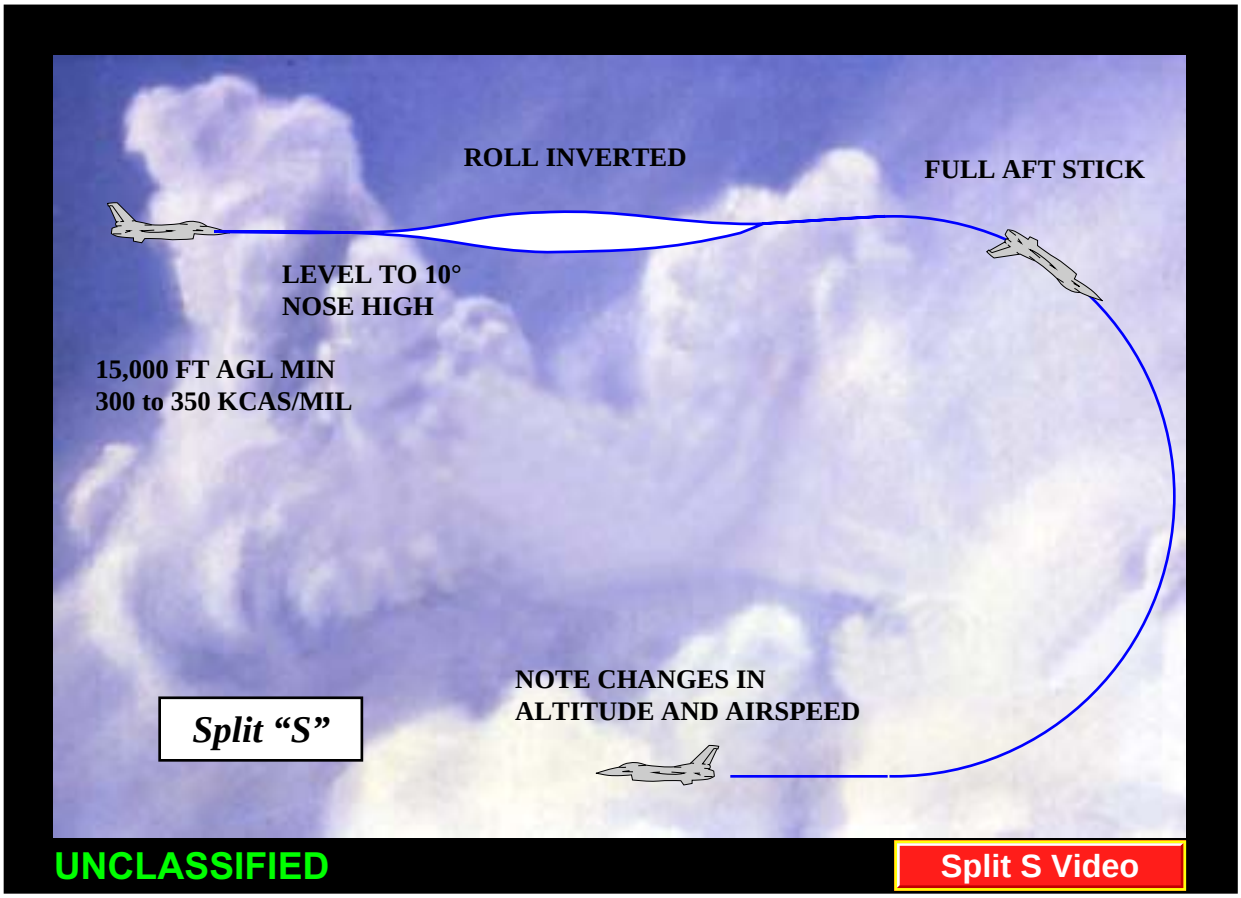
3.13.2.2 Immelmann. At 450 KCAS minimum, above 5,000 feet AGL (10,000 feet AGL recommended), with Mil power, begin a wings-level, 4- to 5-G pull. (See **Figure 3.26**, Loop/Immelmann.) As airspeed dissipates across the top, maintain a smooth pitch rate. The AOA should be 13 to 15 degrees (at 14 degrees AOA you should feel light buffeting). As the nose approaches the horizon inverted, unload and roll the aircraft to arrive upright wings-level in level flight (FPM on the horizon line). If AB is used, enter at 350 KCAS minimum. Roll out at the top remains the same.

Figure 3.26 Loop/Immelmann.



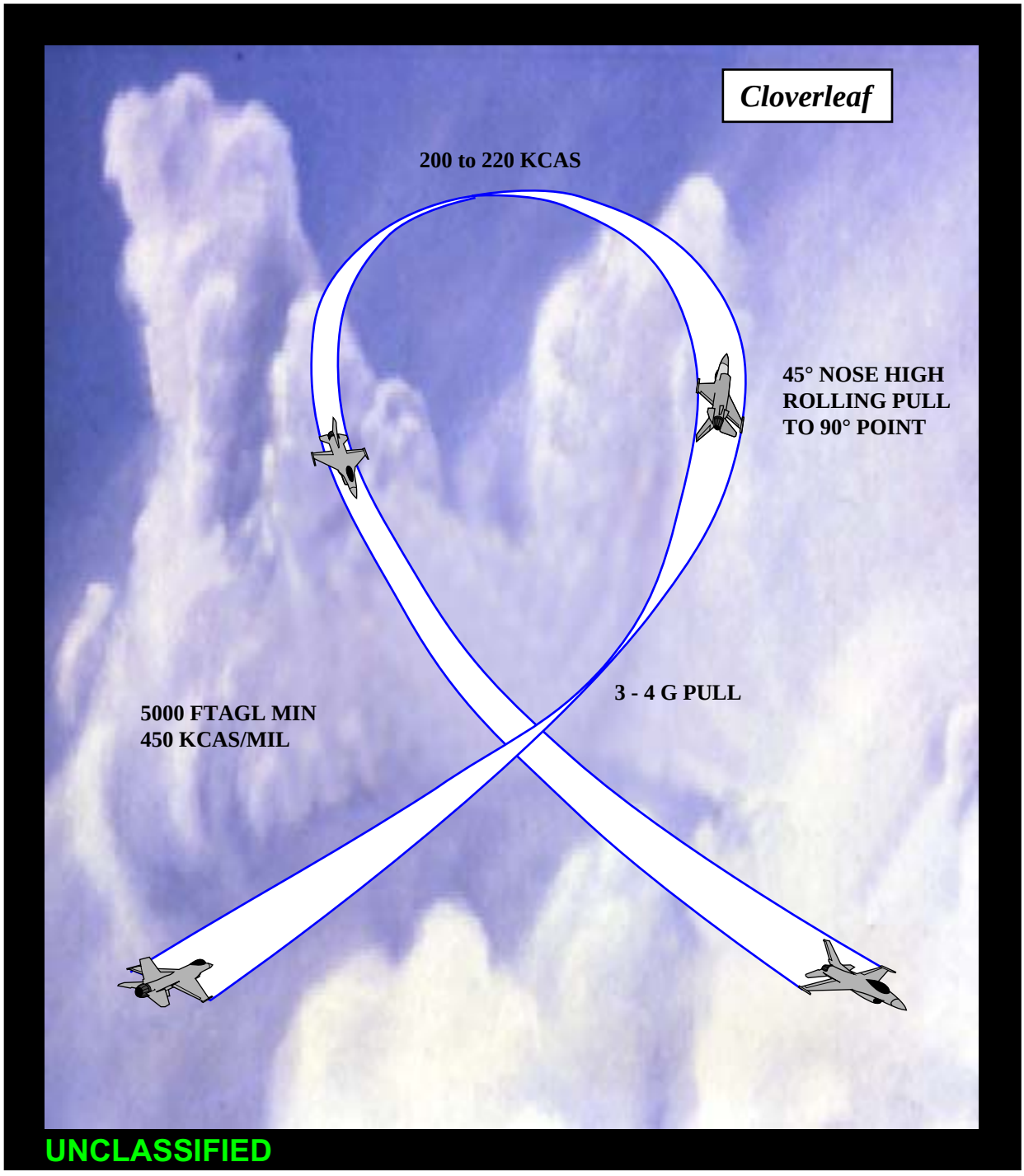
3.13.2.3 Split “S.” Enter at or above 15,000 feet AGL, between 300 to 350 KCAS, Mil power, level to 10 degrees nose high. (See **Figure 3.27**, Split “S.”) Roll unloaded to wings-level inverted and smoothly apply full aft stick. Terminate the maneuver in straight and level flight above 5,000 feet AGL (note change in altitude and airspeed).

Figure 3.27 Split "S."



3.13.2.4 Cloverleaf. Pick a point 90 degrees off the nose in the direction of turn. At 450 KCAS minimum, above 5,000 feet AGL (10,000 feet AGL recommended), Mil power, begin a wings-level 3- to 4-G pull. (See **Figure 3.28**, Cloverleaf.) At approximately 45-degree nose high, decrease back pressure and start a rolling pull in the direction of the 90-degree point. The roll rate should be planned to reach a wings-level inverted position with the nose on the horizon at the 90-degree point (airspeed approximately 200 to 220 KCAS). Continue the maneuver as in the backside of a loop, playing the Gs to arrive near the entry airspeed and altitude.

Figure 3.28 Cloverleaf.

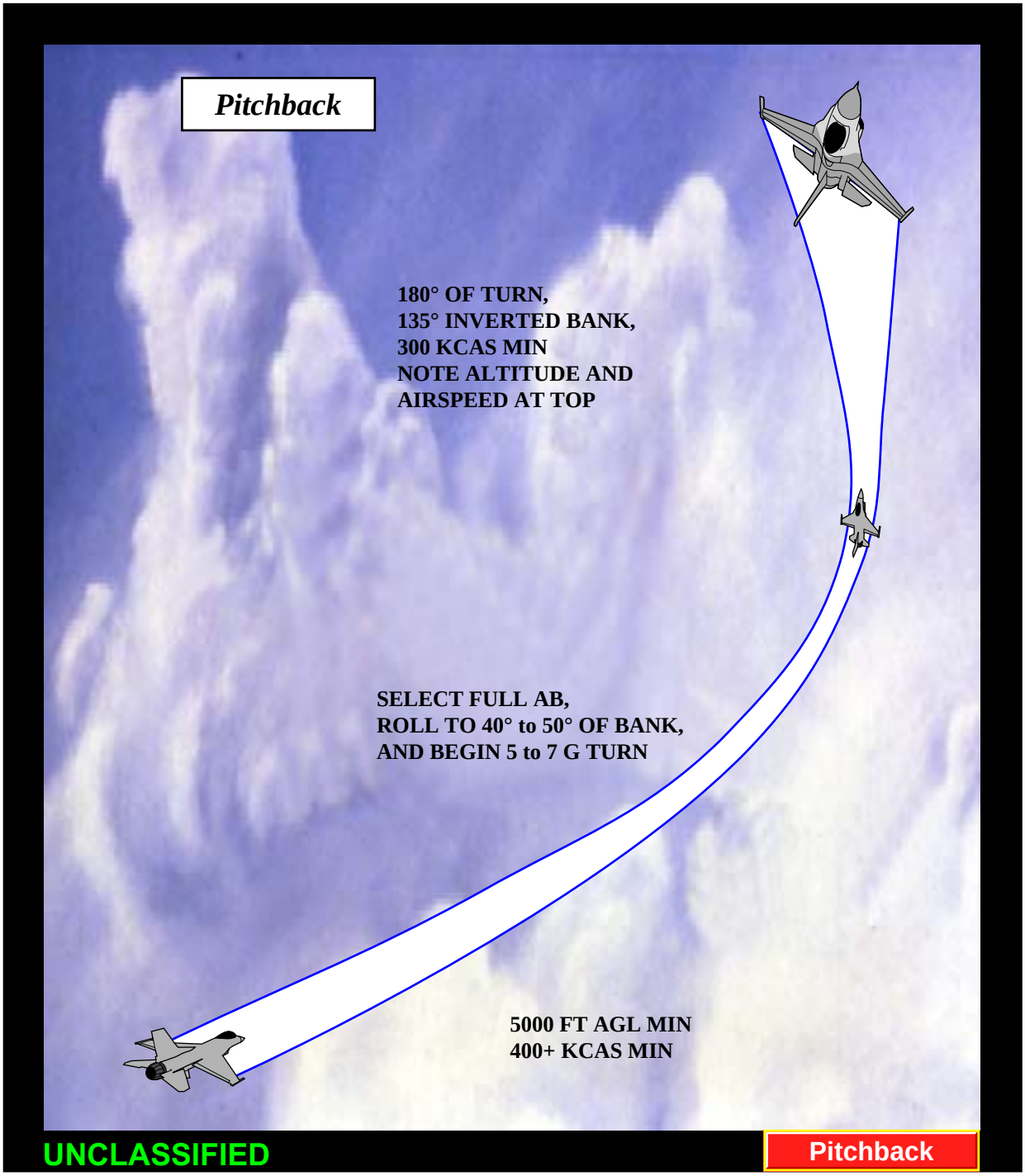


3.13.3 Advanced Handling Maneuvers.

3.13.3.1 Pitchback. This maneuver is a hard, then optimum turn (approximately 13 degrees AOA) beginning with the lift vector above the horizon and ending with it below. (See **Figure 3.29**, Pitchback.) Enter above 5,000 feet AGL at 400 KCAS or higher. Select full AB, roll into 40 to 50 degrees of bank and simultaneously begin a 5- to 7-G climbing

turn. After 90 degrees of turn, bank should be approximately 90 degrees. After 180 degrees of turn, it should be 135 degrees. At this point, the maneuver ends with a gain of 3,000 to 5,000 feet and a minimum airspeed of 300 KCAS. Reduce G during the maneuver to preserve airspeed.

Figure 3.29 Pitchback.



3.13.3.2 Sliceback. Enter at or above 15,000 feet AGL, between 350 to 400 KCAS, Mil power. Initially roll into 135 degrees of bank and smoothly increase aft stick as required to maintain 300 to 400 KCAS. (See **Figure 3.30**, Sliceback.) The maneuver is completed upon roll out in level flight after approximately 180 degrees of turn. The sliceback is a Split "S" type maneuver designed to make a 180-degree descending turn, while minimizing turn time and optimizing energy state. If speed is above 400 KCAS and a descending turn is required, reduced power and speedbrakes may be necessary if minimum turn radius and altitude loss are desired.

3.13.3.3 Reversals/Rolling Maneuvers Demonstration. Enter above 10,000 feet AGL at 300 to 400 KCAS with fuel balanced. Establish a 4- to 5-G turn in Mil power. (See **Figure 3.31**, Reversals/Rolling Maneuvers.) When the instructor calls "REVERSE," reverse the direction of turn while maintaining G-loading. This maneuver demonstrates the characteristics of a vector roll and its affects on energy state. It is used in A/A training by attackers to prevent a flight path overshoot and by defenders, as a last ditch maneuver, to force one. Full lateral stick pressure produces maximum roll rate at any AOA and airspeed, while limiters decrease roll rate below 250 KCAS or above 15 degrees AOA. Rudder is not required at any AOA/airspeed.

3.13.3.4 Vertical Recovery Demonstration. The objective is to demonstrate the effect of the 30-degree seat angle when extremely nose high, G and pitch rate available at low airspeed and high AOA when on the pitch limiter, and the ability to pull down through the vertical without fear of getting the nose buried. (See **Figure 3.32**, Vertical Recovery.) Set up at 10,000 feet AGL minimum, 400 KCAS minimum, Mil power, and fuel balanced. Make a wings-level pull up at approximately 4 Gs and establish a vertical attitude on the ADI. Note how the 30-degree seat angle creates an impression of being more than pure vertical. At 250 KCAS, smoothly apply and hold full aft stick pressure to establish a pitch rate towards the horizon. Continue to hold full aft pressure while the aircraft passes nose down vertical. When the nose is 30 degrees below the horizon, unload and accelerate to 200 KCAS minimum before completing recovery to wings-level flight. During this demonstration, the airspeed will decrease, and with full aft stick, the G will drop to 1.6 to 1.7 but the limiter, controlling AOA, will still permit a rapid pull through approximately 240 degrees of pitch change.

NOTE: If 200 KCAS occurs at any attitude above 60 degrees pitch and other than true vertical, immediately execute the nose-high recovery maneuver described in **Figure 3.22**, Nose-High Recovery Maneuver (HARTS #2).

NOTE: If full aft stick pressure is inadvertently released during the recovery, smoothly reapply aft stick pressure only if required to keep the nose moving toward the horizon. If you have released the stick and the nose is still moving toward the horizon, do not reapply the stick.

Figure 3.30 Sliceback.

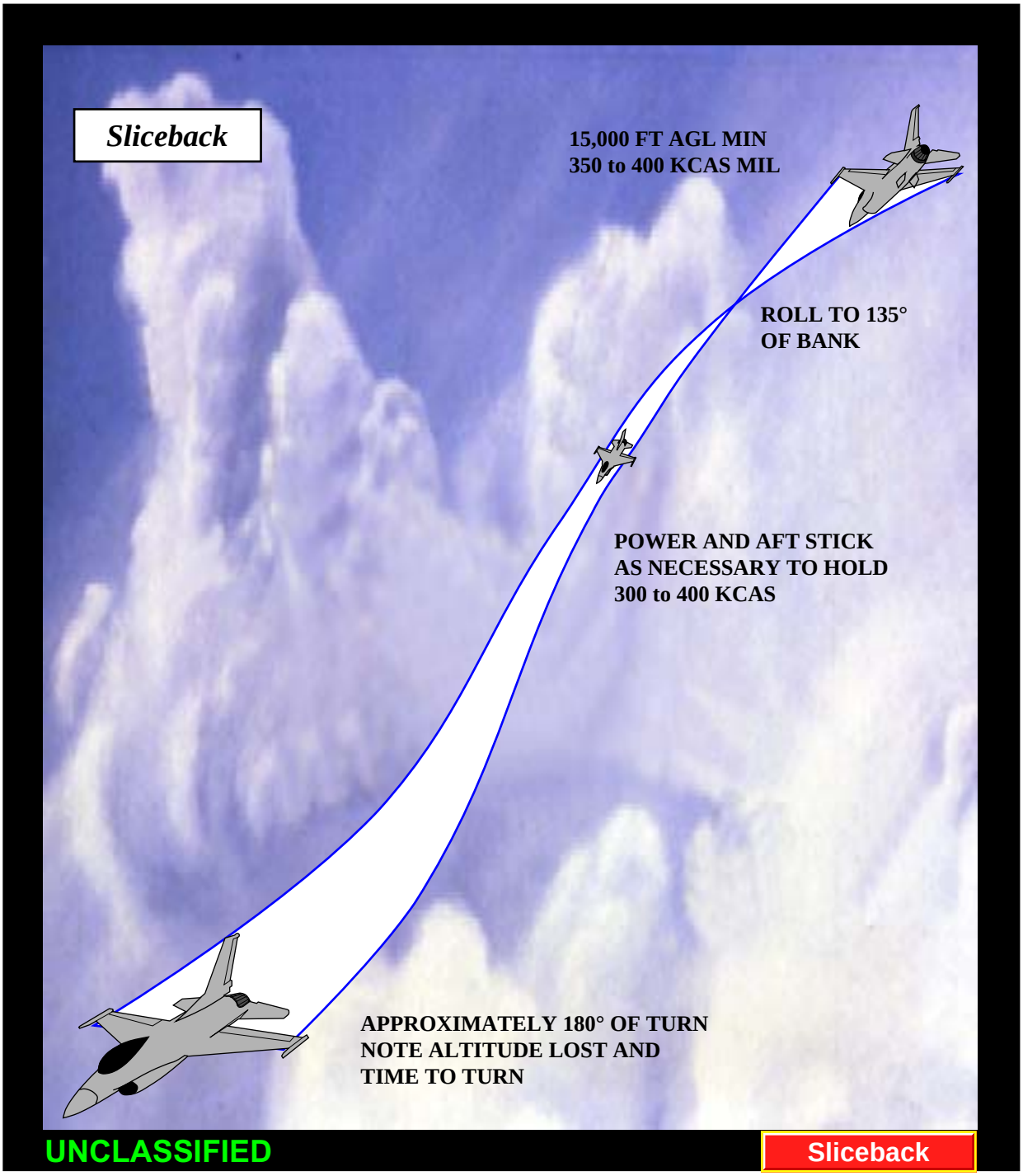


Figure 3.31 Reversals/Rolling Maneuvers.

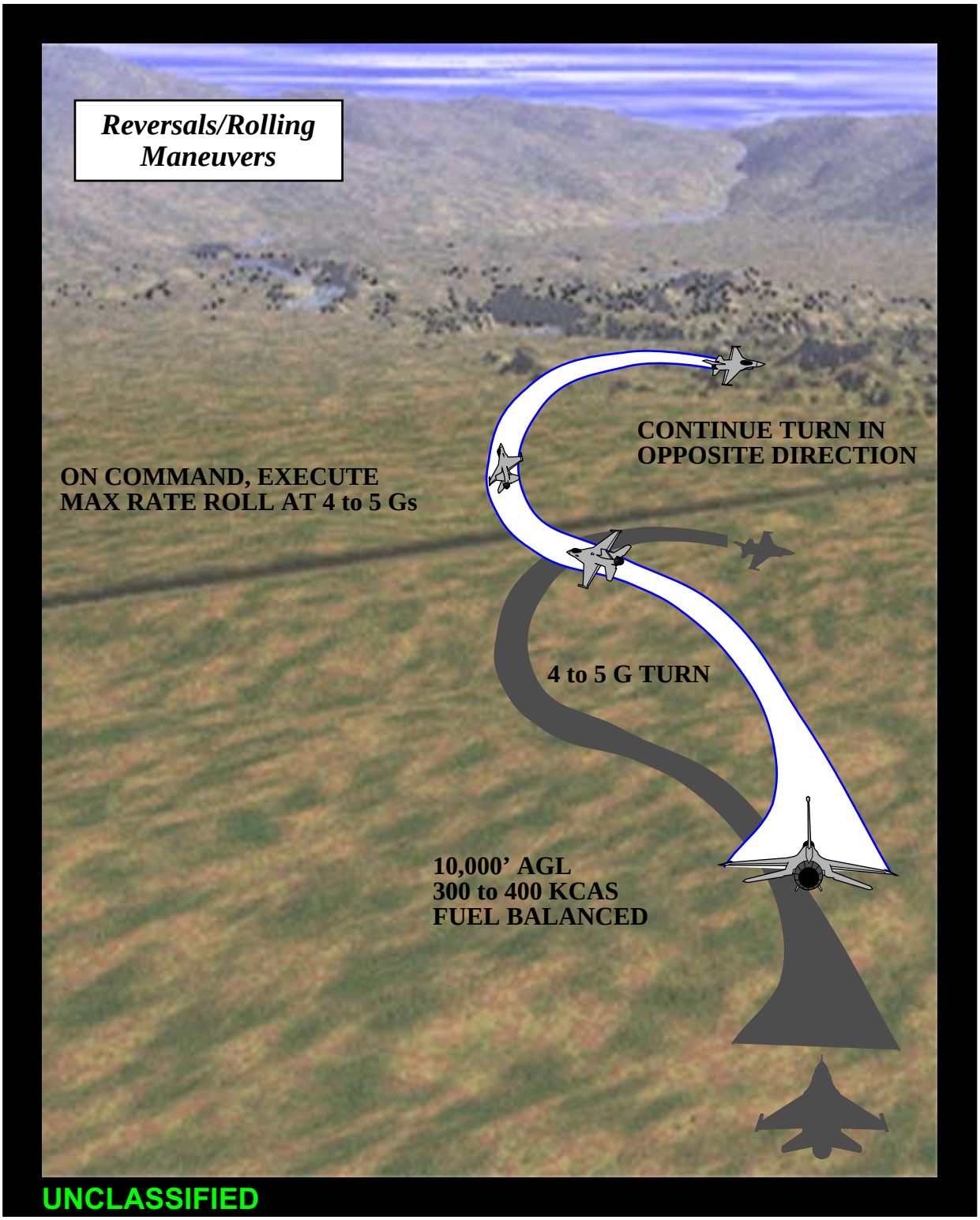
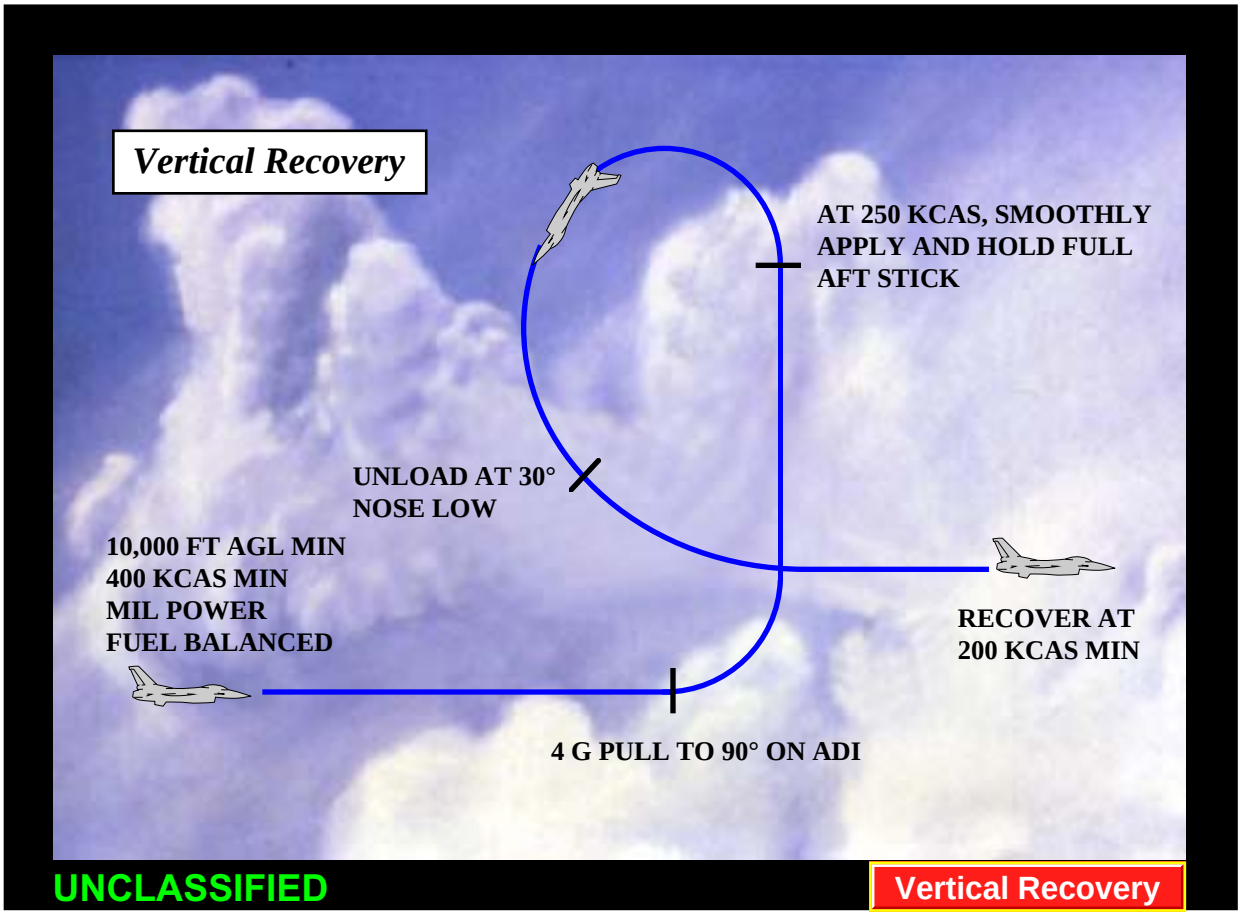
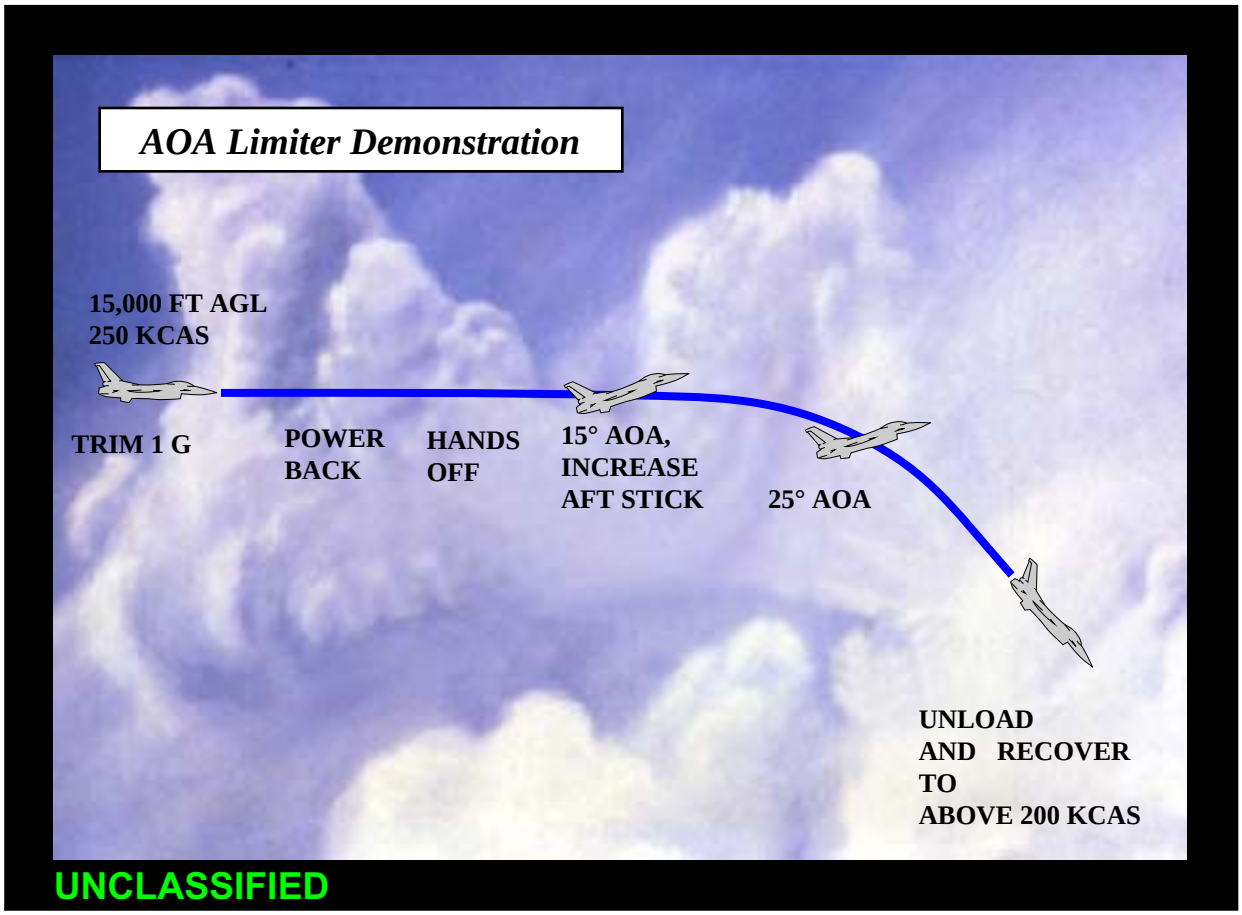


Figure 3.32 Vertical Recovery.



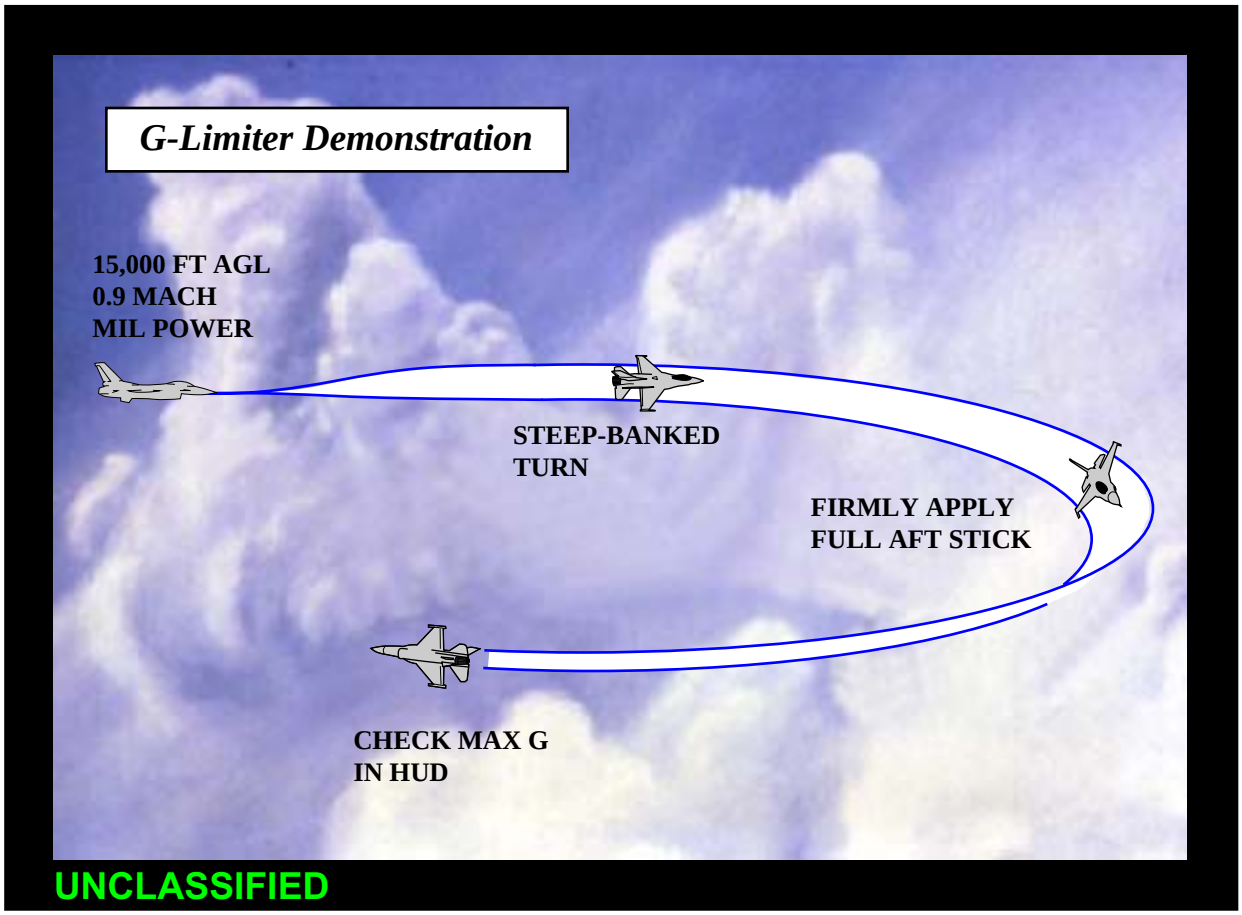
3.13.3.5 AOA Limiter Demonstration. The objective is to demonstrate the AOA limiting feature of the F-16 FLCS. Setup at 15,000 feet AGL minimum, 250 KCAS, trimmed to 1 G. (See **Figure 3.33**, AOA Limiter Demonstration.) Begin the maneuver in straight and level flight. Reduce power to IDLE, trim to 1 G, and release the stick. Notice with no aft stick pressure the aircraft trimmed for 1 G will maintain 1 G until approximately 15 degrees AOA. Note that above 15 degrees AOA, back pressure is required to maintain level flight. Smoothly increase back pressure until reaching full aft stick at approximately 25 degrees AOA. Do not pump the stick in pitch, since a pumping motion could cause an AOA overshoot. Note the AOA limiter allows the nose to fall so maximum AOA is not exceeded. Maintain full aft stick pressure to hold AOA on the limiter. While the aircraft is on the limiter, the high AOA roll control and lack of rudder authority can be demonstrated. Unload and recover to above 200 KCAS.

Figure 3.33 AOA Limiter Demonstration.



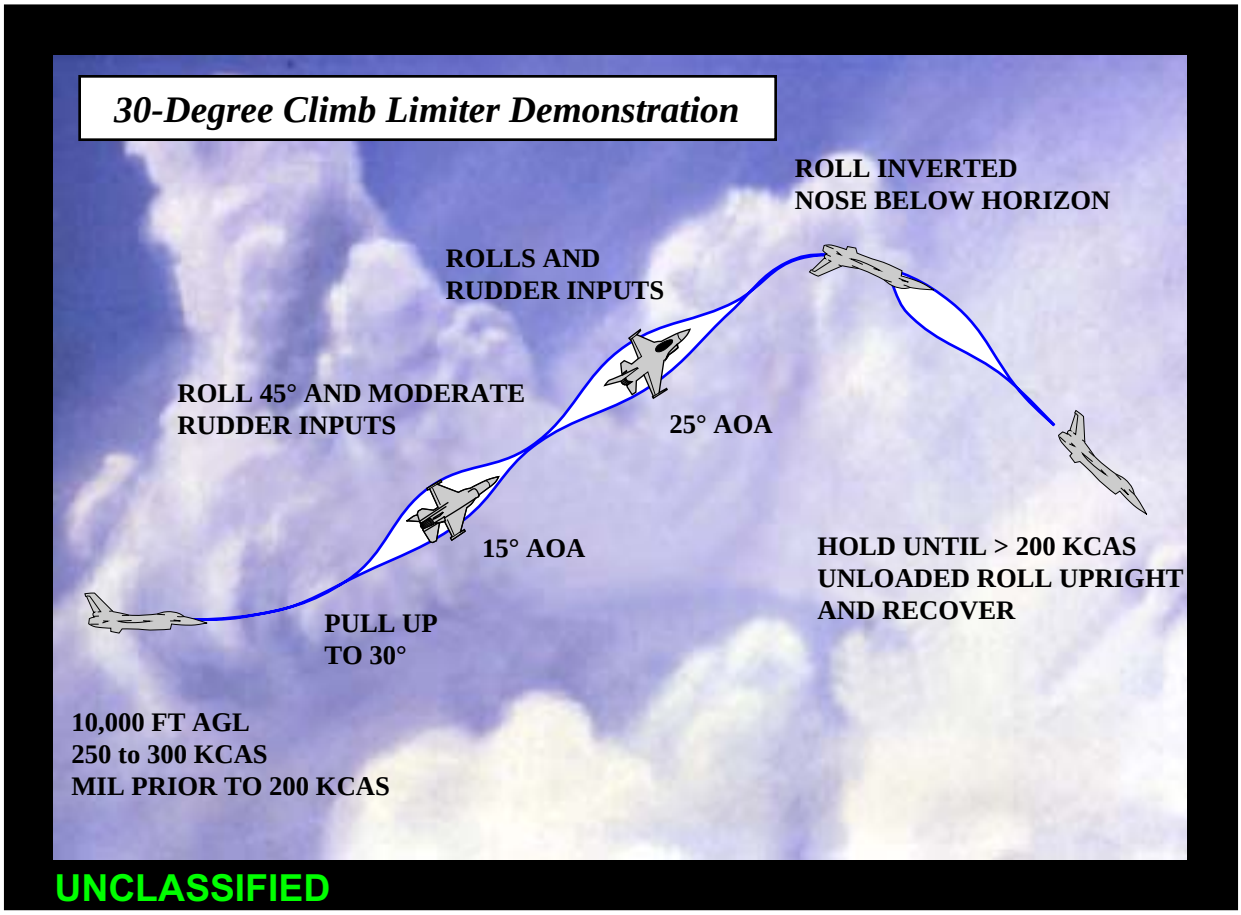
3.13.3.6 G-Limiter Demonstration. The objective is to perform a proper AGSM while demonstrating the G-limiter feature of the FLCS. Setup at 15,000 feet AGL minimum, 0.9 Mach, Mil/AB power. (See **Figure 3.34**, G-Limiter Demonstration.) Begin AGSM early in anticipation of 9 Gs. Select Mil power or AB power, as desired. In a 90-degree bank level turn, smoothly and firmly apply full aft stick. Increase aft stick pressure as G-tolerance allows. If full aft stick is attained, the G-load should peak near 9 Gs. Maximum sustained G-tolerance is often determined by your physiological condition and not by the flight control G-limiter. G begins to bleed down as AOA increases above 15 degrees. Relax back pressure, roll wings-level, and check the HUD for maximum G attained. Carry the lessons learned during this demonstration (i.e., anticipation, onset rate, and symptoms) forward to all of your future high G-maneuvering.

Figure 3.34 G-Limiter Demonstration.



3.13.3.7 30-Degree Climb Limiter Demonstration. The objective is to demonstrate roll rate and rudder fade out at high AOA. Setup at 10,000 feet AGL minimum, 300 KCAS, Mil power. (See **Figure 3.35**, 30-Degree Climb Limiter Demonstration.) Establish and hold 30-degree pitch attitude using the HUD bore cross or ADI. Perform 45-degree bank wing rocks in each direction prior to 250 KCAS and observe the rapid roll rate available. Perform 45-degree bank wing rocks at or above 15 degrees AOA and note the slightly reduced roll rate still available. Make a moderate rudder input from side-to-side and note yaw rate. Monitor AOA while smoothly increasing back pressure to hold a 30-degree pitch attitude. At 25 degrees AOA, you reach full aft stick (AOA limiter) and the aircraft begins to descend. Apply full rudder and note the lack of rudder effectiveness. Repeat the wing rocks and note the diminished roll rate is still sufficient for positive roll control. Unload, roll inverted, and pull to 20- to 30-degree nose low. At 200 KCAS, roll upright and recover.

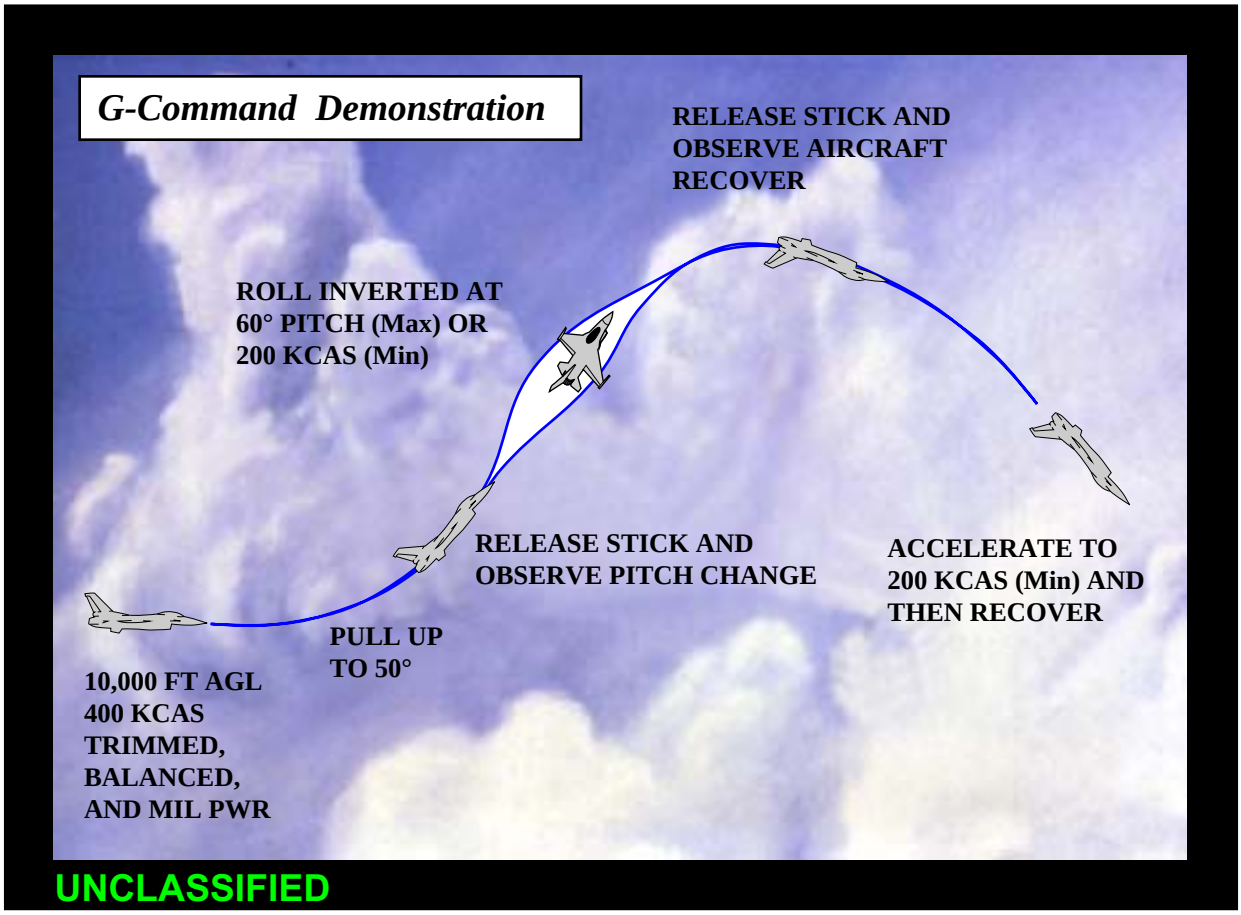
Figure 3.35 30-Degree Climb Limiter Demonstration.



3.13.3.8 G-Command Demonstration. The objective is to demonstrate the effects of FLCS G-command in upright and inverted flight. Setup at 10,000 feet AGL minimum, 400 KCAS minimum, Mil power, trimmed for 1-G flight, fuel balanced. (See **Figure 3.36**, G-Command Demonstration.) Precisely trim for 1-G flight. Pull wings-level and establish a 50-degree pitch attitude. At 50-degree pitch attitude, aircraft G equals approximately 0.6 G. Release the stick and notice how the nose rises as the aircraft seeks 1-G flight. At 60 degrees of pitch or 200 KCAS (whichever occurs first), roll inverted and release the stick again. The aircraft will continue to seek 1 G, resulting in the nose moving toward the horizon. Allow the nose to fall below the horizon and airspeed to build. Accelerate to 200 KCAS and initiate recovery to level flight.

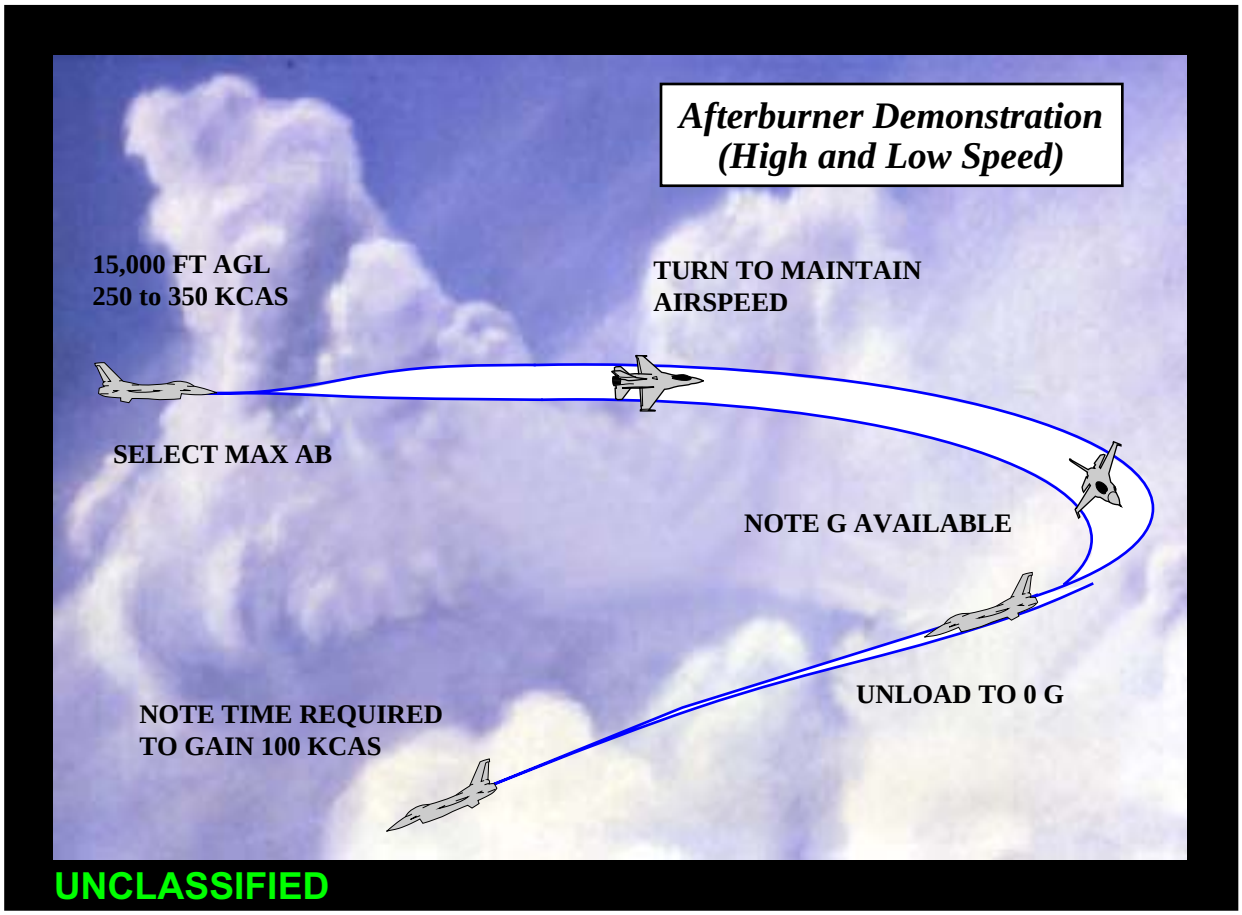
3.13.3.9 Afterburner Demonstration (Slow Speed). The objective is to demonstrate the ineffectiveness of AB at slow airspeed. Setup at 15,000 feet AGL, 250 KCAS. (See **Figure 3.37**, Afterburner Demonstration High/Low Speed.) Select full AB in straight and level flight and observe the 5-stage AB ignition. Use steep-banked turns to hold airspeed at 250 KCAS. Note the sustainable G at 250 KCAS. Roll out, unload to zero G, and note the time required to accelerate 100 knots.

Figure 3.36 G-Command Demonstration.



3.13.3.10 Afterburner Demonstration (High Speed). The objective is to demonstrate the effectiveness of AB at high airspeed. Setup at 15,000 feet AGL, 350 KCAS. (See **Figure 3.37**, Afterburner Demonstration High/Low Speed.) Select full AB in straight and level flight and observe the 5-stage AB ignition. At 400 KCAS, use a steep-banked turn to maintain airspeed. Note the sustainable G at 400 KCAS. Roll out, unload to zero G, and note the time required to accelerate 100 knots.

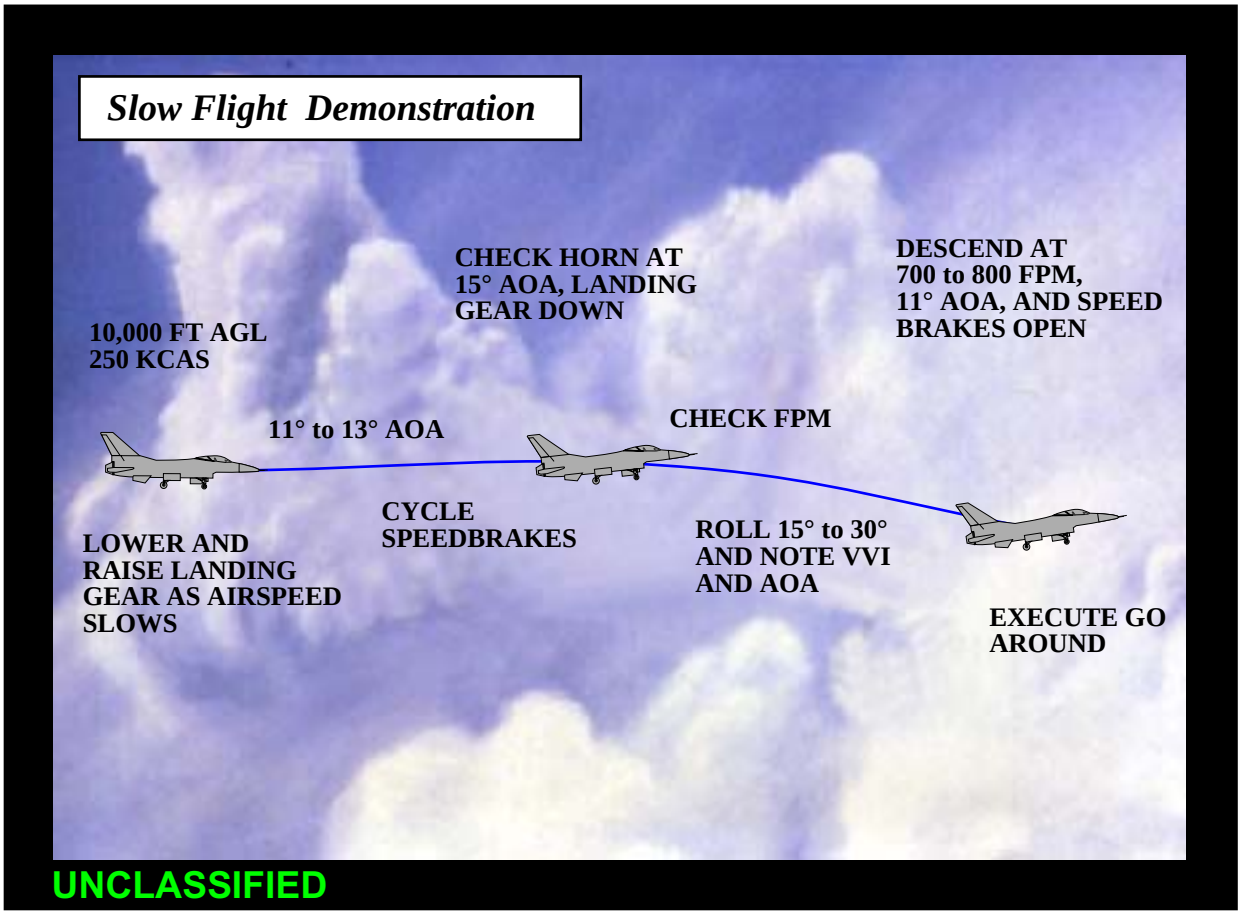
Figure 3.37 Afterburner Demonstration High/Low Speed.



3.13.3.11 Slow Flight Demonstration. The objective is to demonstrate slow speed handling characteristics in the landing configuration. Shorten this demonstration as required to provide time for other training events. Setup at 10,000 feet AGL minimum, 250 KCAS. (See **Figure 3.38**, Slow Flight Demonstration.) Slow to 250 KCAS and lower the gear. Note a very slight pitch up as the trailing edge flaps lower and the flight control system (FLCS) changes to takeoff and landing gains. Extend the speedbrakes and note their effectiveness. Hold the speedbrake switch in override and note the change. Retract the speedbrakes, maintain level flight, and decrease airspeed to 11 to 13 degrees AOA. Note the airspeed and pitch attitude difference between 11 and 13 degrees AOA. Continue slowing down to 15 degrees AOA and increase back stick pressure when the low-speed warning horn sounds. Note the pitch authority that is still available. Increase power and resume level flight at 11 to 13 degrees AOA. Extend the speedbrakes and simultaneously lower the nose, putting the FPM on the 2.5-degree dive pitch ladder reference. Note a 500 to 1,000 fpm rate of descent on the VVI (similar to a precision approach) and an ADI pitch attitude of approximately 10 degrees. Roll 15 to 30 degrees from side to side and note the aircraft roll authority at landing airspeeds. Also note the effect of these rolls on the FPM (or AOA) and the VVI. Execute a missed approach by increasing power, closing the speedbrakes, and maintaining pitch while allowing airspeed to produce a climb. Note altitude lost during

execution of the missed approach. Retract the gear and note the minor trim required as the FLCS reverts to cruise gains. Recover to above 200 KCAS.

Figure 3.38 Slow Flight Demonstration.



3.13.4 Departure Indications. The previously discussed maneuvers are a series of events designed to develop a “feel” for the F-16's handling characteristics. Additionally, the HARTS teaches the proper procedures to recover from a nose-high, low-airspeed situation and avoid departure from controlled flight. While these are planned events, situations may occur which place you in similar circumstances with less recovery or reaction time then optimum. Several, but not all-inclusive, departure indicators are as follows:

- A sensation of lateral side forces developing.
- Uncommanded aircraft movements (pitch and/or roll).
- AOA pegged at +32 degrees if upright or -5 degrees if inverted.
- Airspeed oscillating below 200 KCAS.

3.13.5 Dive Recovery Maneuver. Dive recovery capability is a function of pullout load factor, dive angle, true airspeed, and flight control system (FLCS) limiting. In a nose-low, low airspeed (below approximately 350 KCAS) situation, rolling wings-level, pulling to the limiter, retracting speedbrakes, and selecting and maintaining Mil power or AB thrust minimizes altitude lost. If airspeed is above 350 KCAS, rolling wings-level, pulling to the limiter, opening

the speedbrakes, and selecting and maintaining IDLE thrust reduces altitude lost. During a supersonic dive recovery at or above Mach 1.4, the engine will remain at or near Mil power thrust with the throttle at IDLE. As airspeed decreases below Mach 1.4, thrust decreases, but will not decrease to idle thrust until airspeed is below 0.9 Mach (GE engine) or 0.84 Mach (PW engine). Altitude required for recovery in this situation may be significantly greater than anticipated. Loss of consciousness in this situation could be fatal. During a recovery, constantly assess altitude remaining versus altitude required. If disoriented or unable to determine attitude from the HUD, reference the round dials. If altitude is critical, the FLCS may not allow sufficient G/AOA for recovery. Unnecessarily delaying the ejection decision could preclude safe ejection prior to ground impact.

3.13.6 Dive Recovery Practice. To practice dive recoveries, attain an entry altitude of 15,000 feet AGL minimum, an airspeed of 350 KCAS (high-speed recovery) or 250 KCAS (low-speed recovery), power as required, and establish a 60-degree dive with less than 30 degrees of bank. Prior to 10,000 feet AGL and 550 KCAS (high-speed recovery) or 350 KCAS (low-speed recovery), recover by rolling wings-level, set throttle and speedbrakes as appropriate, and apply maximum G until the aircraft is in level flight or climbing. Refer to TO 1F-16-1-1 dive recovery charts for additional data. While practicing this maneuver, do not "snatch" the Gs to the maximum G-onset rate since this increases the potential for a GLOC incident.

3.14 Steep Turns. Steep turns develop proficiency in making level, constant airspeed turns, and improve your instrument cross-check. Enter the turn at a stable airspeed between 200 and 350 KCAS above 10,000 feet AGL. Roll into 45 or 60 degrees of bank using the ADI and make a level, 90 or 180 degrees turn while maintaining entry airspeed and altitude. Referencing the HUD FPM to the level pitch line makes this maneuver relatively easy. Practice turns in both directions using the primary flight instruments and the HUD.

3.15 Unusual Attitude Recovery. Recover the F-16 from an unusual attitude according to AFMAN 11-217, Volume 1, Instrument Flight Procedures. Practice reinforces the need for an immediate transition to instrument references in case of disorientation or deterioration of visual references.

3.15.1 Contributing Factors. Factors that can contribute to development of an unusual attitude are as follows:

- Spatial disorientation.
- Instrument malfunctions.
- Lost wingman.
- Aircraft lighting during IMC (gear down/landing light and strobe light).

NOTE: Practice unusual attitude recoveries only during simulator training or F-16D sorties with a RCP IP.

WARNING: The HUD will not be used as a sole reference during recovery from unusual attitudes unless no other attitude instruments are available.

3.16 Spatial Disorientation. The USAF aircraft most conducive to spatial disorientation (SD) is the F-16. The primary cause of SD is inattention to aircraft attitude. F-16 characteristics often make it difficult to realize unintentional changes in aircraft attitude. Tactical mission elements with high pilot tasking easily divert attention from aircraft attitude and lead to SD in any kind of weather. Know the conditions that you are more susceptible to SD (IMC, Night, and Fingertip/ Route). You can help prevent SD with the following actions:

- Make a conscious effort to maintain an effective cross-check during these conditions.
- Recognize symptoms and take action (tell flight lead, increase cross-check, and change flight conditions).

WARNING: If action is not taken early, SD may proceed to a point where the pilot is unable to see, interpret, or process information from the flight instruments. Aircraft control in such a situation is impossible. Recognize when you exceed physiological/psychological limits and be mentally prepared to abandon the aircraft.

3.17 Navigation. The F-16 is certified for RNAV, but the TACAN is still the primary instrument navigation aid. Use the INS (when cross-checked and confirmed against the TACAN), to simplify navigation. Use the CDI on the HSI to intercept and maintain a desired TACAN course. In most master modes, wind-corrected INS steering to the selected steerpoint is available in the HUD.

3.18 Instrument Penetration and Approach. Complete checks prior to the IAF—weather, holding, obtain clearance, letdown approach review, descent check, set navigation aids (WHOLDS). Select the instrument modes for the desired HUD/ADI/HSI navigational displays and precede IAW the appropriate published recovery. As a minimum, set the following items prior to descent: DEFOG lever, landing light, altimeter, NWS control button (D-Model), and TACAN. Maintain 300 KCAS or the assigned recovery airspeed to enable proper traffic sequencing.

3.18.1 TACAN Holding. Typical holding airspeed at all altitudes in the F-16 is 250 KCAS, although the Dash 1 says 200 to 250 KCAS. Airspace/altitude restrictions may dictate a minimum airspeed anywhere from 265 KCAS to 210 KCAS. Hold at maximum endurance speed if fuel is critical or you expect a lengthy delay. Use the FPM or the HUD ground track (ground speed selected) to establish drift correction. The FPM displaces downwind (in DRIFT NORM) and indicates up to 10 degrees of drift. Determine drift by comparing FPM displacement left or right from the HUD heading box. Determine no-wind radial displacement for an inbound turn by converting your turn diameter into degrees using the 60-to-1 rule. For example, an inbound turn at 30 DME (2 degrees per mile) and 0.5 Mach (approximately 250 knots) (5 mile turn diameter) requires 10 degrees of displacement in no-wind conditions. Remember, turn radius equals 1 percent of true airspeed with 30-degree bank.

3.18.2 TACAN Penetration and Approach. Fly the penetration descent at 300 KCAS, speedbrakes as required, and 70 percent rpm minimum (PW220). Determine descent pitch attitude (no wind) by dividing required altitude to lose in hundreds of feet by the distance available to lose it (e.g., use 10 degrees pitch to lose 20,000 feet in 20 NM). Follow TACAN course guidance using the HSI. At approximately 3 miles from the final approach fix, slow to 250 KCAS and configure. Slow to final approach airspeed (11 degrees AOA) prior to the final approach fix (FAF). At the FAF, open the speedbrakes and lower the nose to 5 degrees to estab-

lish a 1,500 fpm rate of descent. You must reach the minimum descent altitude (MDA) prior to the published or computed visual descent point (VDP). (If you have the runway environment in sight when you reach the VDP, use the FPM to establish a proper glide slope.) If you reach the MAP (at the MDA), and the runway environment is not in sight or the aircraft is not in a position to accomplish a safe landing, execute a missed approach.

3.18.3 Instrument Landing System Approach. Enter the localizer course and frequency in the UFC and mode select "CMD STRG." This allows the HUD to display correct localizer and glide slope data with TACAN/ILS or NAV/ILS selected. Remember, course input to the FCC and HUD is via the UFC, not the HSI course set knob. During localizer interception, the HUD flight director indicates bank steering commands by deflecting right or left in azimuth along the HUD horizon line. Bank right or left to superimpose the FPM over the steering circle. If you are descending at the time, just align the FPM vertically under the steering circle. Maximum commanded bank is 30 degrees and maximum computed intercept angle is 45 degrees. AOA/airspeed is the same as a HUD off ILS approach. Closely follow the computed steering and you will roll out on the proper localizer course. Once established on the localizer, a tail will appear on the flight director circle just prior to glide slope interception. Simultaneously extend the speedbrakes and lower the nose to keep the FPM superimposed on the flight director circle. Modulate power to control airspeed and hold 11 degrees AOA. Use small pitch and bank inputs to keep the FPM superimposed on the flight director circle, which should direct a glide path equal to the published glide slope. If you do get off steering, the flight director circle provides guidance to get back on steering. Remember, always cross-check HUD information with other flight instruments, and confirm ILS positioning and alignment by referencing the ADI steering bars. Even though you are operating in the flight director mode, the bars in the HUD and ADI still reflect raw deviation. The FPM is superimposed over the flight director circle, the steering bars are centered, and the touchdown point is under the FPM. In a very strong crosswind, displacement of the ILS display in the HUD field of view (FOV) may require you to move your head to one side to see the entire display.

3.18.3.1 Unreliable ILS Information. Watch closely for dashed steering lines or an "X" superimposed on the flight director symbol, indicating unreliable localizer or glide slope information, and revert to the raw data if required. At decision height, if the runway environment is not in sight or the aircraft is not in a position to accomplish a safe landing, execute a missed approach.

3.18.3.2 HUD off ILS Approach. Flying a HUD off ILS in the F-16 is just like flying an ILS in the T-38. Intercept the localizer course using HSI/ADI information. Maintain airspeed in the 200 to 250 KCAS range prior to lowering the gear. Reduce to final approach airspeed, or 11 degrees AOA, no later than glide slope intercept. At glide slope intercept, fully extend the speedbrakes and lower the nose as required to capture the glide slope. Full-open speedbrakes are usually just enough drag to maintain final approach airspeed without significant power changes. Use power to maintain airspeed/AOA. Remember, the localizer and glide slope indicators in the ADI are depicting actual deviation. They are not command steering bars. With the localizer centered, you are on the localizer at that moment; however, your actual track may or may not correspond to the ILS course. Use appropriate power and pitch corrections to keep the ADI steering bars centered, and transition to landing references.

3.18.4 Precision Approach Radar. Precision approach radar (PAR) is very similar to an ILS. Fly airspeed in the 200 to 250 KCAS range prior to lowering the gear. Review decision height, field elevation, and runway heading. Follow the controller's directions while cross-checking the primary flight instruments. The HUD is extremely helpful during a PAR. The heading is "boxed," and you can wire the glide slope by putting the FPM at the corresponding dive angle. The FPM indicates wind drift and helps determine runway position relative to aircraft heading at decision height. At decision height, if the runway environment is not in sight or the aircraft is not in a position to accomplish a safe landing, execute a missed approach.

3.19 Missed Approach. When executing a missed approach, advance power as required, close the speedbrakes, and retract the landing gear after a positive climb is established on the altimeter and VVI. Adjust power to maintain 250 KCAS if remaining in the radar pattern. If diverting, climb in Mil power IAW published procedures for your aircraft block and configuration.

3.20 Minimum Fuel Recovery. If fuel remaining dictates, request minimum vector recovery from the controlling agency and head for the nearest suitable base. If there are no altitude restrictions, use the HOME mode. If required to level off at an altitude less than optimum, use the "Climb/Optimum Cruise" portion of the Dash 1 checklist. Descend with idle power, speedbrakes retracted, and optimum speed (use HOME or RANGE options as applicable). Initiate the descent IAW HOME profile (if selected) or at a range from the base in nautical miles equal to twice your absolute altitude in thousands of feet (e.g., from 20,000 feet AGL, initiate descent 40 NM from the field).

3.20.1 Maximum Range Mode. The cruise energy management maximum range (RNG) option provides a HUD airspeed caret (when mode selected) that corresponds to the optimum airspeed for maximum range at current altitude. The CRUS RNG display on the DED indicates pounds of fuel remaining at the selected steerpoint, if you fly direct and maintain the current ground speed and fuel flow.

3.20.2 Home Mode. The home (HOM) option gives wind-corrected HUD altitude and airspeed guidance for climb, cruise, and idle power descent to 5,000 feet over the home point. The home point is the steerpoint displayed on the DED HOM page when HOM is mode-selected on the ICP (M-SEL). The home point can be changed via the increment/decrement switch without changing the current steerpoint provided HOM is not mode-selected. HOM "Bingo" occurs when fuel at 5,000 feet above the home point is computed to be less than 800 pounds. This warning occurs even if HOM is not mode selected.

3.20.3 Maximum Endurance. The endurance (EDR) option provides airspeed guidance (indicated by a HUD caret) for maximum endurance at the current altitude. The DED provides maximum endurance Mach number and time remaining until reaching the selected Bingo fuel (BNGO) at current conditions.

3.20.4 Bingo. The BNGO fuel mode (LIST 2) allows you to enter a precomputed fuel value in the FCC. After reaching this fuel level, the voice message system provides a "Bingo, Bingo" message, and FUEL flashes in the HUD until reset. (***NOTE:*** Incorrect bingo fuel warnings may occur. Investigate all Bingo fuel warnings and ensure fuel tanks are feeding.) Bingo fuel warning is based either on fuselage fuel with the FUEL QTY SEL knob in NORM, or total fuel with the FUEL QTY SEL knob out of NORM.

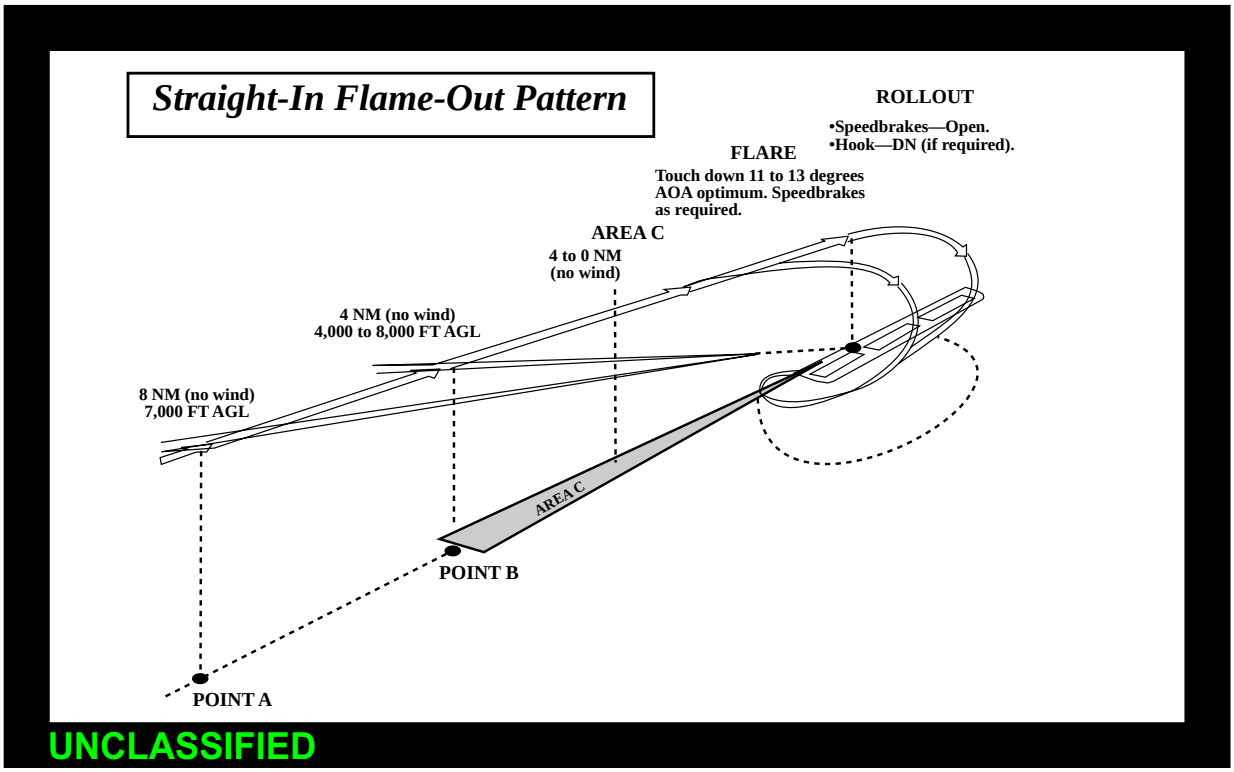
3.21 Flame-Out Approach Techniques and Procedures. A flame-out (FO) approach may be anything from a 360-degree overhead to a straight-in approach. It is entirely a function of available potential energy versus distance, with certain modifiers such as the nature of the emergency, weather, and airfield conditions. The overriding consideration, of course, is the safe recovery of the pilot, with the aircraft a distant second. It is extremely important to recognize when recovery of the aircraft is no longer feasible, so that ejection can be accomplished as early as possible to increase the odds for survival. Do not commit to a dubious or unsafe approach under any circumstances. When in doubt, eject. The good news is that it is relatively easy to determine whether you are within valid FO parameters as long as certain basic criteria are met.

NOTE: A flamed-out F-16 has the capacity to cover a finite distance over the ground based on altitude, aircraft configuration (weight and drag), winds, and field elevation. Assuming that the best glide speed for the aircraft configuration is maintained, the only significant variable to be accommodated is the wind. Since the FPM (if available) takes winds into account and the best glide speed for the configuration generates an optimum glide slope, it is then only necessary to determine where the recovery field is relative to the FPM to determine if the approach will be successful. If the field lies beyond the FPM, the approach will be short and ejection should be considered. If the field lies short of the FPM, excess energy is indicated which may accommodate a variety of successful approaches and landings.

3.21.1 Straight-In Flame-Out Pattern and Approach. In the Dash 1 is a discussion of a straight-in simulated flame-out (SFO). Maintain an optimum speed gear-up glide until the initial aimpoint on the runway is 11 to 17 degrees below the horizon, then lower the gear and continue the glide at optimum gear-down speed. (See **Figure 3.39**, Straight-In Flame-Out Pattern.) Engine-out tests at Edwards AFB, California, resulted in a gear-down best range glide between 10 and 11 degrees flight path angle which could be increased to 17 degrees flight path angle with the speedbrakes; thus the 11 to 17 degrees window for lowering the gear. The Dash 1 does not include HUD techniques for the FO, nor does it discuss the effect that a headwind or tailwind will have on the 11- to 17-degree flight path angle window. Experience has shown that energy can be managed most effectively with reference to the HUD FPM and pitch lines while maintaining optimum airspeed. Pilots should still be ready to accomplish a FO without a FPM. At optimum airspeed (gear up), the aircraft is at approximately 6 to 7 degrees AOA. If the aircraft is gliding at optimum AOA, the 11- to 17-degree window to begin descent occurs as the approach end of the landing runway disappears beneath the nose of the aircraft. Regardless of actual flight path angles involved, lowering the gear will require increasing the flight path angle 3.5 to 4 degrees to hold airspeed. When the engine quits, jettison stores and turn toward the nearest suitable runway. Establish best range speed of 200 KCAS (plus fuel/stores). (NOTE: Trade excess airspeed for altitude.) The EPU should be on. If the engine is windmilling with aircraft fuel available, the jet fuel starter (JFS) should be turned on below 20,000 feet MSL and 400 KIAS to extend EPU operating time (10 minutes with normal demands; up to 15 minutes with the JFS running). Do not start the JFS if the engine is seized or seizure is expected. The JFS will also provide B-system hydraulic pressure for normal gear extension, normal brakes, and nosewheel steering. With an optimum glide established, if the FPM is on the runway or beyond and optimum speed is maintained, the threshold will slowly move downward in the HUD FOV indicating excess energy (in terms of altitude) for the approach. This is good because sooner or later the initial aimpoint (one-third of the way down the run-

way) will lie within the gear-down window. The gear may be extended when the aimpoint is between 11 and 17 degrees and landing is assured. Once you are sure that you have the runway made it is time to transition to a more normal approach. How do you know the runway is made? If you have the gear down and are on or above the optimal gear down airspeed with the runway anywhere between 11 and 17 degrees nose low (or you have better than a 1 to 1) you are going to make it.

Figure 3.39 Straight-In Flame-Out Pattern.



3.21.1.1 EPU Fuel Depletion. If EPU fuel depletion is a factor because of range to the runway, consider a 10-degree gear-up glide when the best range glide given is a 1:1 ratio between altitude in thousands of feet and range to the runway (i.e., 20,000 feet AGL at 20 NM). Airspeed can be increased to 300 to 330 knots, cutting time required to reach the runway and reducing EPU fuel used (see Dash 1, FO procedures for more detailed information). When the gear is lowered (alternate extension required unless the JFS is motoring the engine), continue the glide at best range (gear down) speed. Use speedbrakes as required to maintain the desired glide path and airspeed parameters, and achieve a steady-state optimum gear-down glide prior to the flare point with the FPM on the aimpoint. In a nutshell, if the aircraft flames out, regardless of altitude or distance out (within EPU fuel constraints), and the recovery field is below the 7-degree pitch line, you immediately know you can get there. Winds can affect this equation.

3.21.1.2 Maintaining Optimum Speed. Unless you confirm an energy surplus, it is extremely important to maintain optimum speeds throughout the approach. Failure to maintain optimum airspeed will increase the glide path angle and consequently decrease range. Below the gear down minimum speed, the FPM shifts dramatically toward you

(short), and energy may be insufficient to flare and touchdown without damaging the aircraft, or worse. There is no way to "stretch" the glide. If the aimpoint shifts upward in the HUD FOV beyond the FPM, this indicates that you will not be able to make the runway. Ejection should not be delayed in a futile attempt to salvage a questionable approach.

3.21.1.3 Touchdown. If you have managed your energy to achieve an optimum gear-down glide with the FPM on the initial aimpoint, the only chore remaining is to flare and land the aircraft on touchdown between 10 and 13 degrees AOA with enough runway remaining to stop the aircraft before running out of runway or cables. Once landing is assured, the recommended procedure is to shift the aimpoint from one-third down the runway to a position short of the intended touchdown point. Techniques presented here will consistently produce touchdowns at 2,500 to 3,000 feet. If a shorter touchdown is required, simply adjust the optimum glide aimpoint an appropriate distance short of the threshold. The trick is to transition from a "steep final" to a touchdown flight path angle of less than 2 degrees. If the flare is too abrupt or begun too early, the aircraft will run out of airspeed prior to touchdown. The result is an excessive sink rate and probable damage to the aircraft. The opposite is also true—the aircraft cannot hit the runway in a 10-degree dive and expect good results. Once you are sure that you have the runway made it is time to transition to a more normal approach. How do you know the runway is made? If you have the gear down and are on or above the optimal gear down airspeed with the runway anywhere between 11 and 17 degrees nose low (or you have better than a 1 to 1) you are going to make it. One technique is to shift your aimpoint short of the intended point of landing to get to a dive angle that is closer to the 2.5 degree normal picture. How far do you aim? That depends on your energy state but, in general about 2000 feet short of the runway will be close. This will increase airspeed a little so speed brakes may be required. Avoid getting your nose more than about 15 degrees nose low during this action. As the runway approaches approximately 5-10 degrees nose low (i.e. the runway threshold lies between the 5 and 10 degree pitch ladders in the HUD) start putting the nose back up to the runway. This should be a smooth pull to avoid overtasking the EPU hydraulic pump if the motor is not running. As a general rule of thumb make sure that you are starting your roundout above 500 feet AGL if you are at 15 degrees nose low and 300 feet AGL if you are at 10 degrees nose low. Retract the speedbrakes if it appears you will get too slow during the roundout. See Straight-In SFO **video**.

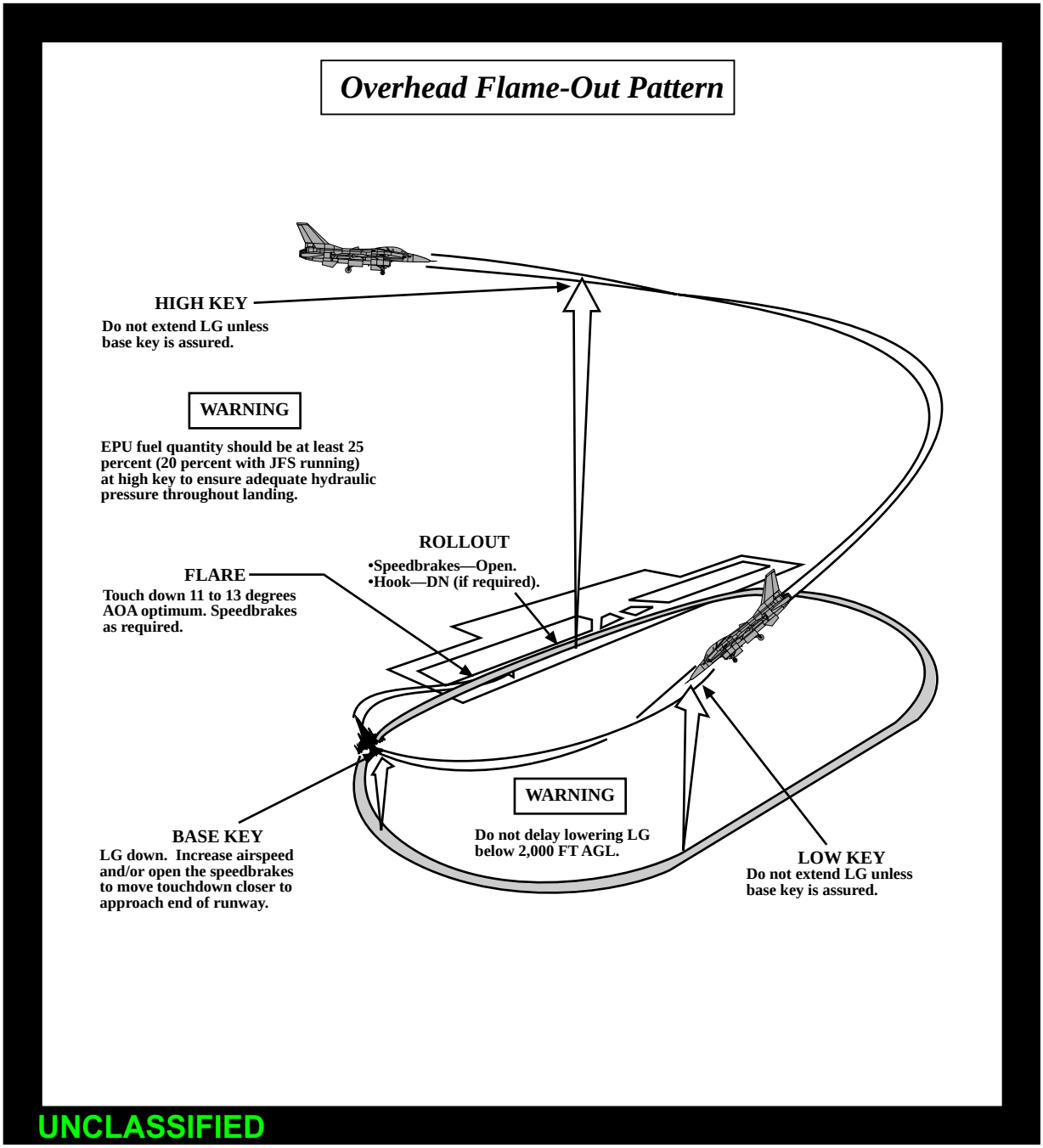
3.21.1.4 Handling excess energy. Once you have lowered the LG and placed the aimpoint on the threshold, make an assessment of your energy state. If airspeed is increasing, open the speedbrakes as required to maintain optimum airspeed. If full (overridden) speedbrakes are not enough to hold the desired airspeed, cross-controlling (slipping) the jet may increase drag enough to control airspeed or descend to a more manageable approach angle, at which time you neutralize the controls and complete the approach. Use caution during cross-control input to insure the toes brakes are not activated by the rudder input, thus depleting the Brake/JFS accumulators. Another technique is to maneuver the aircraft (e.g. S-turn) to burn up excess energy. Use caution S-turning since the maneuver back to correct final approach must be precisely timed to be effective, and excess maneuvering may stress the EPU hydraulic pressure output A third technique is to "S-turn" in the vertical dimension by momentarily increasing dive with full speedbrakes, placing the aimpoint well short

of the touchdown point until losing enough altitude to achieve the desired glidepath, then placing the aimpoint back on the runway and using full speedbrakes to bleed off the airspeed increase from the dive. Use caution when employing the maneuvering methods. It is easy to overdo the S-turn techniques since either method involves removing the runway from the HUD FOV during the correction. The slip technique keeps the flightpath in the same general area while controlling airspeed through increased drag and is easier to perform, plus, the return to normal drag happens instantaneously when the cross-control input is neutralized. If energy is too high to be bled of using any of the above techniques, the overhead approach may be entered at any position (high, low, or base key) provided the proper altitude for that point in the pattern can be obtained. The main concern is to reach high key, low key, or base key at or above prescribed minimum altitudes.

3.21.2 Overhead Flame-Out Pattern Approach. For an overhead approach, plan to arrive at an appropriate high key altitude based upon aircraft gross weight. At high key in the landing configuration, turn to downwind/low key at approximately 50 to 55 degrees of bank and constant airspeed, optimizing the F-16's turning capability, and minimizing altitude loss. (See **Figure 3.40**, Overhead Flame-Out Pattern.) By using a 50- to 55-degree bank turn, more time is spent wings-level, energy state is easily assessed, and altitude loss is minimized. If off parameters at high key, adjust the pattern as necessary (delay landing gear if low and extend down the runway if high) to achieve low-key parameters. Delaying landing gear until low key will decrease altitude loss by 1,000 to 1,500 feet. If on desired conditions, continue downwind until the touchdown point is 10 to 45 degrees aft of abeam, depending on wind. Fly the final turn at optimum airspeed (9 to 11 degrees AOA) and, after rolling out on final, maintain airspeed with nose-low, setting the FPM short of the runway threshold until pre-flare as discussed in **paragraph 3.21.1.3**, Touchdown. Expect the aircraft to float 3,000 to 4,000 feet horizontally before touchdown at 10 to 13 degrees optimum.

3.21.2.1 Low Key to Flare. After meeting low-key parameters, you will usually be high and steep on final unless you adjust during the base turn. If this is the case, use pitch and speedbrakes as required to arrive at the round-out point with a 10-degree flight path angle. In the absence of a positively recognized energy advantage, maintain an optimum airspeed until it is ascertained that the 10-degree aimpoint is on the threshold or close enough to it to place the touchdown point on the runway surface. If it is not, it is time to eject. Do not pull the FPM up to the runway in an effort to lengthen the aimpoint. The resultant loss of airspeed may preclude a successful round-out and flare. Transition to the flare/touchdown as discussed in **paragraph 3.21.1.3**, Touchdown.

Figure 3.40 Overhead Flame-Out Pattern.



3.21.2.2 SFO versus FO. Procedures for an SFO are identical to a FO with one minor exception—the engine is still running during an SFO. Open the speedbrakes slightly and put the power to idle for an SFO. On wings-level final, speedbrakes help control energy during the flare and touchdown. In the overhead pattern, call "HIGH KEY," and "BASE KEY, GEAR DOWN" with intentions. For a straight-in, call "STRAIGHT-IN SFO" with distance measuring equipment (DME) when commencing the approach and "gear down" with intentions when appropriate. Continue to a low approach. If you arrive at the round-out point with less than the desired energy state, take it around and try again. Do not

try to salvage a bad approach under any circumstances. Learn from the mistakes you have made instead of compounding them by flying into a “square corner.” During the terminal stages of the approach, you should be no steeper than 10-degree nose-low by 300 feet AGL. Recover and go around if you are too steep. These numbers are action points, not decision points, and do not include a pad for reaction time.

3.22 Overhead Pattern.

3.22.1 Initial. Fly initial at 300 KCAS and initiate the break over the desired touchdown point, or as directed. Use about 70 degrees of bank and make a 2- to 3-G-level turn. Use the FPM to assist in making a level turn. Extend the speedbrakes as required and “stand up” the throttle (approximately 80 percent) to roll out on inside downwind at 200 to 220 knots with the wing tip missile rail on the runway (no wind). Extend the gear and confirm the landing configuration (three green lights, red light in the gear handle out, landing light on, speedbrakes and extended, hydraulic pressure checked) prior to initiating the base turn. Maintain a maximum of 13 degrees AOA on inside downwind while striving for approximately 180 to 200 KCAS. A good technique for a clean configuration is reducing airspeed to 20 to 30 knots above computed final approach speed to prevent excessive airspeed buildup during the base turn.

3.22.2 Base. Initiate the base turn (no wind) at a 45-degree extension from the desired touchdown point (wing tip on the end of the runway) and make the proper radio call. “Stand up” the power (approximately 80 percent), lower the nose 8 to 10 degrees, and fly the turn striving for 11-degree AOA. Check altitude halfway through the turn to prevent a steep or dragged-in final.

3.22.3 Final Turn. Controlling airspeed in the final turn requires some attention. Near idle, the throttle is positioned much further aft than you may be familiar with, and the tendency is to use a midrange throttle setting, which closes the nozzle and results in excessive airspeed. Use speedbrake override early in the base turn to make small speed reductions, and trim as necessary. Repeatedly cross-check touchdown point, altitude, and AOA, but do not fixate on any one parameter. Use power to adjust airspeed while using bank to maintain 11 degrees AOA at 8- to 10- degree nose low. During the second half of the final turn, you may need to raise the nose and reduce power slightly to get on the proper glide path. Adjust power to maintain 11 to 13 degrees AOA. Use VASI or PAPI lights (if available), to help establish an initial position for glide path. Roll out wings-level on final approximately 300 feet AGL and 1 mile from the planned touchdown point at 11 degrees AOA. Proper glide slope is indicated with both the FPM and 2.5-degree dive pitch ladder on the runway threshold. ***NOTE:*** AOA is referenced rather than airspeed for base and final. This compensates for varied landing weights/configurations. However, always compute final approach airspeed for your gross weight and compare it to the airspeed that provides 11 degrees AOA. Remember, the checklist charts are based on a 13-degree AOA final, so add 8 knots for an 11-degree AOA approach.

3.22.4 Short Final. Maintaining the FPM and 2.5-degree dive pitch ladder on the runway threshold results in a transition to “three red, one white” on the PAPI lights as the overrun is approached. This accommodates the aircraft's flare characteristics, allowing touchdown in the normal zone (150 to 1,000 feet down the runway with 500 feet desired). Airspeed control on final is very important, so make necessary power corrections early on final. The last thing you want is IDLE and full speedbrakes to slow down on short final! A stable power setting above

IDLE is highly desirable in turbofan engines, since it provides faster engine response if more thrust is required.

3.22.5 Closed Pattern. Maintain runway alignment, accelerate to 250 to 300 KCAS, and request a closed pattern. Initiate a rolling pull-up to closed downwind when cleared by the tower. Avoid excessive pitch and bank angles in the pull-up and adjust power and G to roll out at downwind pattern altitude with proper lateral spacing and 200 to 250 KCAS. Adjust spacing in relation to the assigned runway and configure the aircraft for landing when abeam the planned touchdown.

3.23 Landing. Entering the overrun, adjust your aimpoint from the threshold to a point 500 to 800 feet down the runway. Use the FPM to assist you, but do not fixate on HUD symbology at the expense of aircraft control. Rate of descent decreases slightly when entering ground effect. Smoothly flare to decrease descent rate (but avoid leveling off), and fly to the desired touchdown point. Power can be reduced to idle in the roundout when making an 11-degree AOA approach. Transition to 12 to 13 degrees AOA during roundout and touchdown at a maximum of 13 degrees AOA. Airspeed control is always critical during landing. If starting the flare with less than 11 degrees AOA, the aircraft tends to float a considerable distance, resulting in a long landing. If slow, you may land hard and/or short. Be very alert for high sink rates if above 11 degrees AOA with IDLE power approaching the overrun. If this situation occurs close to touchdown, engine response may not be fast enough to prevent a hard landing. Also, guard against the tendency to cushion a probable firm touchdown by pulling back on the stick if above 11 degrees AOA (a balloon will result). Obviously, try to avoid the situation, but if it develops, increase power and maintain landing attitude (11 to 13 degrees AOA). At 15 degrees AOA, the low-speed warning tone comes on. Touchdown at 15 degrees AOA or greater will result in a tail scrape. Hard touchdowns between 13 to 15 degrees may also result in a tail scrape. Do not hold the speedbrake switch open in the override position during touchdown as you might scrape the speedbrakes. Do not touchdown with brake pedals depressed.

3.23.1 Head-Up Display-Off Landing. This prepares you for landing with no HUD or a HUD malfunction. During normal approaches, visualize the glide slope without using HUD references to prepare for this event. Expect the IP to direct you to turn down the HUD symbology (not off) and execute a normal pattern and landing. Airspeed, AOA, altitude, and vertical velocity are available on the instrument panel. Maintaining a correct glide slope requires you to combine this data with familiar outside visual references. Use the two red, two white indication on the PAPI lights to maintain glide slope until short final, then drop slightly low (mostly red) on glide slope, visualizing a glide path which terminates at the runway threshold to accommodate the flare. The flare to touchdown is unchanged, except HUD AOA is not available.

3.23.2 Crosswind Landing. Roll control problems are possible with gusty winds or when landing close behind another aircraft when winds are calm. Because roll response is sensitive at landing speeds, it is easy to overcontrol and get into a rolling pilot-induced oscillation (PIO). This is particularly hazardous because the flaperons dump lift during the oscillation. A rapid roll oscillation quickly and dramatically increases sink rate, possibly causing a hard touchdown or scraped stab, speedbrake, nozzle, or all three. Use 11 degrees AOA maximum if conditions for roll control problems are present. If you find yourself in a PIO, balloon, or

bounce, do not hesitate selecting Mil power or AB, if necessary, while maintaining landing attitude. ***Do not increase pitch!***

3.23.3 Short Field Landing. Refer to section II in the F-16 Dash 1 for procedures. Consider flying a 13 degrees approach for better control of touchdown point and more efficient energy dissipation. Use caution, since the high AOA approach coupled with a headwind may result in a short and/or hard landing if power is reduced too early or too rapidly during the flare. Gusty crosswinds or jet wash may also make it exciting. A 13 degree AOA touchdown and aerobraking attitude is required. Commence maximum wheel braking in conjunction with aerobraking. As the brakes become effective, the nose will fall through. Maintain full aft stick, override the speedbrakes, and continue maximum wheel braking (anti-skid on, of course).

3.23.4 Normal Aerodynamic Braking. Aerodynamic braking reduces the landing distance and extends the life of the wheel brakes. Maximum effective two-point aerodynamic braking is achieved at 13 degrees AOA. After touchdown, during a full stop landing, maintain 13 degrees AOA or smoothly raise the nose to 13 degrees AOA. Slowly rotating to 13 degrees AOA prevents the aircraft from becoming airborne. You can use the FPM and AOA bracket in the HUD to initially set 13 degrees AOA. However, do not depend totally on the AOA indication as it freezes at 13.5 degrees after the aircraft settles and the weight-on-wheels (WOW) switches engage. (Exception: The Block 40/50 WOW switch is on the nosewheel, so AOA information is valid throughout the aerobrake.) You can use the AOA indexer and NWS light brackets if seated at design eye. Just hold the horizon at the midpoint of the brackets. Never exceed 15 degrees AOA since the nozzle and speedbrakes may contact the runway. Continue to fly the aircraft even after landing. Back pressure required to maintain 13 degrees AOA increases as you slow. Be aware of AOA overshoot and over-rotation potential at WOW switch engagement. The F-16 is very light on its feet in the two-point attitude, and tends to skip down the runway with even a slight crosswind component unless effective crosswind controls are applied and maintained. Use rudder to control direction and flaperons to counter any wing rise tendency. Approaching 80 KCAS (100 KCAS for the Block 40/50), fly the nosewheel to the runway. Do not continue to hold the nose in the air below these speeds—the nose will suddenly drop to the runway. Do not fully open (override) the speedbrakes until the nosewheel is on the runway. Once the nosewheel is on the runway, open the speedbrakes fully and maintain full aft stick for maximum three-point aerodynamic braking. Test the wheel brakes to check effectiveness. When practical, smoothly apply moderate to heavy braking and decelerate to taxi speed prior to crossing the departure end arresting cable. Using less than moderate braking to gradually slow the aircraft increases the likelihood of hot brakes. Unless directional control is a problem, engage nosewheel steering only after slowed to taxi speed. A good ROT is to utilize the brakes when twice the distance remaining exceeds 100 times your indicated speed (i.e., 80+ knots with 4,000 feet remaining). Manage your brake applications to stay below this limit until taxi speed (25 knots).

CHAPTER 4

AIR-TO-AIR

4.1 Introduction. The purpose of the air-to-air (A/A) chapter is to introduce the basic training spectrum of the F-16 in aerial combat. This training consists of a series of mission elements and mission types used in a building block approach to reach the required level of proficiency. The training will transition from 1v1 maneuvering to operating as a team providing mutual support as elements in a multi-adversary environment. This chapter discusses ground operations, systems checks, FENCE checks, basic fighter maneuvers (BFM), air combat maneuvers (ACM), intercepts, and gun employment. Aerial combat is by far the most difficult aspect of flight to understand and master. The arena is very dynamic, and the skills used must be learned over time. Personal desire and discipline will determine how quickly the individual masters the required skills. To reach the end objective of achieving a first look, first kill capability, pilots must train in an environment that begin with the basics of a close-in engagement.

4.2 Ground Operations, Takeoff/Departure, Weapon Systems Drills/Checks, and FENCE Checks.

4.2.1 Ground Operations.

4.2.1.1 F-16C HOTAS. **Table 4.1**, F-16C HOTAS Setup, depicts the recommended A/A hands-on throttle and stick (HOTAS) setup for the F-16C.

Table 4.1 F-16C HOTAS Setup.

Master Mode	Weapon	Radar Mode
Dogfight	AIM-9 and 20mm (EEGS) Score ON	ACM
A/A Master Mode	AIM-120	TWS
Missile Override	AIM-120	RWS
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4.2.1.2 Pre-Takeoff Preparation. Plan to accomplish the items listed in **Table 4.2**, Pre-Takeoff Preparation, prior to taxi time.

NOTE: See **Table 4.3**, Aircraft Dimensions, for the wingspans of many current fighters.

Table 4.2 Pre-Takeoff Preparation.

1. Load the SMS to match the actual configuration of the aircraft. In a training environment, the aircraft is generally loaded with an AIM-9 missile and an AMD pod. Load any AMD pod as an AIM-120 or AIM-9P. Do not load the AMD pod as an AIM-9M—doing so will result in not hearing a missile tone if you call up the AIM-9 that was loaded at the AMD station. If AIM-120s are not loaded on the aircraft, but AIM-120 symbology is required for training, load a single MRL and AIM-120. If zero quantity AIM-120 is loaded and programmed for MSL OVRD, then each time MSL OVRD is deselected and reentered the weapon will revert to an AIM-9.
2. Set the wingspan of the planned adversary for training flights or the expected adversary for combat flights. Use 33 feet when flying against other F-16s. Wingspans for many fighters are depicted in **Table 4.3**, Aircraft Dimensions. For combat missions where a variety of enemy fighters might be encountered, 38 to 40 feet is a good compromise wingspan setting.
3. Move the MASTER ARM switch from OFF to SIMULATE.
4. Select DGFT mode and ensure the SPOT, BP, and SLAV options are selected.
5. Cycle through each master mode and confirm all MFD and HUD displays are correct. Confirm the SMS status displays for all actual missiles (whether live or inert) are free from degraded or failed indications. If the AVIONICS caution light illuminates, check for MFLS and SMS error messages.
6. Built-in test (BIT) any actual AIM-120s. Accomplish the AIM-120 BIT only after the radar BIT is complete and the INS is in NAV. Doing the AIM-120 prior to these steps will result in failure of the AIM-120 BIT.
7. For local training missions, command COOL on the AIM-9s prior to taxi in case maintenance is required. Note the tone change on the selected AIM-9. Uncage the selected AIM-9 and verify that it settles on and tracks some heat source. There will generally be something within the HUD field of view (FOV) that the missile will track within a few seconds as it wanders around uncaged. Recage the selected missile, then step through any additional AIM-9s and note that all have cooled and will track. The crew chief must have removed the protective cover from the missile seeker to track a heat source. **NOTE:** All of the above is done in the chocks prior to taxi. In a combat situation, all live missiles are still mechanically safed by the ground crews. This is the time to fix any problems you detect. An AIM-9 that will not cool probably has a bad argon bottle or a bad bottle connection. Either of these can be fixed in the chocks or at last chance. Inform lead, then call the maintenance operations center (MOC) with your tail number and problem. They can have a missile crew work on the problem.
8. Turn on the radar at least 3 minutes prior to takeoff. In all but the hottest weather, turn on the radar in the chocks prior to taxi. It is a good technique to verify the radar BIT passes as early as possible in your ground operations. This gives you maximum time to take a spare aircraft if the radar fails BIT. Make sure the DEFOG lever is in the 3/4-forward position to optimize avionics cooling. Ensure the CNTL page is set up IAW the standard settings unless briefed otherwise by the IP/flight lead.
9. Perform DTOS/camera checks IAW wing standards.
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Table 4.3 Aircraft Dimensions.

Aircraft	Wingspan (feet)	Length (feet)
F-4	38	63
F-5	27	48
F-14	64/38	62
F-15	43	63
F-16	33	49
F-18	38	56
A-10	57	54
MIRAGE F-1	28	53
MIRAGE III	27	49
MIRAGE 2000	30	48
MiG-21	23	51
MiG-23	46/25	52
MiG-25	45	66
MiG-29	38	54
Su-27	48	72

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4.2.2 Takeoff and Departure. After completing your ground checks in preparation for takeoff, return the avionics to the NAV mode prior to takeoff so you avoid the habit pattern of having friendly aircraft in your HUD FOV with missiles selected. If a radar-assisted trail (RAT) departure is briefed, practice taking a radar lock via range-while search (RWS) and flying the departure in the NAV mode. Generally, if a formation takeoff is flown, the IP/flight lead will keep you in close or route formation during the first portion of the climbout, then give a visual signal for you to drop back for any drills or weapon systems checks at level off. On an interval takeoff, you may be directed to rejoin immediately, and then be cleared back for your drills/checks later, or you may be briefed to accomplish the drills/checks first, prior to rejoining to the briefed formation. On a RAT departure, pay primary attention to flying the specified trail departure procedures thereby maintaining spacing during climbout. Once you have called visual and are cleared to rejoin, most IPs/flight leads will have you accomplish your drills/checks while rejoining from trail to the pre-briefed formation.

WARNING: On training sorties, regardless of whether doing an A/A Switchology Drill or an A/A combat weapons system check, ensure you first perform a cold trigger check IAW established training rules.

4.2.3 Weapon Systems Drills and Checks. Avionics and weapon systems checks are an important part of basic A/A execution. Verification of the required systems to effectively employ in the air can mean the difference between a quick kill and a long drawn out

engagement, effectively allowing the bandit's wingman to enter the fight and employ ordnance. The A/A Switchology Drill is an exercise designed for use in a training environment to practice using the ACM radar modes, review the weapons system symbology, and practice employing ordnance. The combat air-to-air weapon systems check is designed for use when carrying live A/A weapons or when simulating the carriage of live A/A weapons.

4.2.3.1 Air-to-Air Switchology Drill.

4.2.3.1.1 Objective. The objective of the A/A Switchology Drill is to reduce the time required for proficiency in within visual range (WVR) weapons employment. The A/A switchology drill allows you to practice ACM radar operation and A/A weapons employment while en route to or from working airspace. The A/A Switchology Drill also verifies the proper function of all your avionics and inert weapons in preparation for a training mission. Once you achieve a good level of weapons employment proficiency, you should still perform occasional A/A switchology drills to stay in practice, particularly in the A/G training phases, when there will be fewer opportunities for practicing A/A employment. During the A/A Switchology Drill you will simulate all types of A/A weapons attacks on other aircraft in your flight. Thus, it must be remembered that this drill is for training use only.

4.2.3.1.2 Execution. Maneuver into the desired envelope or IAW the flight briefing. (See **Figure 4.1**, Air-to-Air Switchology Drill Execution Geometry.) This is most efficiently accomplished geometrically (turning) instead of reducing power significantly, especially if accomplishing the drill during climbout on departure. Maintain this envelope using S-turns maneuvering back and forth across lead's 5 to 7 o'clock position while practicing switchology and weapons employment. Maintain a slight airspeed advantage over your leader, avoiding getting trapped in a tail chase. Continuously monitor range and closure, both visually (during no-lock attacks) and via your radar and HUD displays when locked on.

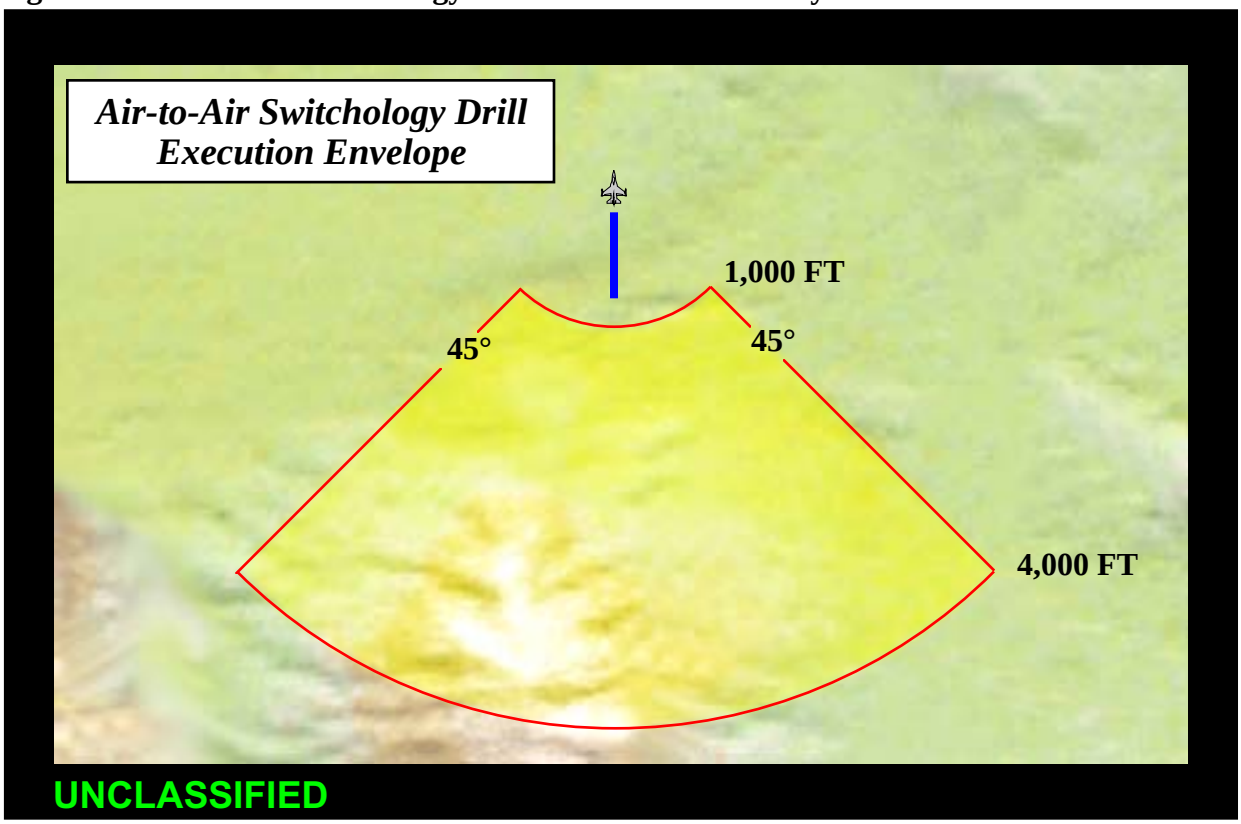
4.2.3.1.2.1 The actual execution of your switchology drill is largely a matter of technique, and not driven by a specific procedure with one exception. When flying with a cold gun, you must perform a trigger check in SIMULATE, with the gun pointed in a safe direction, to confirm it does not fire. This trigger check is performed prior to making any simulated gun attacks.

4.2.3.1.2.2 First, over unpopulated areas, select dogfight and perform a cold gun trigger check and observe no-lock gun symbology. Next, in a no-lock mode, achieve an infrared (IR) self-track and listen to the tone, observing the missile gimbal limit. Call up boresight ACM and lock onto the target and observe an in-range DLZ.

- Uncage, confirm tone (verify good self-track tone), and shoot.
- Maintain lock, uncage and float nose off target to observe missile gimbal limits.
- Break lock. Maneuver to parallel leads direction.
- Command slewable ACM with dogfight selected and with nose off target at least 35 degrees slew ACM slewable in direction of lead.

- When lock-on is achieved, gradually reduce your nose-off angle to the target.
- Note tone increase; this reflects the missile slave limit.
- Continue to pull target to the nose (in HUD), exercise the MSL BORE function via the z-axis of the cursor on the throttle.
- Uncage and verify tone, and shoot.

Figure 4.1 Air-to-Air Switchology Drill Execution Geometry.



4.2.3.1.2.3 Repeat the process of lock-on, verification of missile self-track visually and aurally, and shooting with remaining ACM modes (10 degrees x 60 degrees or 30 degrees x 20 degrees). Select AIM-120 (if applicable) and observe the symbology while taking practice shots as described for the AIM-9. Maneuver side-to-side with the target within radar gimbal limits and observe EEGS programming. Next, try a number of no-lock shots. Practice no-lock shots in dogfight ACM (NO RAD). Once complete, break any lock and resume the briefed formation position.

4.2.3.1.2.4 Do not confuse this drill with the A/A combat weapons system check. This is a training drill accomplished separately in the context of weapons engagement zone (WEZ) recognition/missile employment and radar ACM mode/switch practice. Combat weapons system checks are accomplished without ever uncaging missiles or depressing the weapons release button/trigger. Pilots have actually shot wingmen during weapons system checks while carrying live missiles due to poor habit patterns suitable only for peacetime/inert ordnance carriage.

4.2.3.1.2.5 A common student error is falling too far back in range during the switchology drill. 4,000 feet may seem to be a fairly restrictive range, but remember that this drill is sometimes executed in a four-ship formation. Since Number Three and Number Four need to remain no more than 1 NM behind lead to maintain standard formation, it is obvious that you need to remain close to lead to avoid posing a conflict to Number Three. Another common error is to use speedbrakes to attain separation and then leaving them extended too long. Any time you fall out of position, you are wasting time and fuel. Remain level with lead, especially when flying under positive air traffic control (ATC). If lead requests an altitude block (e.g., FL 190 to FL 220) for the switchology drill and you are within the block, use altitude as required but stay within the block at all times.

4.2.3.1.3 Other Radar Modes. Select RWS mode by selecting MSL OVRD. Verify the master arm switch is in SIMULATE, then lock on RWS contact. Manual lock-on capability is an important radar function you check at departure or en route. Be alert for pop-up traffic and exercise manual lock-on capability on several targets. Practice entering and exiting single target track (STT) as well as changing the SAM target. Check the search altitude display (SAD) by moving the cursors over a search target. Select AAM to transition to track-while-scan (TWS) and ensure the SAM target becomes the bugged target in TWS. Verify TWS capabilities (auto and manual), mode transitions from TWS (single- or multiple-target track) to RWS and ensure the bugged target becomes the SAM target. Observe the symbology change in the MFD and HUD as you change targets.

4.2.3.1.4 Ranging. Throughout the switchology drill, estimate range from various aspects and verify estimates with the lock-on data provided. Take a good look at the heart of the missile envelope, the minimum missile range, the heart of the gun envelope, and “the bubble” as a minimum. Use the target locator line to verify your canopy codes. (See **Figure 3.6**, F-16 Canopy Codes.)

4.2.3.1.5 Radar Warning Receiver (RWR). Turn on and test the RWR before takeoff. At some point your lead (or another flight member) will do the switchology drill on you. This is an excellent time to accomplish several things. Check the volume and azimuth of the RWR when another aircraft locks on. Your lead may also brief a defensive ranging exercise to increase your ability to estimate range from different azimuths and ranges.

4.2.3.1.6 A/A Switchology Drill Summary. This drill does not necessarily have to be performed in the order described above. The important point is that you know the full search, lock-on, and track capability of your radar prior to entering the engagement. Use any available time en route to explore radar capabilities and practice switchology.

4.2.3.2 Combat A/A Weapons System Check.

4.2.3.2.1 Objective. The combat weapons check establishes a procedure to verify the correct function of A/A radar modes and live A/A weapons without placing ground personnel or friendly aircraft in any danger. That last underlined clause is a pretty broad definition. Obviously, as long as all systems function properly, you could do anything, including pickle button depressions, as long as you have the master arm switch

in SIMULATE. In designing the combat weapons check, safety must be assured even if switch errors or system malfunctions cause an inadvertent or unintentional weapon release. Form good habits early in performing the combat weapons check.

NOTE: When performing a combat weapons check **do not** depress the pickle button or squeeze gun trigger.

4.2.3.2.2 Execution. Use the following procedures to perform a combat A/A weapons system check:

4.2.3.2.2.1 Ground Checks. Follow the same steps described in **paragraph 4.2**, Ground Operations, Takeoff/Departure, Weapon System Drills/Checks, and FENCE Checks.

4.2.3.2.2.2 Airborne Checks. The recommended sequence of steps for the A/A combat weapons system check is listed in **Table 4.4**, Air-to-Air Combat Weapons System Check. For more information, also see **Figure 4.2**, Combat Air-to-Air Weapons System Check.

WARNING: On training sorties, regardless of whether doing an A/A Switchology Drill or a A/A combat weapons system check, ensure you first perform a cold-trigger check IAW training rules.

Table 4.4 Air-to-Air Combat Weapons System Check.

1. Master arm switch—SIMULATE.
2. If mission duration does not allow cooling AIM-9s on the ground cool airborne, and monitor tone changes, but do not point or uncage on any friendly inside R_{max}.
3. When cleared for weapons check, maneuver to place the "target" aircraft outside AIM-9 gimbal limit. Remain within 4,000 feet slant range during the entire procedure. (See **Figure 4.2**, Combat Air-to-Air Weapons System Check.) With the target outside gimbal limit, select slewable ACM and lock the target. Note that the selected missile slaves along radar line of sight (LOS) and that EEGS correctly programs.
4. Step through all AIM-9s and confirm they all slave toward radar LOS (maintain LOS at greater than gimbal limit). Confirm each missile responds to HOTAS BORE command. Also, if AIM-9s are assigned to A/A MSL and/or MSL OVRD, confirm correct HUD displays are presented (aspect, range, and closure).
5. Maneuver to put radar ATA greater than AIM-120 gimbal limit. (See **Figure 4.2**, Combat Air-to-Air Weapons System Check.) Select A/A master mode or missile override (as applicable) to call up AIM-120. Confirm AIM-120 DLZ correctly programs (ASC offsets correctly and caret shows less than R_{min}). Confirm no displayed missile failures or degradations. Re-BIT if required.
6. Break lock and confirm ACM bore, 10 degrees X 60 degrees and 20 degrees X 20/30 degrees select normally. There is no need to lock. If slewable ACM locks, all will lock.
7. De-select ACM and return to briefed formation.
8. Master arm switch—As required.
OVERALL NOTES: 1. If cleared to perform weapons check during rejoin from takeoff, the AIM-9 may be checked at any range as long as radar LOS is greater than gimbal limits. Delay checking AIM-120s until inside R_{min}. If any missile/avionics malfunctions are discovered or suspected on training flights with inert missiles, it is acceptable to drop back into actual missile WEZ to troubleshoot and correct problems. 2. Do not uncage AIM-9 missiles or perform "practice pickles." When complete, resume original formation. 3. Not much maneuvering is required to execute this procedure. When cleared for your check, maneuver out to the starting position, then call up DGFT and begin your checks. Note that the position required is basically fighting wing. The only required maneuvering is to spread from AIM-9 gimbal limit to AIM-120 gimbal limit.
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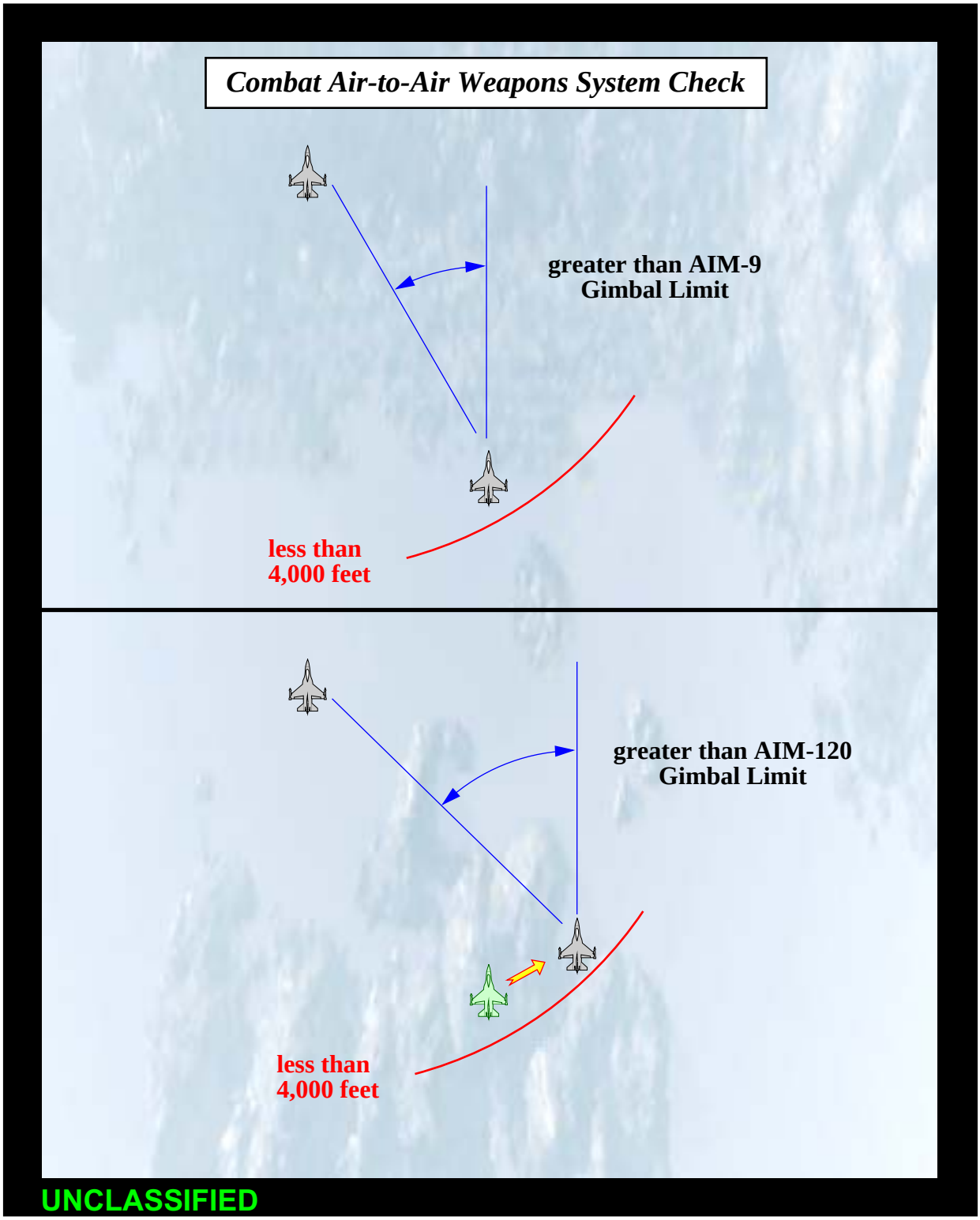
Figure 4.2 Combat Air-to-Air Weapons System Check.



4.2.4 FENCE Check.

4.2.4.1 Purpose. The purpose of the FENCE check is to enhance survival and ensure that essential mission tasks are accomplished prior to actual combat. Many of the tasks are accomplished on the ground. To develop a good habit pattern, touch all switches and controls—even those not essential on training sorties. In actual combat, most of the items in the FENCE check are done prior to takeoff and a few at forward edge of the battle area (FEBA) crossing. For peacetime training this will vary (based on training area restrictions); portions of the check will be accomplished in or approaching the area, or not at all. A good FENCE check prevents dry passes on the range and missiles that do not launch because switches are not properly set. (See **Table 4.5**, FENCE Checks.)

Table 4.5 FENCE Checks.

FENCE		CLEMSHIRT G	
F	Firepower, fuel (balanced and inert)	C	Chaff/flare, comm, and camera
E	Emitters	L	Lights
	T—TACAN Set to A/A or off, TAD	E	ECM
	R—Radar, RALT and Radios	M	Master arm and missile
	A—ALR and ALQ	S	SMS
	I—IFF	H	HUD, HSI, and HSD
	L—Lights	I	INS and IFF
N	Navigation	R	Radar and RWR
C	Chaff/flare Armed, and camera on	T	TACAN, tank inert, and TAD
E	Employment of ECM		
	Employ: Master arm	G	G-suit

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4.2.4.2 Execution. The checks are accomplished at a predetermined point, IAW the flight briefing, prior to entering the combat arena. There is no specific length of time for completing the FENCE check. Take time to ensure that your aircraft is set up as required/desired. A/A and A/G missions require different checks or a combination of checks. Whatever you accomplish, the important point is to develop a consistent habit pattern.

4.2.4.2.1 Ground Checks. While still on the ground, ensure that all items are properly set and verified. Many of these items are “set and forget” actions that you should not have to deal with again unless you have to revert to backup modes. See **Table 4.6**, Ground FENCE Check Considerations, listing many of the items that you should check.

Table 4.6 Ground FENCE Check Considerations.

Radios	• Set the audio panels for both UHF and VHF radios • Adjust the radio volumes as required • Set the secure voice and/or HAVE QUICK as required
ECM	• Confirm ECM pod settings and status (malfunctions)
TACAN	• Check operation and self-test • Set the TACAN for departure route (if applicable)
INS	• Verify steerpoints (latitude/longitude, elevation, and swing check)
IFF	• Verify/set modes and codes are properly set for departure
UCF/ FCNP	• Verify/set cruise modes and other data (Bingo, wingspan, camera coefficients, bullseye, and system time) • Mode select desired cruise mode • Verify/set ALOW and Line-in-the-sky values • Verify data link information is correctly set (if applicable)
Radar	• Verify/set modes, azimuth, bars, target history, channel, subset, and notch • Adjust symbology, brightness, and contrast • Set electronic protection (EP) level capability
RWR	• Check operation and settings • Turn audio volume up • Accomplish a system self-test
Throttle	• Check it and confirm that you have got hands on radar control with the DGFT/MSL OVRD switch • Reconfirm your hand position in relation to the countermeasures (slap) switch
CAT I/III	• Ensure the switch is set for your current configuration
SMS	• Recheck programming of A/A modes (DGFT, AA MSL, and MSL OVRD) • Selective jettison. Set up required selective jettison sequence actions for fuel tanks so immediate jettison is available if you need it
AIM-9	• Set volume as desired • Cool any AIM-9 missiles and in SLAV and in BP • Verify that you have a god missile tone
AIM-120	• Accomplish a BIT check
AVTR	• Check OFF while on the ground unless performing tape title or DTOS check • Check ON as briefed
HUD	• Set the HUD control panel as required (drift cutout and declutter features) • Set the HUD symbology brightness • Set the manual milliradians (mils) for AIM-9 missile boresight
Fuel	• Verify tanks are feeding and check fuel, state, balance, and NORM feed • Verify the refueling door is closed • The tank inert is used for actual combat situations or as directed in the checklist due to an in-flight emergency
RALT	• ON, unless briefed otherwise
Chaff/ Flares	• Verify/set settings • Arm the system (if applicable). In training, you will wait until in the appropriate airspace to arm the chaff/flare. In combat, you may arm them after the arming crew is done with your aircraft, but prior to takeoff depending on the local procedures and the threat
Master arm	• MASTER ARM, OFF or SIMULATE, as required
Lights	• Set as briefed
Loose Items	• Stowed
G-Suit	• Checked
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4.2.4.2.2 Airborne Checks. Accomplish an airborne FENCE check prior to entering the training area or combat arena. Most pilots use an acronym or pre-printed list on the lineup card to remind themselves of the items that need attention. The original acronym "FENCE" comes from the words Firepower, Emitters, Navigation, Chaff/Flare, and Employment of electronic countermeasures. However, over the years the FENCE check has evolved to include other items. Another common acronym used to accomplish all necessary checks is "CLEMSHIRT G." Both of these techniques are depicted in **Table 4.5**, FENCE Checks. Some considerations for the airborne FENCE check are listed in **Table 4.7**, Airborne FENCE Check Considerations.

4.2.4.2.3 Air-to-Ground FENCE Check Items. The items discussed above include the FENCE check items for an A/A sortie. You should consider every sortie you fly as an A/A sortie and therefore check these items. Additionally, on missions with an air-to-ground (A/G) role you should also check items such as navigation and targeting pods; Maverick missiles; HARM; and any SMS settings for your A/G weapons.

4.2.4.2.4 FENCE Out. Upon completion of the mission you will need to safe up the aircraft at some point during the return to base. Basically, you will run the FENCE check again to set all switches properly. Generally, that will mean safing the master arm and chaff/flare systems. Also, you need to reset the navigation aids such as the TACAN and INS for the recovery procedure. Do not forget to set the proper IFF modes and codes.

4.2.4.3 Summary. A FENCE check is a critical cockpit activity. The flight briefing will probably establish the point at which you will perform the FENCE check. You will probably develop your own priorities for the items to include in the check. The only constraint is in selecting master arm and arming chaff/flares in a training environment—make sure that you are in an established training area prior to arming these items. The sequence and content of this check varies according to mission type, threat encountered, and personal preferences. As you strive for "realism in training," develop a FENCE check sequence that is your own. This ensures everything gets done and you are confident entering the combat arena. You will not always get a radio call to "FENCE IN." ***Just do it!***

4.3 Basic Fighter Maneuvers. This section begins with a discussion of the concepts that you must understand when flying BFM, then exploring the mechanics of how to fly offensive, defensive, and high-aspect BFM. Next, you will learn about some common in-flight exercises used to prepare yourself for BFM maneuvering. Lastly, the common methods to set up BFM engagements will be introduced.

4.3.1 Basic Fighter Maneuvers Concepts.

4.3.1.1 Objectives. The primary objectives of BFM are twofold: (1) Develop confidence to maneuver the aircraft to a desired position in space, both for the dynamic A/A and A/G environment; and (2) Develop the skills to kill and survive in the aerial combat arena. Specifically, you want to:

- Maneuver the aircraft into weapons parameters to employ ordnance.
- Maneuver to deny and defeat enemy ordnance.

Table 4.7 Airborne FENCE Check Considerations.

Chaff/Flare	• Arm chaff and flare systems • Verify that proper programs are set
Comm	• Set all comm volumes. The most important radio should be the loudest • Be prepared to turn the squelch off if you receive weak or partial transmissions
Camera	• Check the camera on unless briefed otherwise
Lights	• Set as briefed
ECM	• Ensure ECM pod is ready with no faults • Turn it on at the briefed time/location
Master Arm	• Select MASTER ARM, SIMULATE, or OFF as briefed
SMS	• Verify that the SMS has the proper load • Verify that all A/A and A/G modes are set up properly
HUD	• While checking the SMS for proper modes, ensure the HUD displays the proper symbology
HSI	• Set the CDI and captains bars in the HSI to the desired course and heading
HSD/TAD	• Verify/set desired displays
INS	• Verify/set correct steerpoint and/or bullseye
IFF	• Verify/set proper modes and codes
Radar	• Verify proper modes are called up in the various weapons modes • Verify/set the proper A/A search volume/elevation
RWR	• Verify that no faults are displayed • Perform a self-test if there is time before entering the combat arena • Turn up the volume to a loud setting
TACAN	• OFF or set proper A/A TACAN if briefed
Tank Inert	• Set as briefed
G-Suit	• Check connections and test prior to the G warm-up maneuver
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4.3.1.2 The required maneuvers are not scripted to arrive at the endgame solution, but are combined as necessary based upon continual reassessment of the situation. The entire process of observing, predicting and maneuvering is repeated until either a kill or disengagement has been achieved. These fundamental skills are necessary to perform all missions in the F-16.

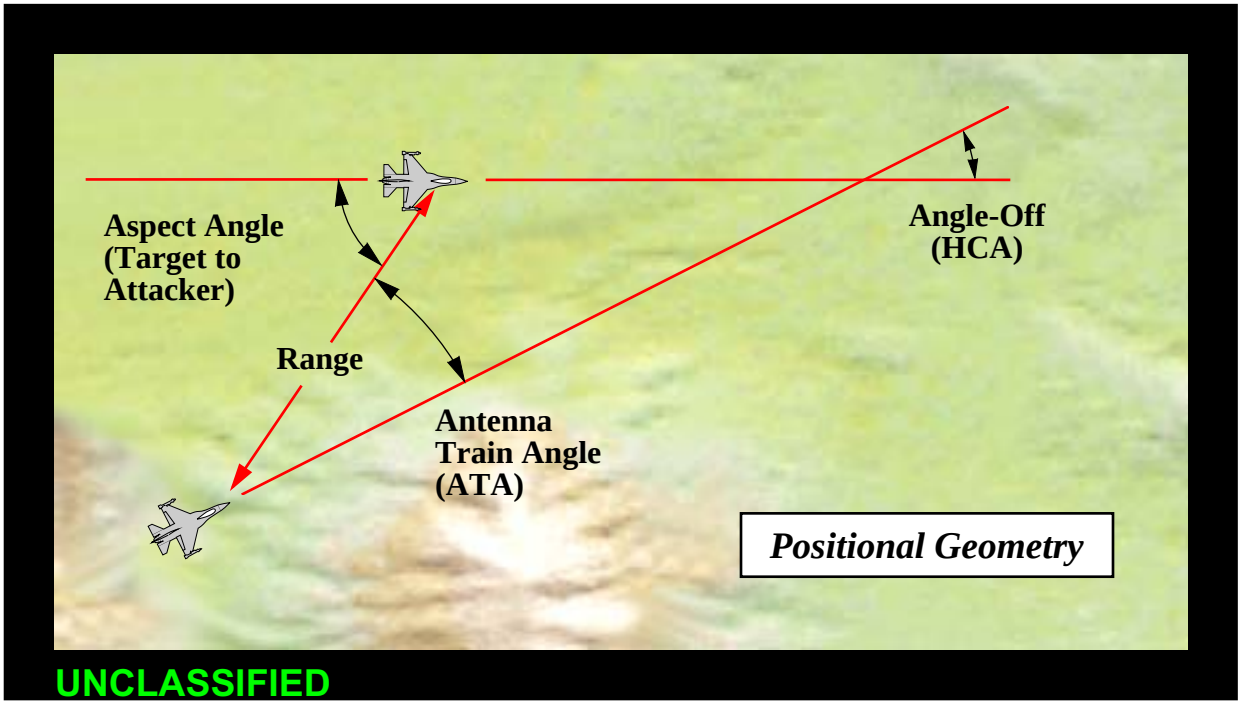
4.3.1.3 Prescribed training setups facilitate a building-block approach to teach these necessary skills. Training setups are designed to present a solvable problem to teach the appro-

priate cues necessary to develop the mental picture and stick and rudder coordination required in BFM. As the pilot learns the basics of BFM from a controlled setup, he should progress to varied setups and expand his knowledge to the tactical implications of BFM. Every pilot should try to expand his skills on each and every sortie. The endgame result of BFM training should prepare the pilot for nearly every adversary maneuver or tactic.

4.3.1.4 Successful BFM'ers must understand the dynamics of aerial combat. These dynamics include: geometric relationship to the target, weapons employment zones (Wezs), turn and energy performance and a basic understanding of flight physics. The geometric relationship of two aircraft can be analyzed from three perspectives: positional geometry, pursuit course and the weapon envelope.

4.3.2 Positional Geometry. One aircraft's position relative to another in range, aspect angle, heading crossing angle (HCA) and antenna train angle (ATA) are used to describe current conditions. (See **Figure 4.3**, Positional Geometry) These four factors dictate which aircraft enjoys a positional advantage, and to what extent.

Figure 4.3 Positional Geometry.



4.3.3 Terms & Concepts.

4.3.3.1 Range. The distance between two aircraft. Ranging exercises and experience with various airframes (dissimilar training) build the needed skills to estimate range.

4.3.3.2 Aspect angle. The relative position of the attacker to the target without regard to the attacker's heading. It is defined as the angle measured from the tail of the target to the position of the attacker.

4.3.3.3 HCA. HCA is primarily concerned with the relative headings of two aircraft. It is defined as the angular distance between the longitudinal axes of the attacker and the

defender. Whenever the attacker is pointing at the defender, the AA and angle off will be the same.

4.3.3.4 Antenna train angle. The number of degrees the defender is off the boresight of the attacker. With a radar lock ATA is displayed on the target locator line in the offender's HUD.

4.3.3.5 Pursuit Curve. There are three available attack pursuit courses: lead, lag and pure. The attacker's nose position or his lift vector will determine the pursuit course being flown. If the attacker is in the defender's plane of-motion (POM), the position of the attacker's nose determines the pursuit course. With his nose pointed in front of the defender (such as in the case of a gunshot), he is in lead pursuit. If he points behind the defender, he is in lag pursuit. If he points at his adversary, he is in pure pursuit. Note that an initial lead-pursuit attacker could be driven into a lag-pursuit course if he has insufficient turn rate available to maintain lead. Outside the defender's POM, the attacker's lift vector and amount of gravity (g) pulled determines the pursuit course. (See **Figure 4.4**, Pursuit Course, and **Figure 4.5**, Insufficient Turn Rate).

Figure 4.4 Pursuit Course.

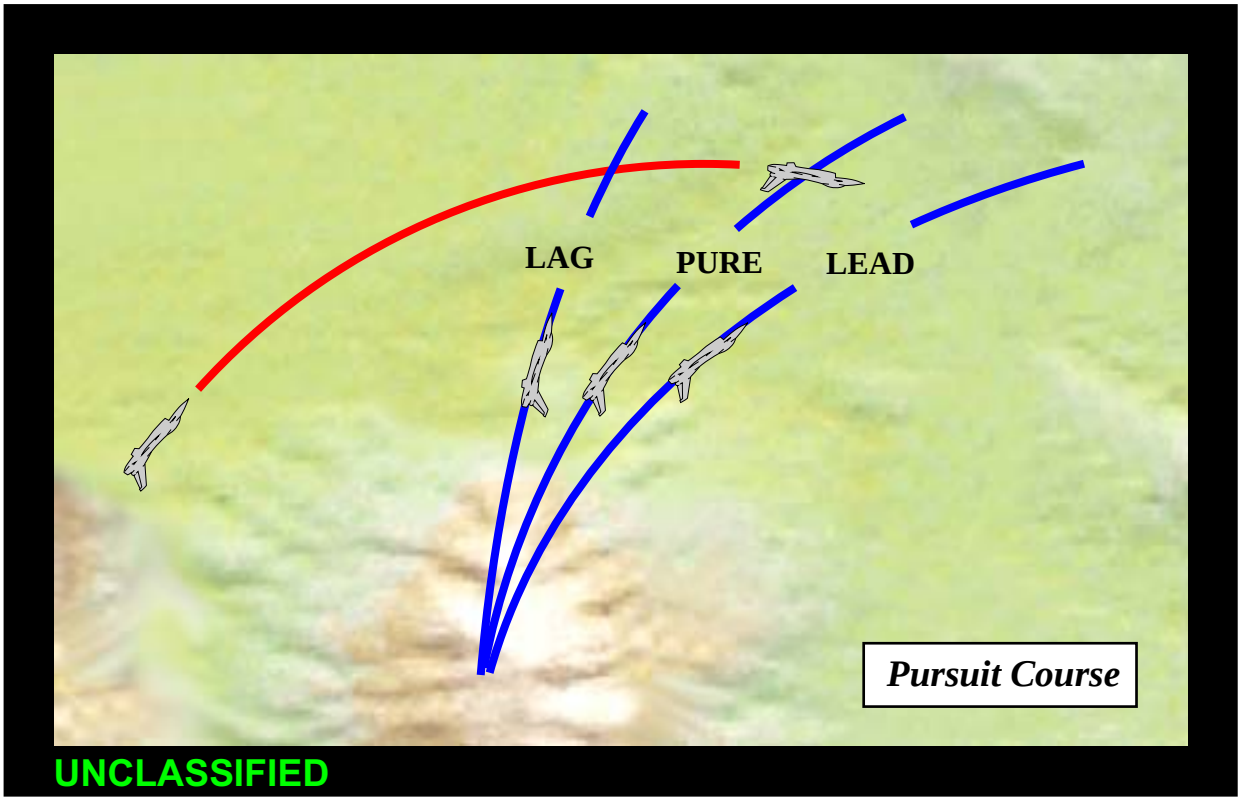
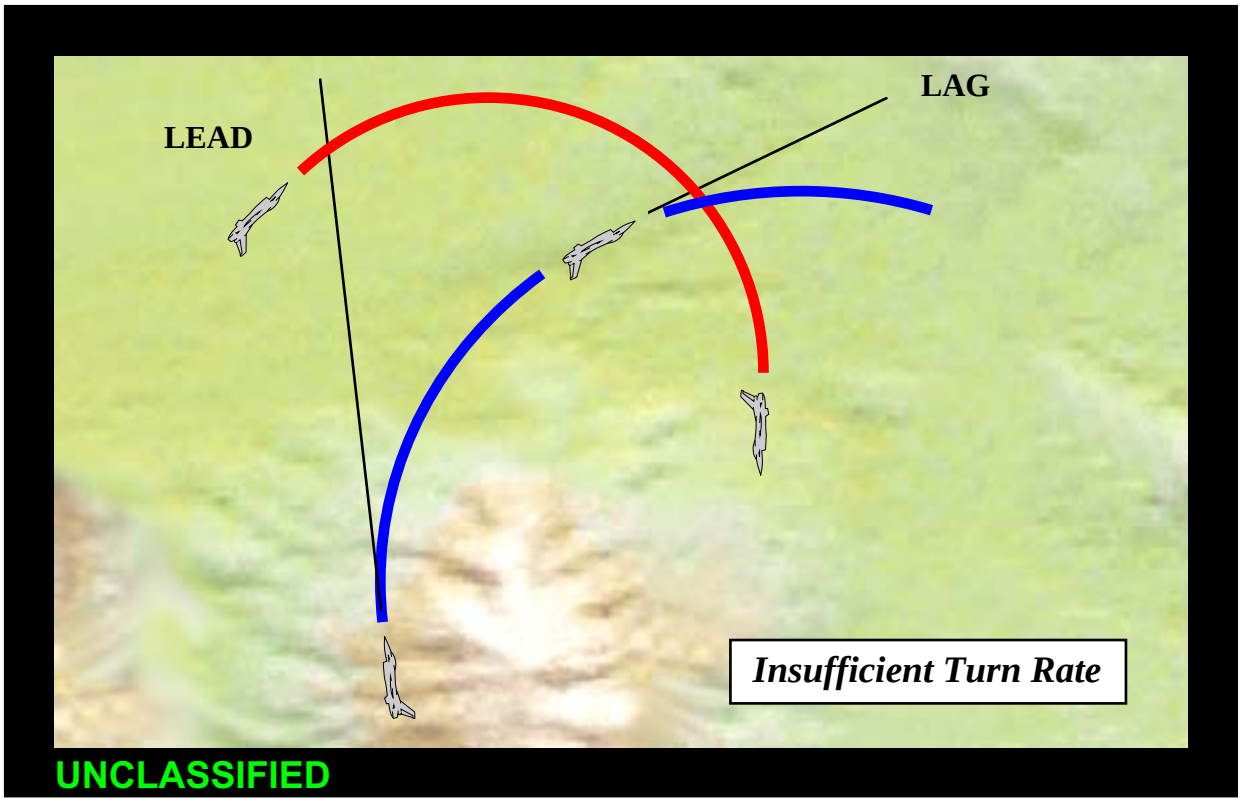
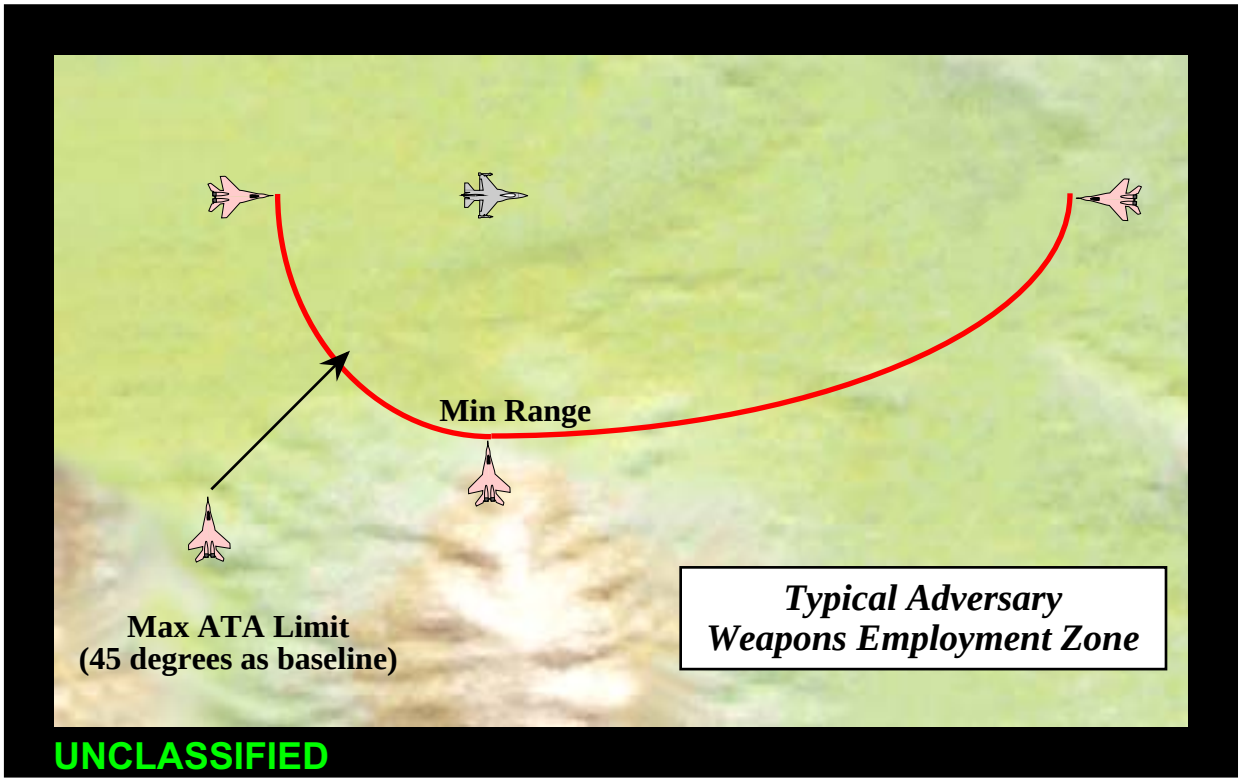


Figure 4.5 Insufficient Turn Rate.



4.3.3.6 Weapons Employment Zone. The WEZ of different ordnance is defined using range, aspect, ATA and closure. BFM may be necessary to achieve a WEZ as the offender or to deny a WEZ as the defender. For realistic training, you must know the WEZ of each weapon you employ as well as the enemy. To keep this unclassified, a generic fourth generation adversary with generic all-aspect heater and radar missiles and a generic off-boresight capability will be used. (See **Figure 4.6**, Typical Adversary Weapons Employment Zone).

Figure 4.6 Typical Adversary Weapons Employment Zone.



4.3.3.7 Turn. Turn radius determines the size of the turn circle. This radius is based on the aircraft's true airspeed (TAS) and radial g. The size of the circle and the relative turn-rate capability of the two aircraft will determine how well the pilot can solve the angular problems the defender presents. The objective is to maneuver to where available g will allow the attacker to point his nose at the defender and achieve a missile or gunshot with an acceptable specific power (Ps) bleed-off. How well an aircraft can turn is a function of the turn rate and radius it generates. Radius defines the size of an aircraft's turn or its turning circle. In the F-16, turn radius at maximum angle-of-attack (AOA)/G is relatively constant over an airspeed range of 170 knots calibrated airspeed (KCAS) up to 330 KCAS. Above 330 KCAS turn radius increases slightly as maximum g is obtained (440 KCAS). Above 440 KCAS turn radius increases dramatically. Because of the F-16 flight-control system, the F-16 does not have a true corner velocity. It has a corner plateau, which occurs between 330 to 440 KCAS and produces a good turn rate based on available G. It is interesting to note that turn rate and radius are simple functions of airspeed and g regardless of airframe or engine. The difference lies in the different aircraft and motors that allow an aircraft to pull g and the thrust to sustain g levels. A breakdown of rate and radius is shown in **Table 4.8**, Rate and Radius Formula.

4.3.3.8 Instantaneous rate. The highest rate an aircraft can generate. Usually implies a negative Ps.

4.3.3.9 Sustained rate. The rate an aircraft can generate while maintaining airspeed and altitude (Zero Ps).

4.3.3.10 Bleed rate. Amount of energy lost (unfortunately Ps diagrams do not equate –Ps with airspeed lost (KCAS), but instead all charts are in a nebulous feet per second [ft/s]) when aircraft achieves a specific G-level. (See **Table 4.9**, Bleed Rate and **Figure 4.7**, Turn and Energy Performance.) Remember, the Ps charts are for a level turn in AB/MIL at one specific altitude. The Ps charts are tools that show aircraft performance advantages and disadvantages but quickly lose some relevance when power changes, altitude and effects of radial G come into play. Radial G affects the turn performance of every aircraft. Pulling up, away from the earth causes a greater loss of airspeed and less net G, which increases the turn radius. Pulling toward the earth preserves some airspeed and more net G is produced.

Table 4.8 Rate and Radius Formula.

Turn Radius	Turn Rate
(feet) = V2, (G x G_{radial}) V = KTAS x 1.69 G = 32.2 feet per second G_{radial} = Cockpit G level	(degrees per second) = (G_{radial} x 1092), KTAS
OVERALL NOTE: * Turn rate and radius are simple functions of airspeed and G, regardless of airframe or engine. Differences lie in the ability of an aircraft to pull G and sustain energy levels. Energy definitions: Instantaneous rate: The highest rate an aircraft can generate at the current airspeed. This usually implies a negative P_s. P_s: Rate of energy loss or gain during a particular maneuver. Sustained rate: The rate generated while maintaining current airspeed and altitude. Bleed rate: Similar to P_s. The amount of energy lost at a particular G-level.	
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Figure 4.7 Turn and Energy Performance.

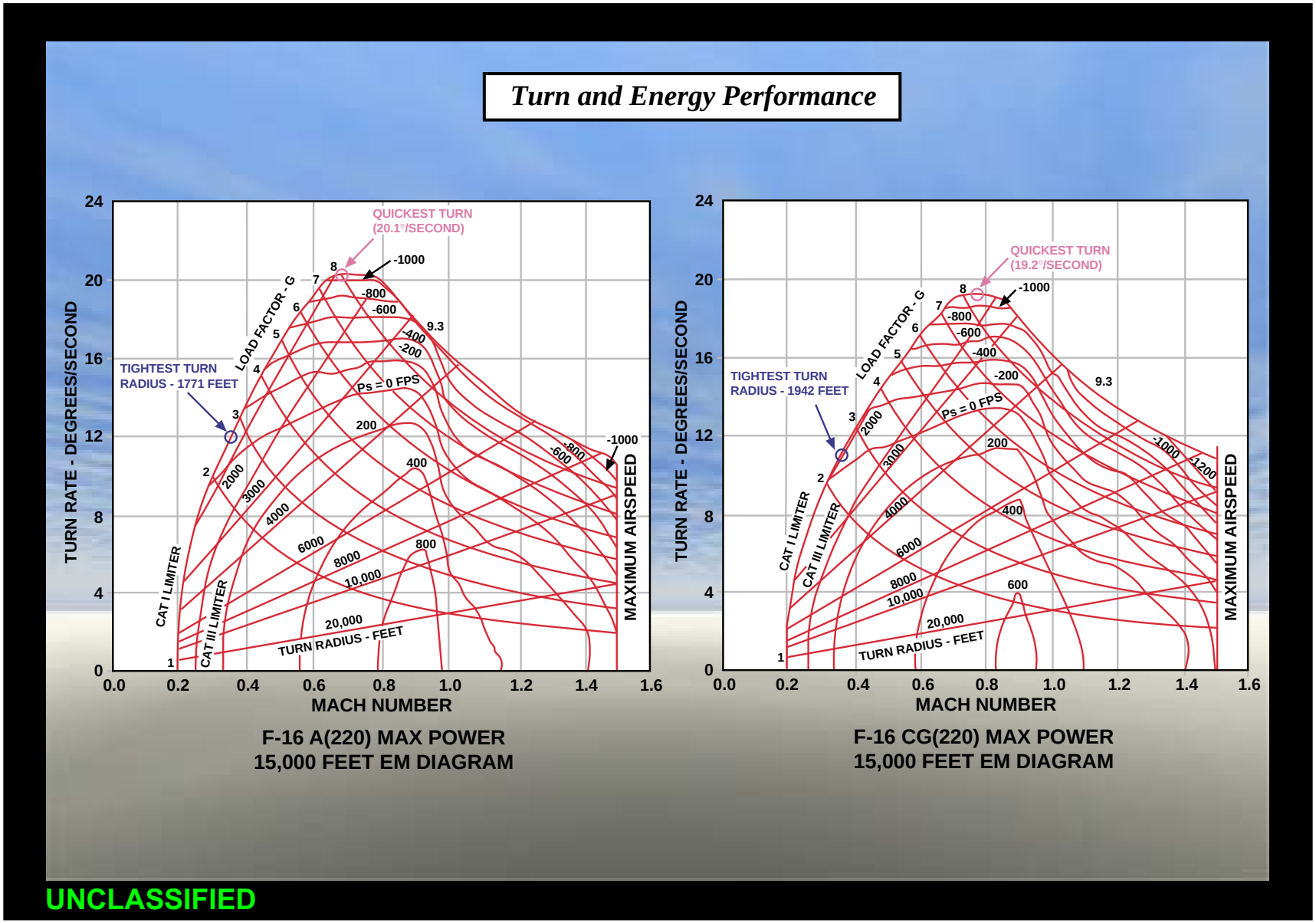

Table 4.9 Bleed Rate.

Turn Rate/Radius/Ps

F-16 CG Blk 42 15,000 FT MSL MAX AB Drag=0 GW=22,000 Turn Rate/Turn Radius/Energy Bleed Rate in KCAS/Sec

KCAS/M/ TAS/ FT/sec	2G	3G	4G	5G	6G	7G	8G	9G
500/ .96/ 600/ 1014		5/12k/+12	7/8.5k/+11	9/6.6k/+5	10.5/5.5k/2	12.5/4.7k/-5	14.5/4k/-13	17/3.5k/-29
475/ .92/ 580/ 980		5.5/10k/+13	7.5/7.5k/+11	9.5/6k/+7	11/5k/+3	13/4.5k/-3	15/3.6k/-10	17.5/3.3k/-26
450/ .87/ 550/ 925		5.5/9.5k/+14	8/7k/+13	10/5.5k/+8	12/4.5k/+5	14/3.8k/-2	16/3.3k/-12	18.5/2.8k/-20
425/ .83/ 525/ 887		6/8.5k/+15	8/6.4k/+12	10.5/5k/+9	12.5/4k/+3	14.5/3.5k/-5	16.5/3.1k/-5	19/2.7k/-33
400/ .78/ 495/ 832		6.5/7.5k/+13	9/5.5k/+11	11/4.2k/+7	13.5/3.5k/0	15.5/3k/-13	17.5/2.6k/-22	19/2.5k/-44
375/ .73/ 460/ 777		7/7k/+16	9/5k/+10	11.5/3.8k/+5	14/3.3k/-3	16.5/2.8k/-17	19/2.4k/-34	
350/ .69/ 435/ 735		7/6k/+12	10/4.3k/+9	12.5/3.4k/+2	15/2.8k/-9	17.5/2.5k/-27		
325/ .64/ 435/ 735		7.5/5k/+11	10.5/3.8k/+7	13/3k/-2	16/2.5k/-17	18/2.2k/-30	(6.5g max)	
300/ .59/ 370/ 625		8.5/4.5k/+12	11.5/3.2k/+4	14.5/2.6k/-8	17/2.1k/-30			
275/ .54/ 340/ 575	5/6k/+14	9/3.8k/+9	12.5/2.7k/0	15.5/2.1k/-23				
250/ .49/ 310/ 525	6/5k/+15	10/3k/+5	13.5/2.2k/-10	16.5/1.8k/-21				
225/ .44/ 280/ 475	7/4k/+9	11/2.4k/0	13/1.8k/-10	(3.5g max)				

SIGNIFICANT POINTS ON CHART

CONSTANT TURN #'s	0 Ps	INSTANTANEOUS (W/BLEED RATE)
425 KIAS	13.5°/sec/3,700' T_R	19°/sec/2,600' T_R @-33 Knots/sec
330 KISA	12°/sec/3,200' T_R	18°/sec/2,100' T_R @-30 Knots/sec
275 KIAS	12.5°/sec/2,700' T_R	16°/sec/2,000' T_R @-23 Knots/sec

BREAK TURN (AVG. MAX G PULL FOR 6 SEC)	IDLE	MIL
Tr:	2,500 FT	2,500 FT
A/S BLEED:	425 KCAS = > 250-275	425 KCAS => 325-300
AVG. TURN RATE:	16°/sec (100°)	16°/sec (110°)

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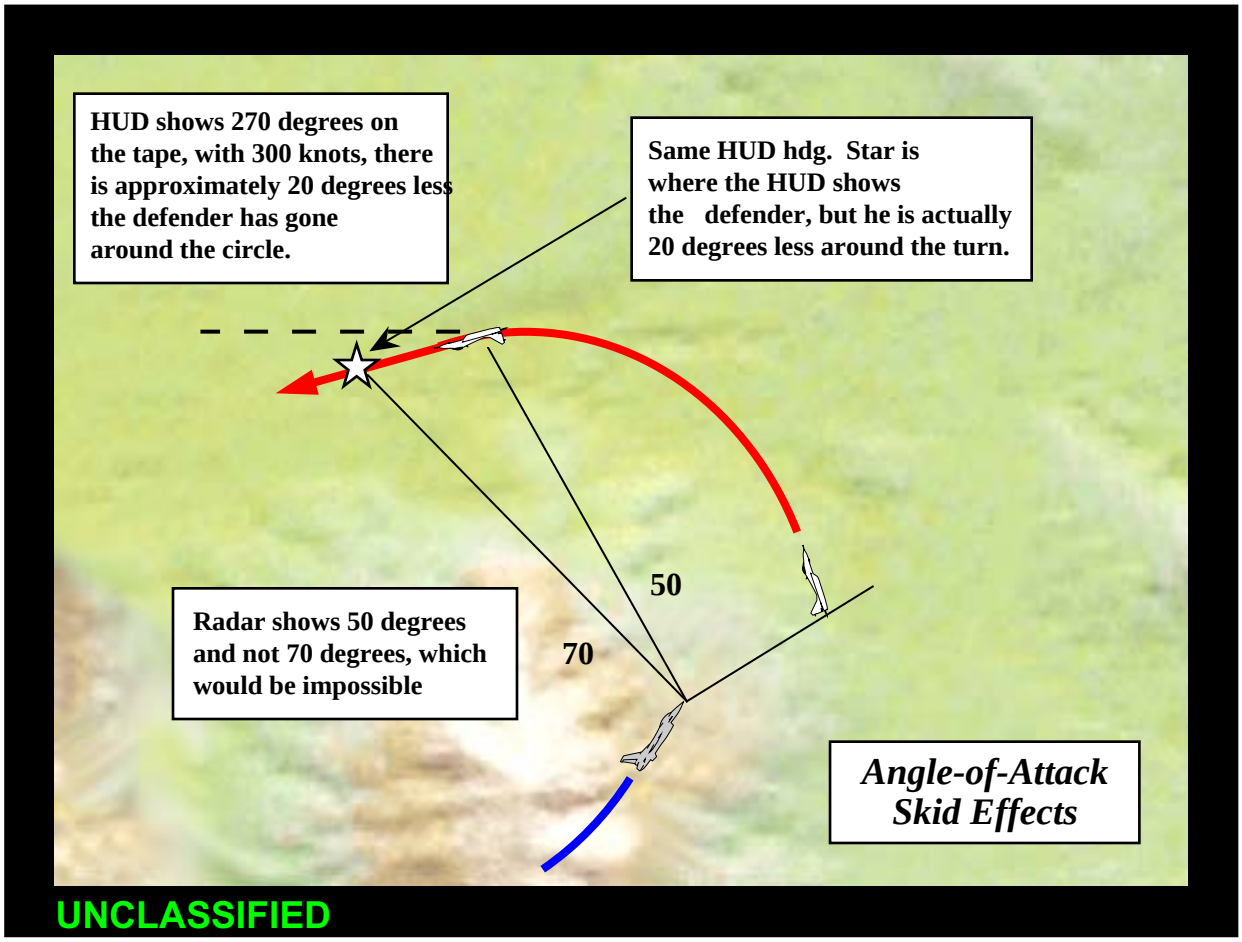
4.3.3.11 AOA Effects. Another phenomenon that is not fully understood is the AOA effects as it applies to sight pictures and drawing reconstruction. Simply put, an aircraft skids around the turn. This means the heading shown in the head-up display (HUD) is the direction the nose is pointing at any given instant, but isn't the amount around the turn circle when drawing. As the F-16 slows the AOA increases; this makes a larger difference between the nose heading and the actual position drawn in reconstruction. To illustrate this point, there are two significant points where this is important, the turn-circle entry and the conversion to guns. When drawing, most people err when they stop the defender's tape at a heading and use that heading to depict how far around the aircraft has gone. At maximum G, above 350 knots, the AOA is approximately 10 to 15 degrees, and increases to approximately 25 degrees below 350 knots. Although degrees of AOA do not directly correlate to the difference between the HUD heading and the vector heading, they are close enough for reconstruction purposes. As a technique, take 10 to 15 degrees off the heading when above 350 knots and 20 to 25 degrees when below 350 knots (at maximum G-loading) to depict the true position of the aircraft. The sight picture the offender sees is always higher than the radar displays. This difference is in the amount of AOA the jet is under. At higher AOAs the jet appears to have a higher HCA, and the offender is at a higher aspect. The true line-of-sight (LOS) though is much less as the defending jet is skidding through the sky. The tactical implication of this phenomenon is that the sight picture may look worse than the true HCA/AA condition. For example, a 90-degree gunshot (apparent to the eyeball) may produce only a 60-degree AA and corresponding closure-rate problems. The bottom line is that the offender can probably continue to take some shots that just look too high aspect. (See **Figure 4.8**, Angle-of-Attack Skid Effects.)

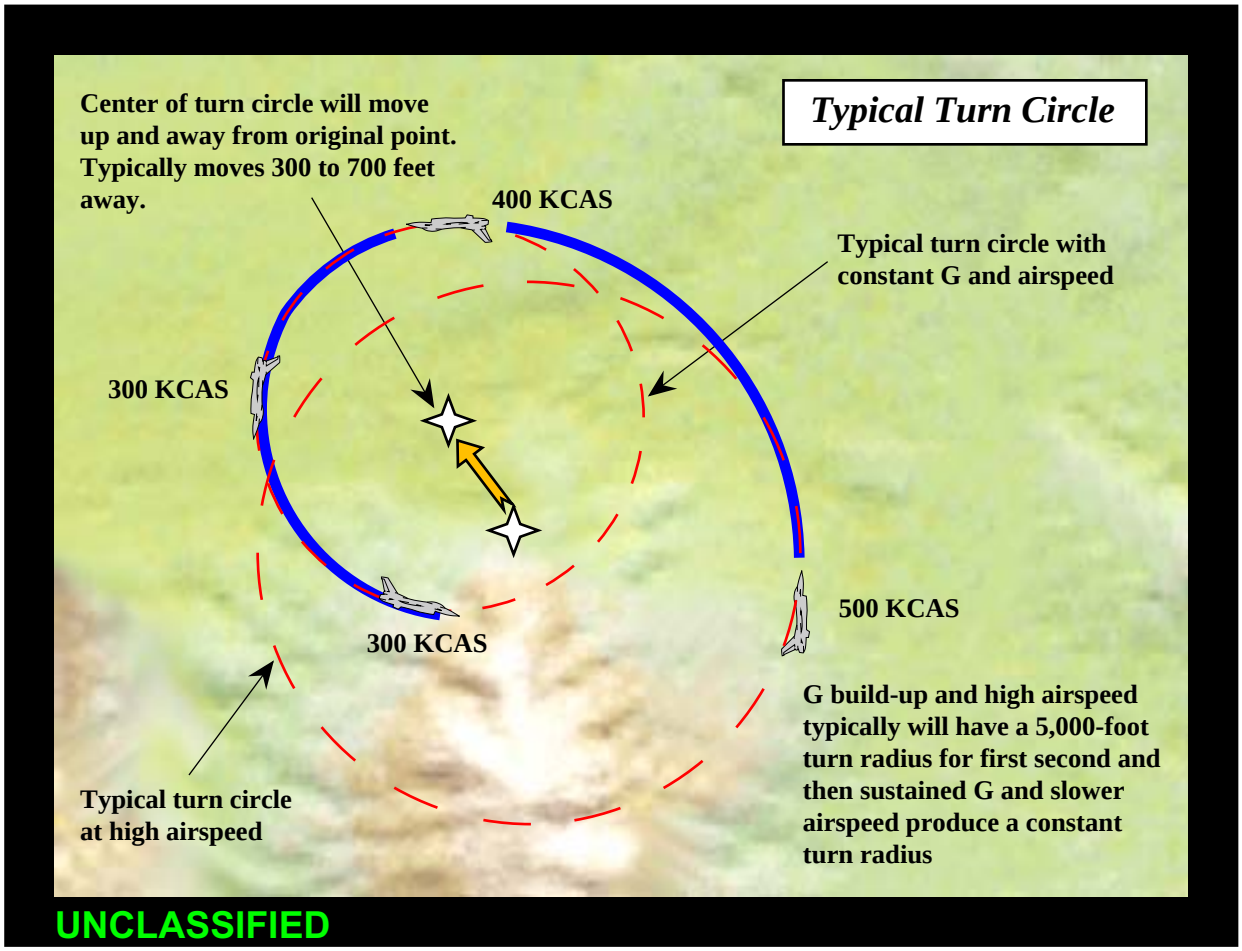
Figure 4.8 Angle-of-Attack Skid Effects.



4.3.3.12 Turning Room. In order to discuss how BFM can solve range, aspect and ATA, a concept called turning room and turning circles is used. Turning room is the separation between the two aircraft that can be used to accelerate, decrease range or turn and decrease aspect angle and ATA. A turn circle (the diameter) is determined by aerodynamics and is based on radial G and airspeed. Turn rate is how quickly the aircraft goes around this circle. It is very important to note that turning room can be acquired in either the lateral or vertical planes or a combination of both. Another important note is turning room can be used by either aircraft. Lateral turning room is in the adversary's POM. The adversary's turn direction (into or away from the attacker) will affect how much turning room is available. If the attacker is inside the adversary's turn circle, he must have a turn rate and radius capability that will allow him to put his nose-on the adversary or make the corner. If the defender turns away from the attacker, turning room increases. If the attacker is on the belly-side of the defender's turn, part of his geometry problem is being solved initially since the adversary is rotating his vulnerable cone towards the attacker. The disadvantage of lateral turning room inside the adversary's turn is that it frequently requires high-energy bleed rates to generate the turn rate required to make the corner and stay in the adversary's POM. Vertical turning room is acquired out of the adversary's POM. Generally speaking, out-of-plane is lift vector greater than 45 degrees from the adversary's POM. If the adversary is in a vertical turn, this turning room may be located in a horizontal plane. If the

adversary is in the horizontal, then turning room will be available either above or below his POM. Range and closure will govern the amount of turning room that can be generated. (See **Figure 4.9**, Typical Turn Circle.)

Figure 4.9 Typical Turn Circle.

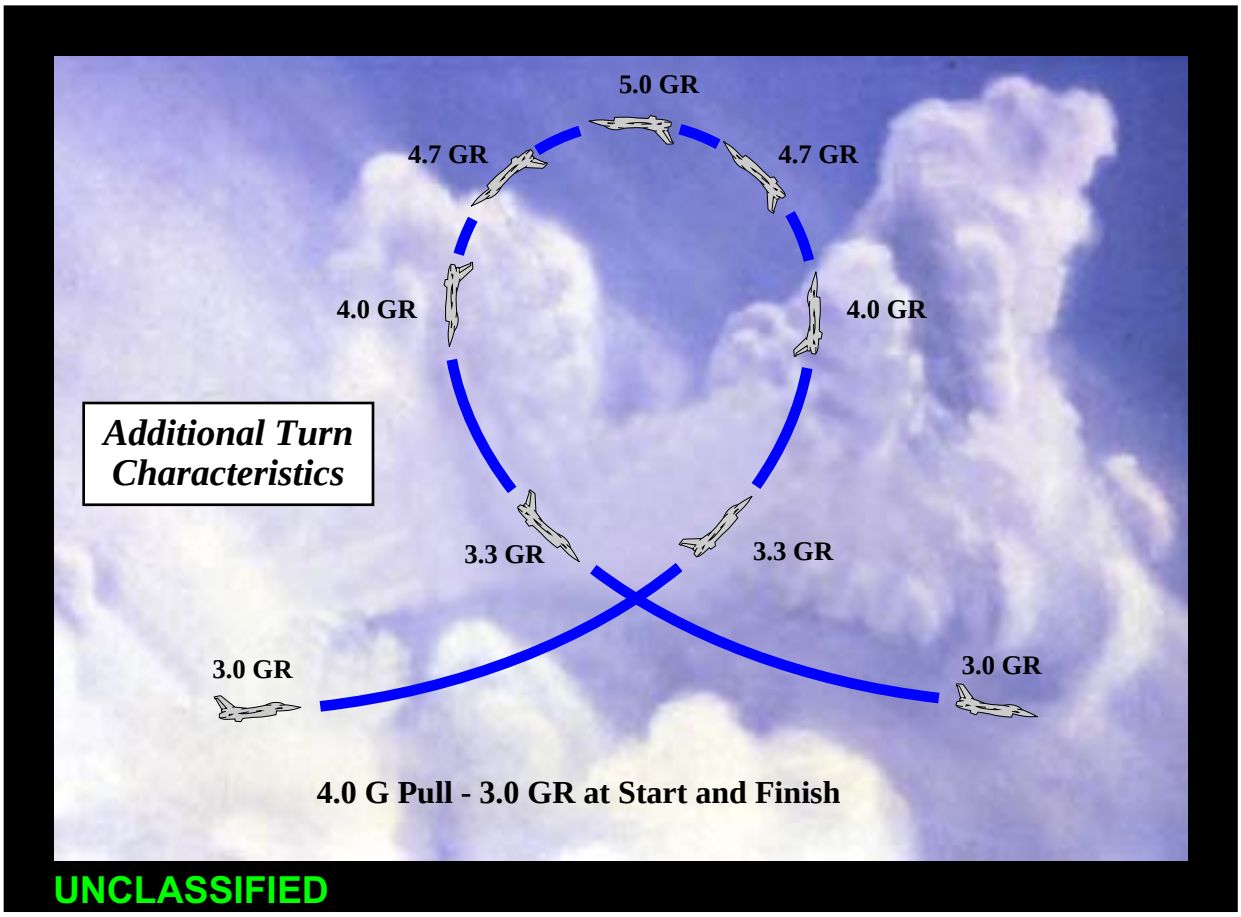


4.3.3.13 Roll. Roll allows the pilot to position his lift vector, thus determining the POM in which he will turn. At high speed and low AOA, the F-16 has a very high roll-rate capability. However, as the airspeed slows and AOA builds, the roll performance begins to degrade. At slow speed in order to roll more rapidly, the AOA must be reduced prior to initiating the roll. It should also be noted that the slower the airspeed, the longer it takes to command a reduction of AOA. This factor becomes very important in slow speed-lift vector positioning such as might be required to defeat a gunshot. An important aspect of roll is the ability to slow the forward velocity of the aircraft. If G is maintained and a roll is initiated, a spiral is made in the flight path, thereby increasing the through the air distance the aircraft flies to arrive at any selected point.

4.3.3.14 Vertical Turning. If a pilot can utilize a downhill turn at key points in a BFM engagement, his relative turning performance will be better than his adversary's. This fact allows an attacker, flying proper BFM, and starting from inside the defender's turn circle to maintain a positional advantage. The attacker can use superior turning performance to

solve angle-off problems and choose the desired pursuit curve to fly to weapons employment parameters. Another important concept of vertical turning is optimizing turn rate and energy (airspeed) expenditure. Utilizing a maximum G turn while entering a purely vertical turn (loop), excessively bleeds energy while working against gravity. Generally, a lower G vertical turn is more efficient at the beginning and end of a loop, while maximum G (maximum rate) vertical turns can be best employed when working with gravity—from nose pointing straight up until nose pointing straight down. Flying an optimum loop, (pull to the green doughnut or use 10 percent of KIAS in G: 300C = 3G's) at beginning and end, using maximum G available while flying over the top, maximizes vertical maneuvering potential. Time to use a maximum turn rate at the bottom of vertical turns include: to force a trailing aircraft's nose into lag; or to cause the trailer to overshoot in the vertical. Additionally, vertical turns performed in the pure vertical; i.e., no lateral or horizontal component, deny a trailing (similar) aircraft in the same plane of motion, at a lower energy state, the capability to counter the result of the energy differential by performing an oblique or horizontal turn. (See **Figure 4.10**, Additional Turn Characteristics).

Figure 4.10 Additional Turn Characteristics.



4.3.3.15 Acceleration The three primary factors affecting acceleration are altitude, attitude and airspeed. Other factors such as gross weight and aircraft configuration will not be discussed for sake of simplicity.

4.3.3.16 Effects-of-altitude. The lower the density altitude, the more effective the acceleration will be because of increased thrust.

4.3.3.17 Effects-of-attitude. The total energy gained during an acceleration maneuver is a trade-off between airspeed gained and altitude lost. Aircraft attitude determines the effect of gravity on an acceleration maneuver. If the aircraft velocity vector is above the horizon, acceleration effectiveness is reduced. If the aircraft velocity vector is below the horizon, effectiveness is enhanced. Aircraft G-loading affects induced drag and acceleration effectiveness. The fastest airspeed gain occurs in an unloaded (0 G), nose-low acceleration. The end result of this maneuver is a large altitude loss and very nose-low attitude that may be unacceptable in an aerial engagement. If altitude is a factor, select afterburner (AB) and fly a 0.7 G to 0.9 G slightly nose-low extension maneuver. While airspeed gain will not be as rapid as at 0 G, altitude loss is minimized and you will not bury the nose. The point to remember is that the closer you are to 0 G, the faster you will accelerate; but you will bury the nose more and lose more altitude.

4.3.3.18 Effects-of-airspeed. Acceleration is a trade-off between thrust and drag. Thrust increases at a greater rate than parasitic drag between 100 and 450 KCAS (or 0.95 mach, whichever comes first) due to the ram air effects on the engine. Above 450 KCAS acceleration rates decrease as drag becomes dominant (both parasitic and compressibility drag). As a rule-of- thumb (ROT), the best acceleration rates occur in the speed range from 300 KCAS to 400 KCAS. Often, the purpose of an acceleration maneuver is to separate from an adversary—get beyond his maximum missile range. In this case, the object is to fly a straight line over the ground to prevent the adversary from arcing. As bank angle increases from wings level to 90 degrees, the corresponding optimum acceleration G decreases (to maintain a straight-line flight path). At 0.9 G and 90 degrees of bank, the aircraft is turning laterally. To reduce the potential for arcing, reduce G to 0 when approaching 90 degrees of bank. Keep in mind a radar missile-equipped adversary can probably turn and achieve a WEZ as you flee. A separation will usually only be successful if the adversary chooses not to pursue or can't because he loses situational awareness (SA) on your position.

4.4 Offensive Basic Fighter Maneuvers.

4.4.1 Mindset. Stay Offensive and Kill the Hostile.

4.4.2 Gameplan. Take all missile shots while flying to a follow-up gun WEZ.

4.4.3 Objectives.

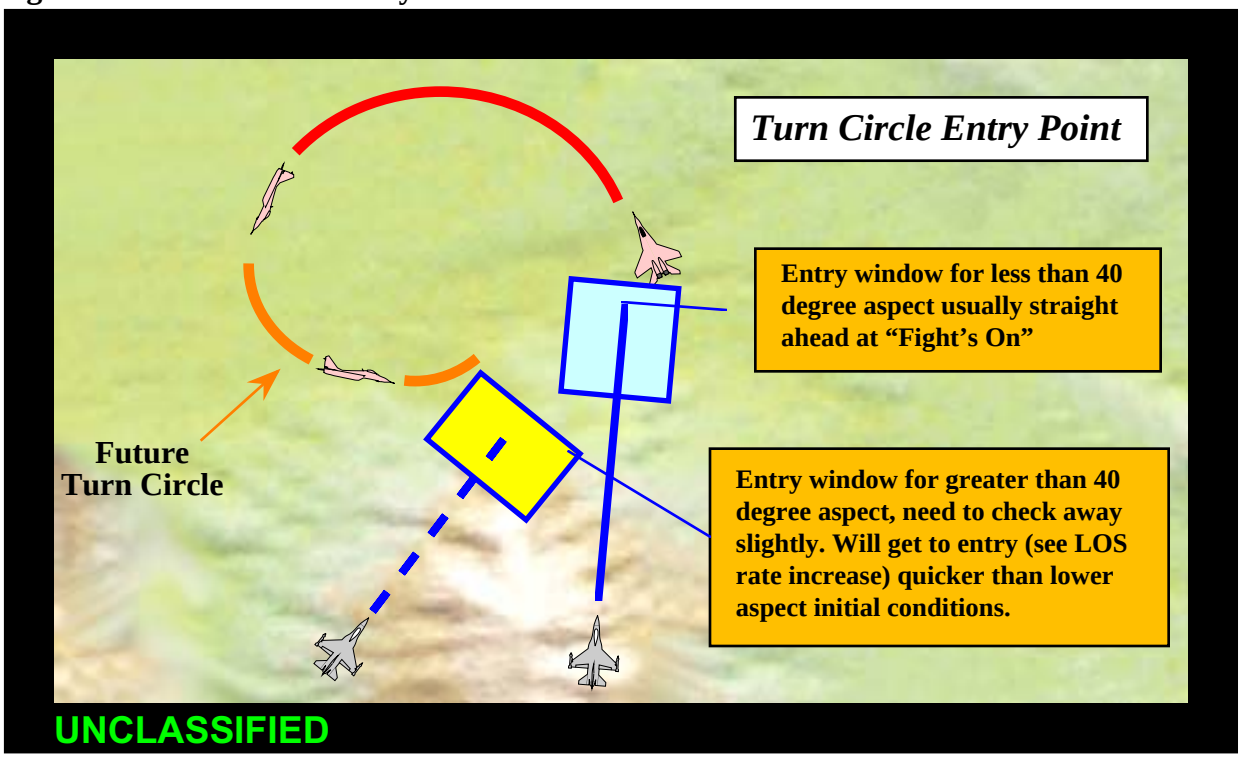
- Kill.
- Recognize and Enter Turn Circle if Appropriate
- Maneuver to Stable Gun WEZ
- Exploit all Weapons Opportunities
- Employ Valid Ordnance

4.4.3.1 The purpose of offensive BFM is to kill the defender as quickly as possible without wasted time or gas. Every sortie should have as its goal to sharpen the skills and expand the offender's lethal envelope, enabling him to employ valid ordnance quicker than the pre-

vious sortie. A well thought out and executed plan is critical to build these skills. In order to prosecute a higher aspect shot, high-aspect gunshot exercises should be utilized to build the necessary skills in a controlled situation. These skills can later be used in the dynamic, fluid BFM fight.

4.4.3.2 The thought processes in solving offensive BFM problems are sequential in nature. With the ultimate goal of achieving a kill, one must maintain an offensive position and a WEZ. These critical steps must be accomplished prior to going for the kill. Constantly assess the situation and determine if the defender is presenting an acceptable WEZ based on your ability/proficiency. When the answer to this question is yes, the offender should go for the shot. If the answer is no, the offender needs to solve the problems the defender is presenting. If you are too close or aspect is too high, continue to solve the angular problems while preserving the necessary range to stay offensive. Attempting a shot before you solve the problem will result in a fleeting WEZ at best and a reversal or neutralization worst case. (See **Figure 4.11**, Turn Circle Entry Point.)

Figure 4.11 Turn Circle Entry Point.

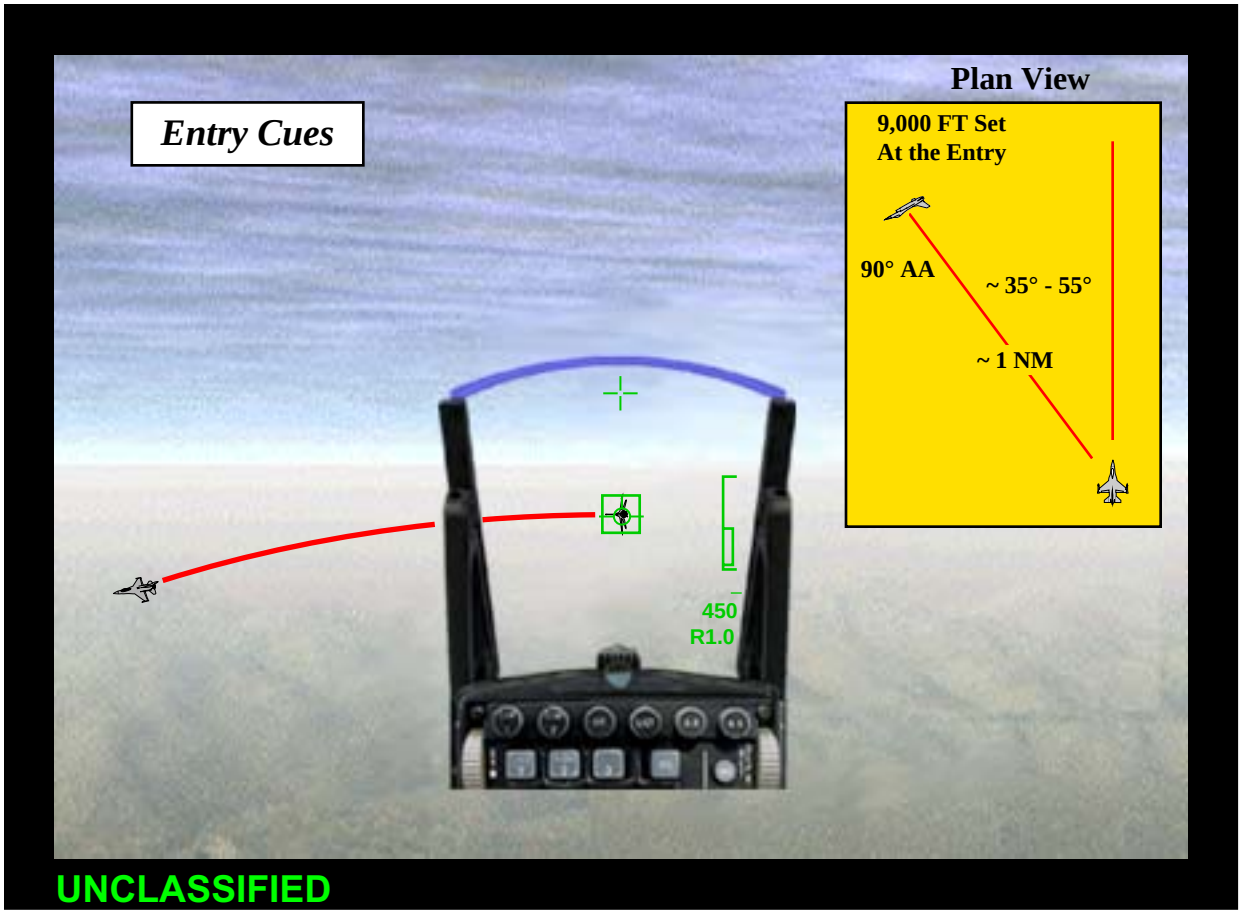


4.4.4 Outside the Turn Circle (9,000 feet). In order to prosecute an adversary, one must get to the turn circle, and then solve the angular and range problems presented. Typical fourth generation fighters have a turn radius about 3,000 feet (feet) at maximum performance. This roughly produces a 6,000 feet turn circle. The first critical step is to recognize your position relative to the adversary's turn circle. Fighting a maximum performing F-16, you will definitely be outside the turn circle at the start of a 9,000 set. The sight cues presented are typical of any fourth generation fighter. It is important to recognize these sight cues, since the aircraft you are behind may not be a fourth generation fighter performing a maximum performance turn, and the sight cues, not the starting range, dictates your actions. You are

outside of an adversary's turn circle if there is more rotation than translational movement from his aircraft. The defender will appear to rotate in space with a very slight LOS movement across the horizon. Also, the defender is still able to turn and increase AA. Knowing that you are outside the turn circle, your first task is to employ ordnance while maneuvering to a position to employ follow-on ordnance.

4.4.4.1 Turn-Circle Entry. The steps to getting to the turn circle are critical to maintain your offensive advantage. A desired entry window is a spot just inside the starting position of the defender. If the attacker starts the fight from less than 45 degrees AA with the adversary in the center of the HUD, straight ahead works and is an excellent tool to build the recognition cues necessary for more dynamic starting conditions. A flare dispensed at the fights on is another spot to aim for. CAUTION: 10 degrees of difference in the HUD = 1,000 feet of lateral turning-room difference (given you travel 1 NM en route to the turn circle). A 10-degrees aiming error may be too much to overcome and emphasizes how critical the initial entry is to the attack (See **Figure 4.12**, Entry Cues).

Figure 4.12 Entry Cues.



4.4.4.2 The second step is to get to the turn circle as quickly as possible while maintaining a controllable airspeed (450 KCAS to 480 KCAS). Accelerate level in AB until 450 KCAS to 480 KCAS. Any more speed at the initiation of turn will increase your radius quickly and any less reduces your average turn rate advantage over the adversary. Starting a slight

climb (2 to 3 degrees) if greater than 480 KCAS (up to 500 feet, adversary one fist below the horizon) is another way to help control your airspeed and build a little extra turning room above the adversary's POM. However, airspeeds above 500 KCAS may require throttle modulation or use of speed brakes in order to control turn radius. A lack of missile shots is the most often missed step during the turn-circle entry. Although the emphasis is on follow-on BFM; hopefully, the ordnance employed from this starting position will kill the adversary. Until proficiency allows, missile shots may take a lower priority in initial BFM training to ensure the sight cues and actions are firmly ingrained in the pilot's mind. Recognize off-boresight shot opportunities and take those shots (don't let BFM suffer by continuing to point at defender). AIM-9: check the desired launch zone (DLZ), tones, and symbology. With avionics tapes that correlate the missile diamond to the radar track, you can ensure the missile is tracking the aircraft outside the HUD field of view. With an AIM-120 simply analyze the DLZ. (See **Table 4.10**, Entry Airspeed Effects.)

Table 4.10 Airspeed Difference.

Airspeed (KCAS)	Time to Get to Tc Entry Point (sec)	Turn Defender Makes at 15°/sec (degrees)
420	7.5	112.5
480	6.75	101.25
510	6.4	96

NOTES:

The difference between 420 KCAS and 480 KCAS is only 11 degrees more that the defender generates, and 5 degrees from 480 to 510 KCAS. The slight advantage gained by the faster airspeed may not be as effective overall if the pilot needs to make drastic power modulations once reaching the turn circle entry window.

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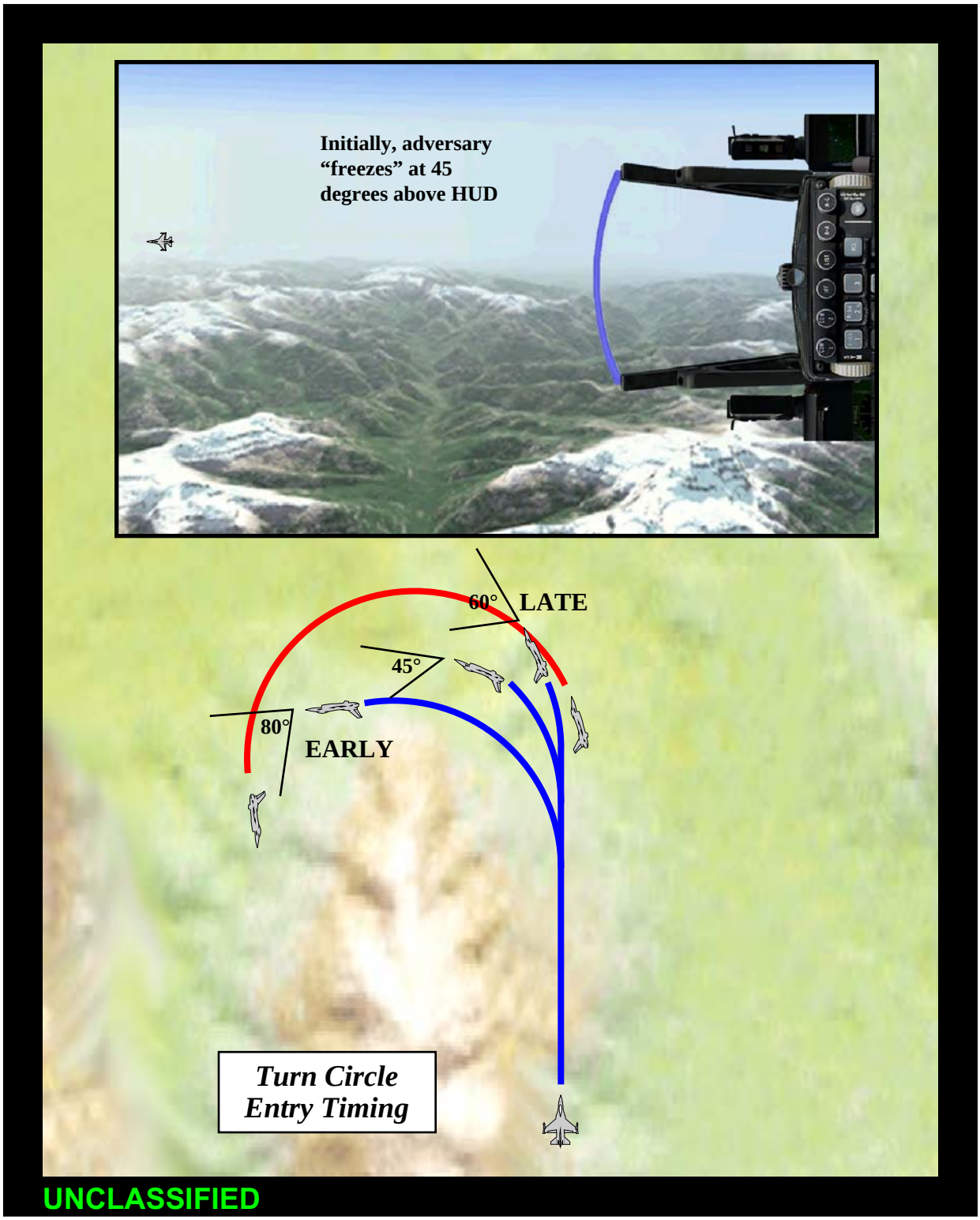
4.4.4.3 Unloading will get airspeed quicker, but force the pilot to make several other corrections to establish the proper plane to pull in. The theory of least-moving parts is the simplest, easiest to execute and usually the most successful plan. Therefore, a level-to-slight-climb will place the pilot in a good starting position with the least amount of moving parts.

4.4.4.4 Turn-circle arrival recognition is the next step in offensive BFM. Rotation changing to translational movement is the key. The LOS rate will pickup and start moving rapidly aft, coincident with this is the Aspect Angle and Range stops decreasing. (the pause) From a 9,000-foot set this will occur when the defender is at the 1:30 o'clock to 2 o'clock or 10:00 o'clock to 10:30 o'clock position. Some other cues include: eyeballs reach their gimbal limits and you start to turn your cranium to keep the aircraft in sight, 6 seconds (s) to 7 s from a 9,000 perch, and approximately 4,000 feet to 6,000 feet, 35 to 50 degrees on the locator line. (See **Figure 4.13**, Turn Circle Entry Timing.)

Figure 4.13 Turn Circle Entry Timing.

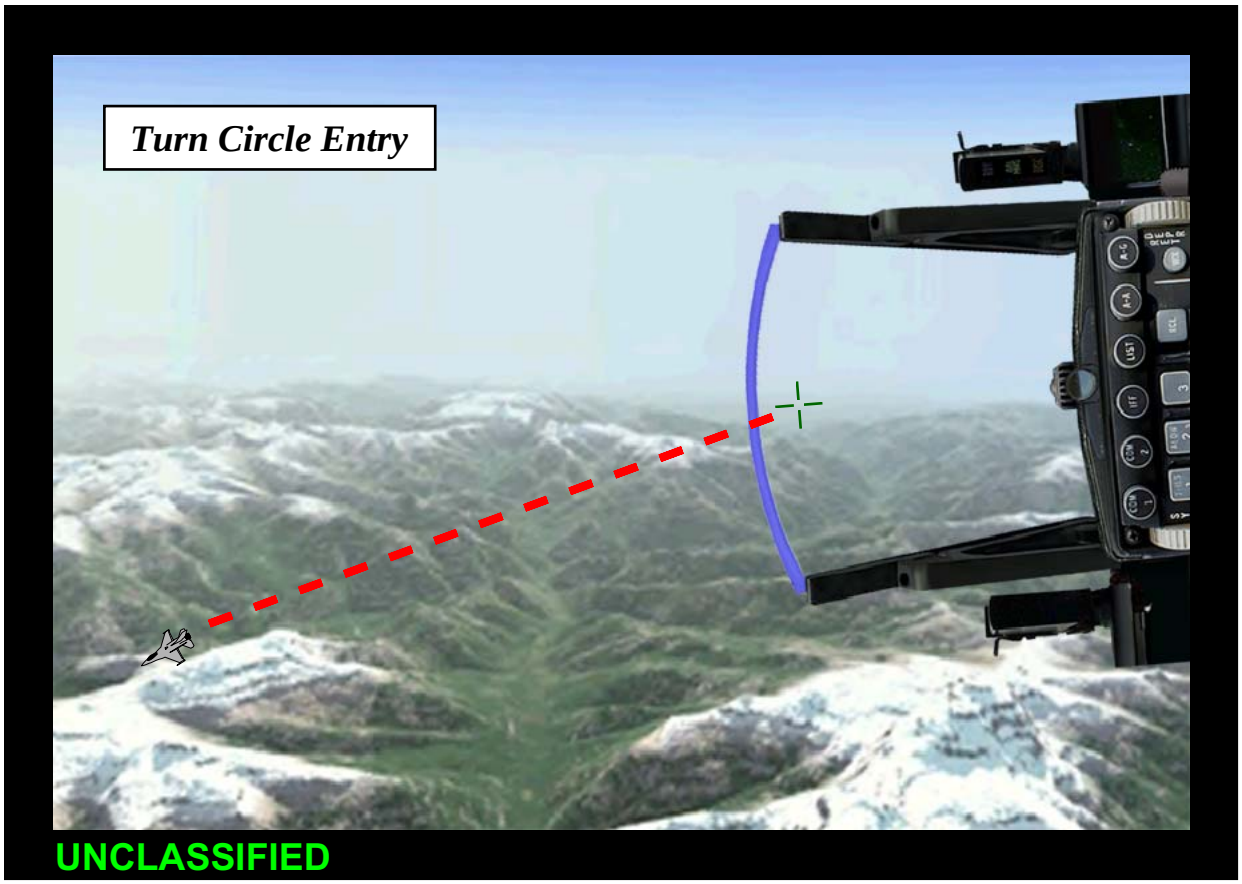


4.4.5 Action at the Turn Circle.

4.4.5.1 Recognize problem and assess adversary's action. An F-16 performing a maximum G break and converting to a constant turn rate defense should give 4,000 feet to 5,000 feet of range and approximately 80 to 110 degrees of aspect at the turn-circle entry point. A continuous turn radius defense will produce less range and slightly more aspect. A weaker G break turn will show more range and less aspect. A large vertical break will show more than ±500 feet of vertical difference. (See **Figure 4.14**, Turn Circle Entry.)

4.4.5.2 Initial pull execution. As the pilot approaches the turn-circle he should use an unloaded roll to set Lv in the adversaries POM and confirm the AB is lit. At the turn circle entry cues start a high-G pull (typically, 6 G to 8 G) to begin solving the angular problems. In order to confirm you POM relative to the adversary, watch for vertical movement on the canopy. If you see the adversary's aircraft moving down you your canopy, your Lv, and therefore, your POM, is too high. In this turn it is critical to remember that it is not mechanical, but a pull to solve the given problem. One Lv technique is to place the gun cross just above the adversary's POM, placing the adversary on your low knee. This helps keep 500 feet to 1,000 feet above the adversary to use later. This also allows me to preserve some range while max performing the jet.

Figure 4.14 Turn Circle Entry.



4.4.5.3 If the slant range decreases to less than 4,000 feet, then the pilot needs to do something to get it back. One technique is to slightly relax the pull until range is back to 4,000

feet, then immediately getting back on the pull. Another option is a slight out-of-plane reposition; decrease your bank angle towards the adversary while you continue your pull to control HCA and Aspect. This is accomplished by repositioning your lift vector slightly above the adversary's POM (about a fist width) until you see a slight aft LOS cue. When you see the cue, reposition your Lv back on or slightly above to continue to ride or attack when attack cues are met.

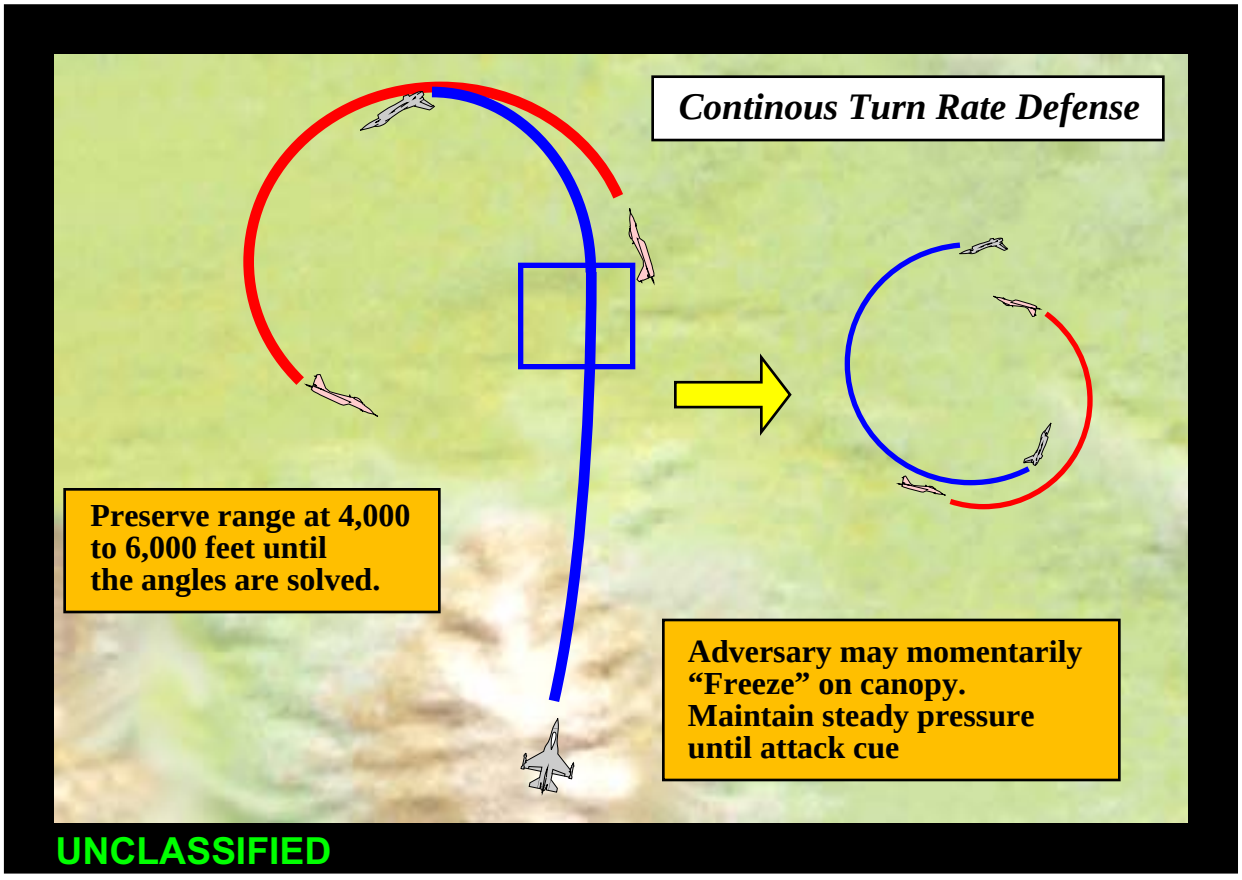
4.4.6 Continuous Turn Rate Defense.

4.4.6.1 Recognize. Range closing down and aspect is staying fairly constant—see top of the aircraft and LOS across the horizon.

4.4.6.2 Actions.

4.4.6.2.1 Pull to control range (4,000 to 6,000 feet). This will typically slow or freeze the aft LOS on the canopy and result in ATA (35 to 50 degrees). Initial turn-circle entry should be as previously discussed. Lift vector placement should be slightly above the adversary's POM. (See **Figure 4.15**, Continuous Turn Rate Defense.) This will help to preserve some vertical turning room high (500 feet to 1,000 feet), to use later during your pull to lead pursuit at your attack cue. If proficiency allows, a quick glance at the MFD as you begin your turn may be helpful in assessing the adversary's energy state and potentially his intentions.

Figure 4.15 Continuous Turn Rate Defense.



4.4.6.2.2 The objective at this point is to solve aspect with your rate advantage while maintaining range. To keep a higher turn rate, you will need to keep G on the jet and an energy advantage over the adversary. How much G will depend on adversary rate, radius, G and airspeed, but it is typically just off the limiter. The higher sustained G capability will produce this rate advantage that is required to solve the angular problems. Pull enough G to keep the adversary roughly 2 HUDs high (35 to 50 degrees ATA). Desired energy state is 50 knots to 75 knots airspeed advantage over the adversary. The energy advantage will provide you with a higher sustained turn rate. Keeping the airspeed in the range of 325 knots to 375 knots optimizes sustained rate and preserves some instantaneous rate capability; but do not mechanically pull to n airspeed. Too much airspeed advantage can result in flying too far outside the adversary's turn circle due to increased radius.

4.4.6.2.3 The pilot should see aspect and HCA decrease. Range may decrease as this happens but you should still preserve 4,000 to 6,000 feet of slant range. One of the quickest ways to get stuck in lag is to pull too hard when not required and lose valuable range while aspect and HCA are still too high. If the range is decreasing without the desired aspect, you need to fix closure. One technique is to adjust your POM by adjusting lift vector placement slightly above the adversary's POM. While keeping G on the jet, roll wings to point just above the adversary. You will notice the adversary then begin to move downward on the horizon. Adjust roll to capture the picture discussed previously. Another technique is to slightly let off the pull or accomplish the out-of-plane maneuver discussed. As you relax backpressure slightly, you will notice some LOS and increased AA begin to develop. You need to immediately get back on the G (1 potato) to prevent aspect and HCA angles from getting out of control. This series of hard pulls and/or slight let-offs should solve the range and angular problems until a WEZ is recognized. The transition to a gunshot, typically at a lower aspect, will be covered later. As proficiency increases, the pilot can take the higher aspect shot, reducing the time it takes to achieve a follow-up kill. (A great way to train to this level is through the use of HEAT to high-aspect gun exercises.)

4.4.6.2.4 In the case where the pilot is not seeing the problem solve itself through a better turn-rate advantage, the pilot must establish a greater rate advantage. The best tool the pilot has to create a rate/energy advantage is to threaten the defender. By pulling hard to achieve a heater WEZ, the defender will have to honor this threat with a power reduction. The defender's other alternative is to keep the power up and absorb a missile shot. As the offender pulls to threaten, use avionics (slewable, 10 x 60, 20 x 30, Boresight in order of preference) to acquire a lock if needed, and fire off-boresight missiles. As you pull nose-on, determine whether to continue to press (gun on under your BATR) or reposition, but don't just leave the adversary in the HUD. This will kill what is left of your range and potentially force another reposition or worst case a quarter plane. In the reposition let the defender slide 1 to 2 clock positions away from the nose and look for the LOS movement aft on your canopy. Then pull to solve the range and angular problem. It is important to realize that this move is aggressive enough to force a defender's power reduction, but it must be done quickly. Watch that HCA does not

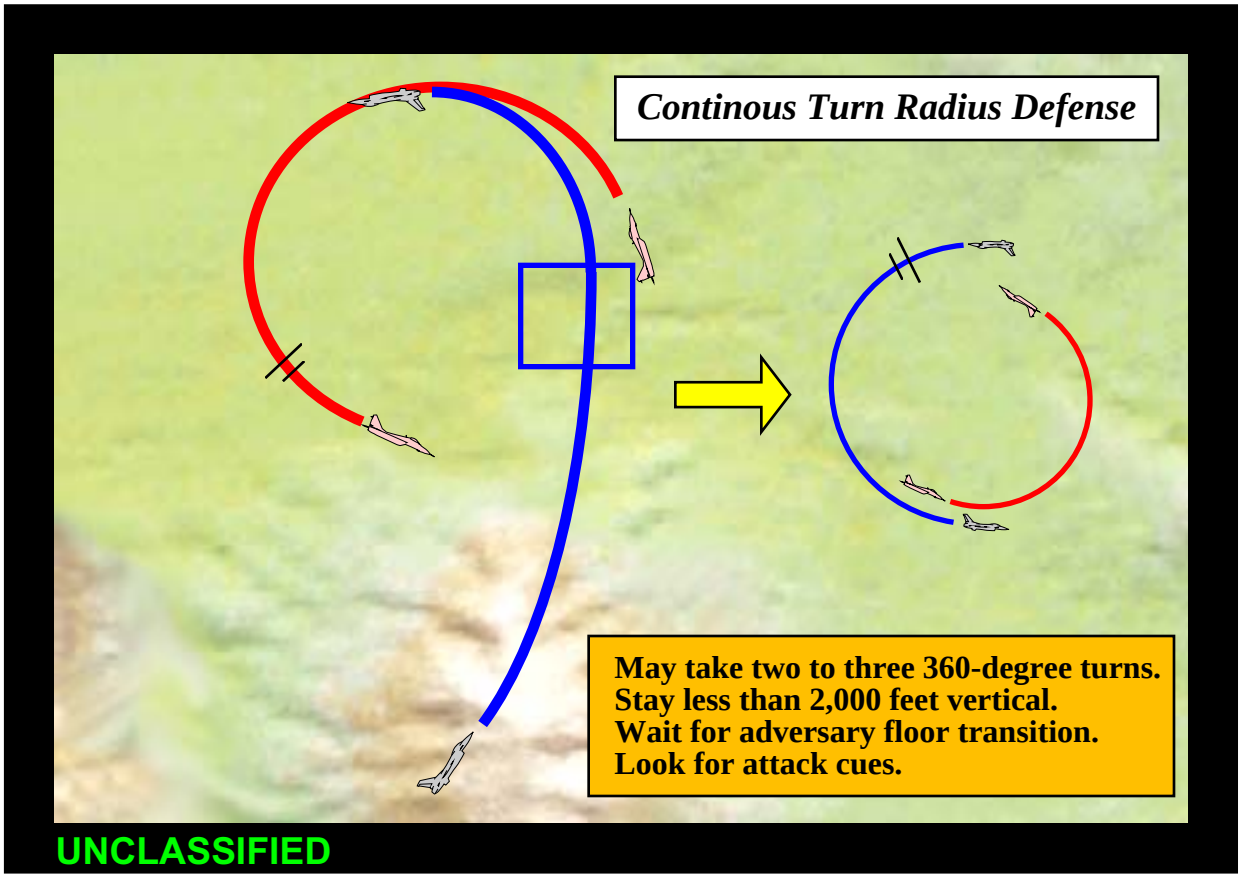
get too large. As HCA and/or AA lower, the offender can and needs to let the range decrease. (See **Figure 4.15**, Continuous Turn Rate Defense.)

4.4.7 Continuous Turn Radius Defense.

4.4.7.1 Recognize. Range closing down rapidly and aspect is higher—see top of the aircraft and LOS across the horizon. A defender, using the vertical to keep a high turn rate, uses lots of potential energy in his attempt to cause the offender problems. The sight picture may start out as an in-plane break turn followed by the defender over rotating his lift vector greater than 30 degrees nose low, pulling maximum G in full AB.

4.4.7.2 Actions. Same Turn circle entry mechanics; range is closer since the adversary used a limiter pull and vertical turning room to tighten up his turn circle. The BFM problem facing the attacker is an adversary with an extremely small turn circle coupled with a very high-sustained nose rate. CAUTION DO NOT stay on the limiter and try to fit inside the adversary's turn circle. Accept a closer range (3,500 to 4,000 feet) keep your pull going to control HCA and use LV placement to stop the vertical LOS. The offender needs to keep the pressure on the defender by matching his rate down and using the same potential energy. It is critically important to not let too much vertical difference build, no more than 1,500 to 2,000 feet. The attacker will need AB and near-limiter pull to match the adversary but the objective is still pull to preserve range (3,500 to 4,000 feet). A higher aspect shot or a quick solution to a lower aspect shot is not normally presented. At the floor the defender's turn radius opens up significantly. Prior to the defenders floor transition the offender should re-orient his Lv to slightly above the defender to not give up the vertical turning room (500 to 1,000 feet) he can use to attack with. The attacker needs to be in position to then threaten with nose-on. As the offender converts to the final gun solution and/or missile solution, the defender has little vertical use to complicate the gunshot. (See **Figure 4.16**, Continuous Turn Radius Defense.)

Figure 4.16 Continuous Turn Radius Defense.



4.4.8 Break and Extend.

4.4.8.1 Recognize. Range fairly constant as the offender pulls hard and aspect rapidly decreases; more tailpipe is seen and less top of aircraft with LOS back towards the HUD

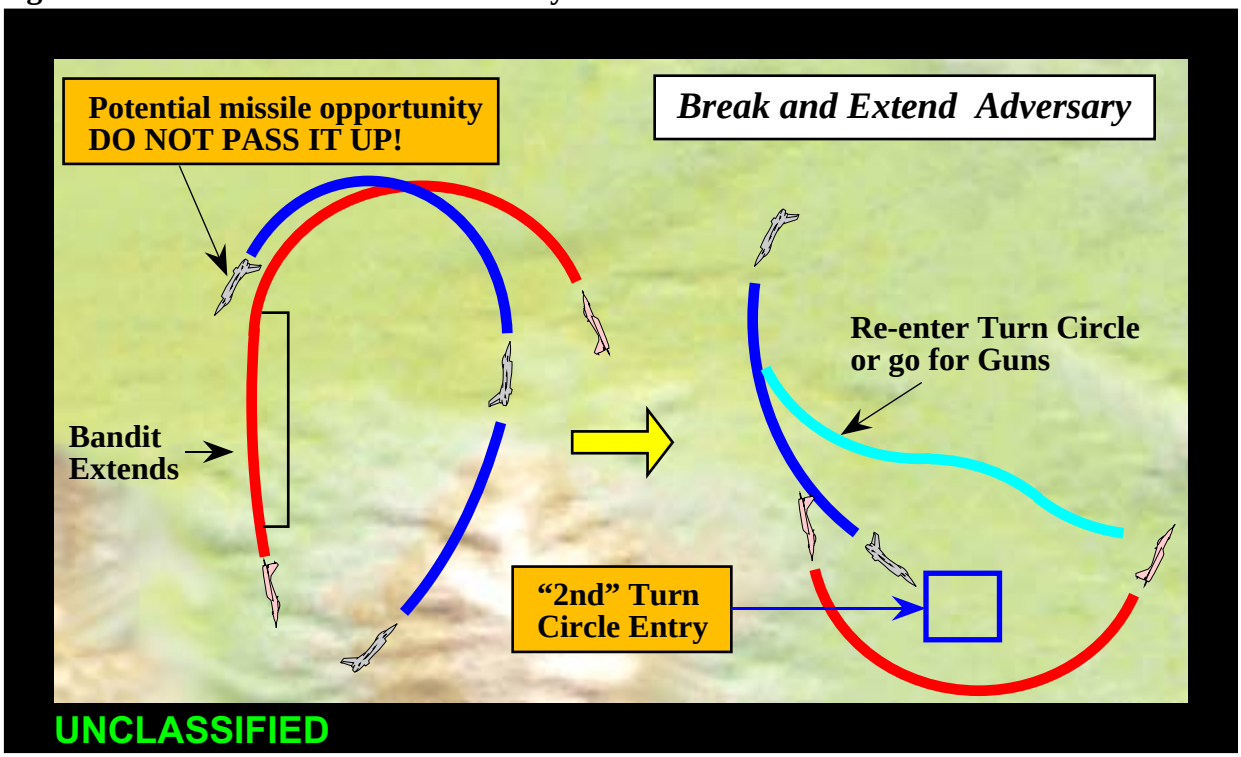
4.4.8.2 Actions.

4.4.8.2.1 Pull aggressively, maximum G, look for WEZ and shoot. Initial turn-circle entry into this fight is the same. Once the adversary shows extension cues, pull maximum G in AB. Pull with lift vector on to slightly low. Use air combat maneuvering (ACM) modes of the radar to regain a lock if broken. As referenced earlier use slewable first (outside HUD), 10 x 60 (with Lv on), 20 x 30 (approaching the HUD) and finally boresight (in middle of HUD). Select the appropriate missile based on range, clear avenue-of-fire, flares present, etc.; and take the shot. The adversary may continue extending or break back into the offender again. If the adversary does not die, reenter Tc if necessary; i.e., not a desirable gunshot picture. Keep in mind the energy the defender has gained can be used to break back in aggressively and present a higher final aspect solution to your gunshot attempt. It is important to reassess the defender's new turn circle and enter as you did before.

4.4.8.2.2 The sight pictures, timing, locator line and/or range cues may be different. Remember, that LOS rate increase and AA are the keys. The other option is to take advantage of the range the defender has given the offender and pursue a higher aspect

gunshot, which will be covered later. The last option, and certainly most desirable, is to use a missile to dispatch the defender. The same reasons and contingencies that we are following up for a gunshot still apply. Keep in mind that maneuvers, which complicate follow-on BFM, may be putting all your eggs in one basket. If you get a successful shot, and the defender is taken out of the fight, you have solved your problem. Yet if the defender survives, either through skill, cunning or luck, your BFM problem may be unsolvable now. (See **Figure 4.17**, Break and Extend Adversary.)

Figure 4.17 Break and Extend Adversary.



4.4.9 Infrared Countermeasures/Limiter Breaking Defender.

4.4.9.1 Recognize. Recognize lots of planform (higher aspect) and closer than normal range at the normal entry point. LOS rate across the horizon slows (the defender may also rapidly descend to preserve his rate).

4.4.9.2 Actions.

4.4.9.2.1 Maximum AB pull with lift vector slightly above the adversary's PM to shrink your turning radius, then adjust Lv to hold adversary slightly closer (approximately 3,000 to 4,000 feet) until aspect decreases. Then pull lead for missiles and guns.

4.4.9.2.2 Keep the power up in full AB, and start a normal turn-circle entry. You still need to decrease aspect, so a 7 G to 9 G pull will still be necessary at the initial turn-circle entry. The idea is to get rid of some of the AAs and still keep pressure on the adversary. The offender will find that after the initial part of the turn-circle entry it takes significantly less G and time to arrive in the 3,500 feet to 6,000 feet region. The initial reaction will probably be to ease off the G to preserve range. Don't! This actually

allows the adversary to generate excessive angles, further complicating your BFM problem.

4.4.9.2.3 The keys to fighting this type of defender are to control your lift vector until your turn radius and airspeed are under control. As you recognize the adversary performing the limiter defense, you'll probably need to pull a bit harder to shrink the turn circle to more closely match the adversary' turn circle. Do this by keeping the lift vector just above the adversary's POM, full AB and maximum G. Shoot to put the adversary about one beer can below the horizon (1,000 feet to 1,500 feet maximum). This will allow you to gain some total slant range (turning room) while still pressuring the adversary and decreasing aspect and HCA. Vertical turning room is gained since the adversary has decreased the available lateral turning room.

4.4.9.2.4 The sight picture will be slightly different than the continuous turning defender. You will be closer (approximately 3,000 feet to 4,000 feet) and the aspect and HCA will be a bit higher. Your airspeed will probably be slower as well (275 knots to 325 knots). Be patient and knock out some angles as you drive around the turn at a superior rate. Continuously update your position as you assess adversary maneuvering to prevent too much altitude delta building (1,500 feet maximum). (See **Figure 4.18**, Infrared Countermeasures/Limiter Breaking Adversary.)

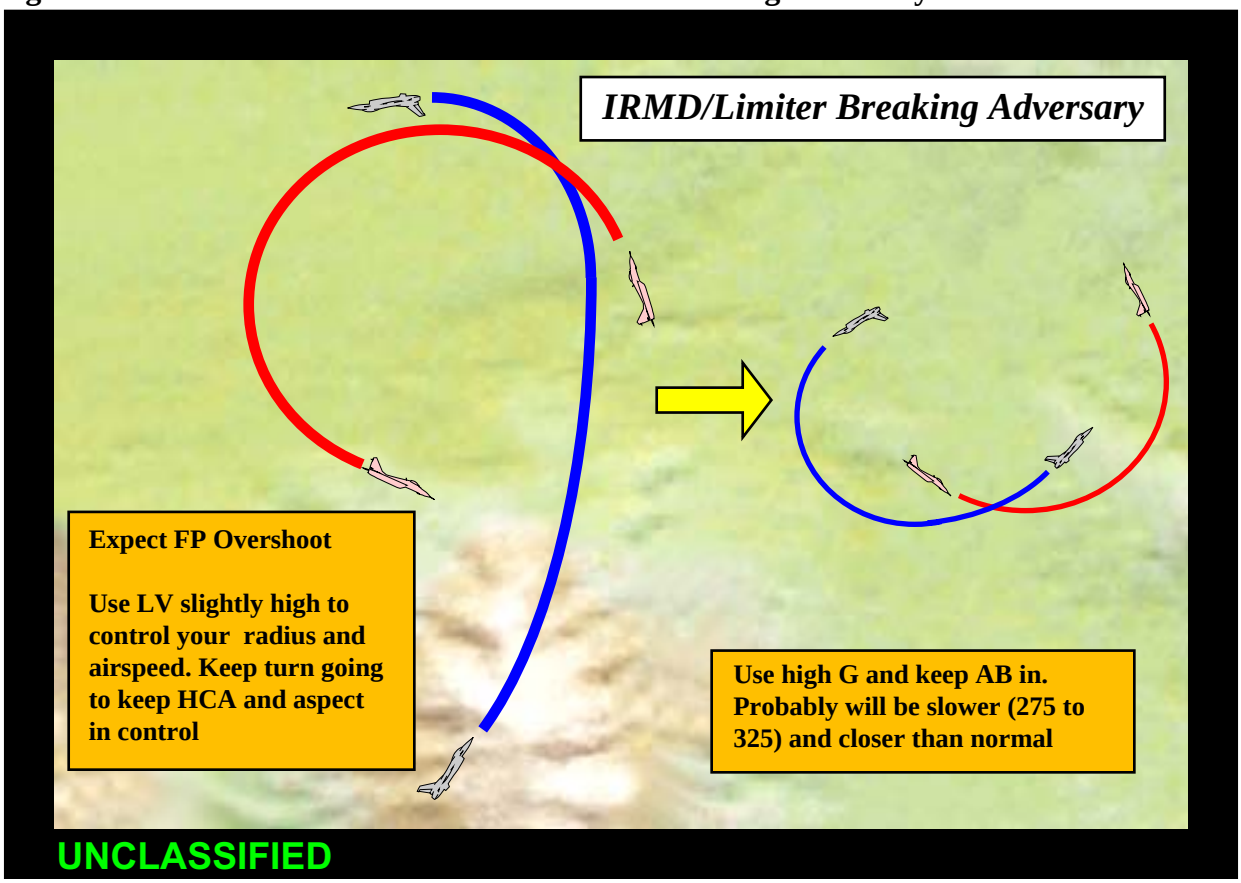
4.4.10 Vertical Fight from the Offensive Perspective. The defender's use of the vertical basically resets the fight in a new plane, which has some distinct differences from a normal descending fight. These differences include; the ability of a defender to maintain a high turn rate, an attempt to go over the top, or use excessive vertical to confuse the offender. The solutions to these tactics are simple once understood.

4.4.10.1 Pure vertical lift vector on.

4.4.10.1.1 A defender who goes pure vertical down with lift vector on the offender is trying to capitalize on a perceived turn circle entry error, or is trying to change the POM of the fight to confuse the attacker. At first this seems to be a difficult problem. However, the key to handling this BFM problem is to recognize it early and fly the correct pursuit course. Initially there is an ugly sight picture with the adversary's lift vector on the offender with increasing HCA and aspect. The defender will give up vertical turning room as his aircraft descends. If the attacker stays in the same POM and tries to fly a circle around toward the adversary's 6 o'clock, he will find himself high aspect at best, or worse case, in a WEZ. A potential solution is to use the vertical turning room given to you by the adversary. Pull maximum G in AB (in the horizontal) to where the adversary was when he started down. Stay level or even accept a slight climb until you start to see LOS movement on the canopy (Same TC entry cues). If established in your turn the adversary will be at 3 o'clock or 9 o'clock and 3,000 to 4,000 feet below your altitude. Check your airspeed as you begin a slice-back type turn into the adversary's new POM. A ROT for a clean Viper is using MIL power above 400 knots and AB below 400 knots. This will help keep your turn radius in check and still provide maximum rate. If the defender (or offender) is going to use pure vertical down, a minimum of 3,500 to 4,000 feet above the floor is generally required. The tactical implication of

this is as the fight approaches 4,000 feet above the floor, the adversary loses the pure vertical option.

Figure 4.18 Infrared Countermeasures/Limiter Breaking Adversary.



4.4.10.1.2 Avoid trying to pull lead or point at the adversary going pure vertical down; a miss here sets up a reversal opportunity for the adversary. Pull to place the adversary 30 to 40 degrees off your nose (ATA) and assess range and aspect. Shoot off-boresight missiles to get the adversary to defend against the missile. As you pull the nose through the horizon, assess the adversary, as he will now need to likely change his POM back to the horizontal. Closure control is key as you pull lead for the gunshot.

4.4.10.2 Adversary goes vertical up. A defender attempting to go over the top is opening himself up to a prime missile WEZ and potentially a gunshot at the top. Simply assess if you can achieve a gun WEZ as the defender starts his pull and pull lead. Fire a lethal burst at the normally slow/stable aircraft as he is pulling through the vertical (just past 90 degrees nose high). If you cannot get there in time, pull to align fuselages as best you can in full AB. Start up in the Vertical before the adversary gets through 90 degrees HCA. Never let his nose get greater than 90 degrees out of phase with you in a vertical fight (assuming adversary went up first). If you don't pull in the oblique to hold him 1 to 2 HUD widths away, the adversary may use the top of the egg (God's G) and a slow airspeed to flop over and point. If less than 90 HCA, fly to a spot just prior to the start of his pull and follow him up and over. Lead going up and lag going down is a technique until you achieve

attack parameters with the energy to pull lead and gun him. A word of caution for when you perceive a gun WEZ on the backside or at the bottom; pulling lead on the backside will potentially cause an overshoot in an area where the defender can reverse on you in the vertical if you miss.

4.4.10.3 Reversing Adversary at Turn-Circle Entry.

4.4.10.3.1 If you have entered the turn circle properly, a reversing adversary is offering the offender a solution to the BFM problem. If the offender has made an error with a tight Tc entry, late Tc entry, excessive HCA or a combo of these, a reversing defender is attempting to exploit it. The solution to the defender's error of an untimely reversal is relatively simple, but the offender must be ready for it. Surprise is sometimes a very effective weapon in BFM. In all cases the attacker must get his airspeed under control and use lift vector corrections to get back to a lag pursuit course.

4.4.10.3.2 The offender has several options against a reversing adversary. If the offender sees himself in a desirable and controllable WEZ range, closure AA and HCA), a transition to guns is the answer. If not, a bid to lag to preserve the offensive potential is the other move. If the defender is making a move to put 3/9 position in doubt, there are several options to preserve the offensive advantage. (See **Figure 4.19**, Reversing Defender at Initial Entry and Pull).

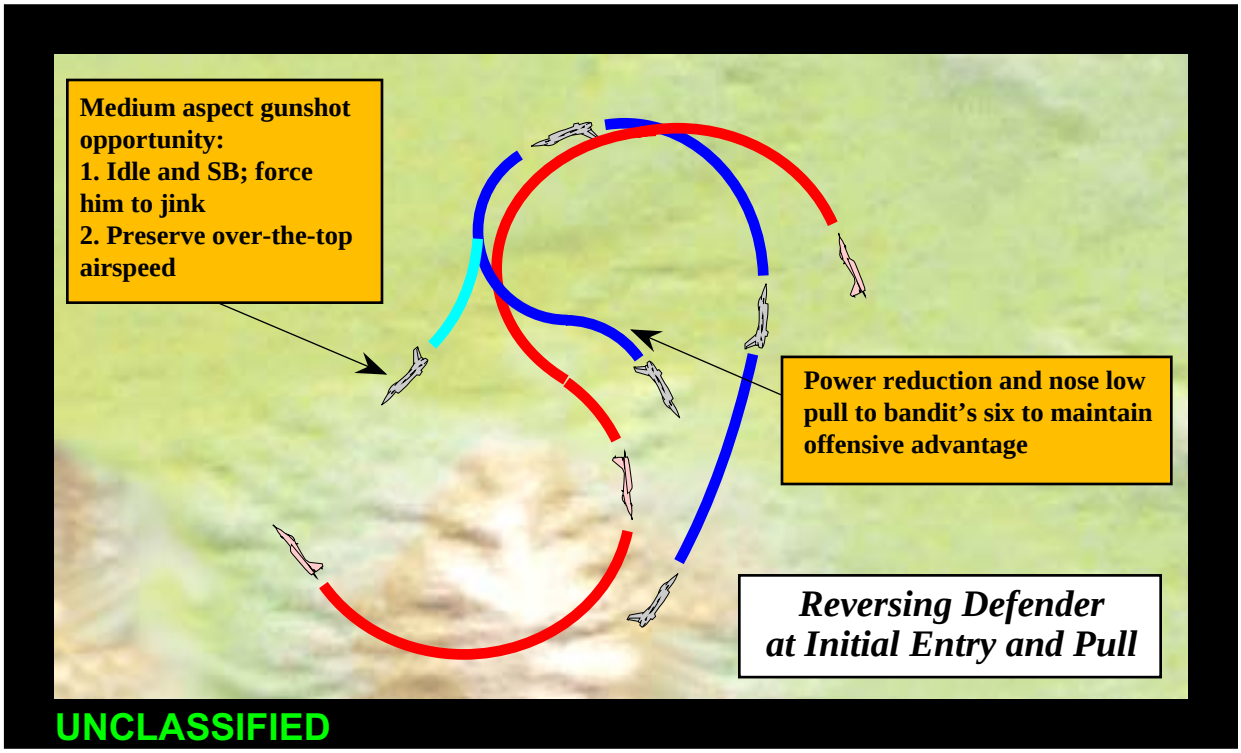
4.4.10.4 Transition-to-Guns. Pull power, maximum G, lift vector and low pull until the defender nears the HUD. Reverse the turn while setting up for the gunshot and prosecute the attack. (See the high aspect gunshot section.)

4.4.10.5 Bid-to-Lag.

4.4.10.5.1 Modulate power to control the size of the turn. Maximum pull with lift vector low, pull with lift vector low, pull to a position 2,000 feet to 3,000 feet behind adversary.

4.4.10.5.2 As adversary passes through the HUD, reverse direction of turn to keep HCA under control (keep nose within 30 degrees of adversary to keep pressure on). Blend in the G to keep the adversary within 30 degrees of the nose and hold the range you've got until ready to pull lead. Be ready to repeat (or go for guns) if defender reverses again.

Figure 4.19 Reversing Defender at Initial Entry and Pull.



4.4.10.6 3/9 in Doubt.

4.4.10.6.1 Power in AB, intimidate with gun and missile and preserve over-the-top (OTT) airspeed. Get the defender to jink, and transition to the vertical (covered later as well).

4.4.10.6.2 Quarter-plane to stack. (See the defensive section for guidance; and more importantly, fix the errors that got you here!)

4.4.11 At the Turn Circle (6,000 foot sets).

4.4.11.1 In a long-range perch set (9,000 feet), the initial problem was to close the range while decreasing aspect. At the start of the medium range set (6,000 feet) there is neither a range nor an aspect problem. In fact, if the adversary did nothing at the fights-on call you could simply squeeze the trigger and kill him. The BFM problem presented with the 6,000 foot set is the adversary has almost unlimited maneuverability to do almost anything he wants to right now. The goal is to keep the adversary predictable while you beat him down on energy. A small misjudgment in timing can lead to disaster. The basic gameplan of keeping control of range and angles as you force the adversary to deplete energy remain the same.

4.4.11.2 The principals for attacking reversing and vertical adversaries remain relatively the same. The ranges will obviously be closer, so timely corrections to pursuit courses and power modulation for closure control are crucial. The initial turn-circle entry options are a conservative or an aggressive approach. Your proficiency, configuration and scenario will determine which avenue is best at any particular moment.

4.4.12 Conservative Entry. This option requires application of the skills discussed in the 9,000 feet section and patience. It is easier to prosecute than the aggressive approach, and lends itself to handling follow-on adversary maneuvers.

4.4.12.1 Actions. At the fights-on, drive to where the adversary was until a slight LOS begins to develop. This equates to the adversary moving 1 clock to 1 1/2 clock positions outside the HUD. Power application is subject to debate. A clean Viper requires only MIL power initially. A combat loaded jet after performing a Selective Jettison may require AB due to increased drag and weight. A switch to CAT 1 is required post stores jettison. Rapidly blend in G to keep the nose tracking within 30 to 40 degrees of the adversary to keep the pressure on. As you reach the limiter, bring power into AB to keep the nose tracking and to keep your energy advantage. Range will be at 3,000 feet, and you will overshoot his flight path slightly, but in a position to prosecute should the adversary reverse. Maintain this picture until aspect is acceptable, then modulate power to control closure as you close for the gunshot.

4.4.13 Aggressive Entry. The aggressive entry requires your gunnery skills to be in tune, and the ability to solve high-end game closure problems. This is a useful entry when conducting a coordinated attack as an element such as in ACM or a visual identification (VID) intercept. It forces the adversary to react to the attacker and frees up the supporting fighter for a more conservative entry if required.

4.4.13.1 Actions. At the fights-on call pull the power to idle (clean jet), roll and place the adversary at the top of the HUD and near the gun cross. Blend in G to keep adversary there as you put out speed brakes. Approaching approximately 4,000 feet, pull adversary to the gun sight and fire a 1-2second burst then ease off. This is a 4-5G gunshot. As you close inside of 3,000 feet let the adversary slide back to the top of the HUD to slightly outside the HUD. Immediately get back on the limiter to keep the pressure on and retract speed brakes. Power may need to go to MIL initially, then idle or AB depending on the adversary's next actions. The flight path overshoot that occurs will not be enough to trigger overshoot cues for the adversary. If the adversary continues to turn, AB is required and slow speed maneuvering and patience will get you back to the desired perch. Should the adversary reverse, you are in a perfect position to shoot missiles and the gun.

4.4.14 Gun Employment. The gun may become the weapon of choice due to missile failure or depletion, WEZ exclusivity (too tight), or bandit maneuver potential. There is no minimum range for the gun, but consider bandit frag effects and the single engine FOD problem after the shot. Gunshots range from very controlled tracking opportunities to very dynamic snapshot situations.

NOTE: The video clips used in this manual (CD-ROM version) are in the A/A Gun mode so you will not see missile symbology that you would normally see while in the Dogfight mode. This was done to keep this document unclassified.

4.4.14.1 Tactical Considerations. Every gun opportunity must be judged and handled with proper concentration given the trade off between target destruction and survival. How predictable can you be? How much energy can you expend and what will you do after the shot? Can you afford the time to take the shot? There are two basic situations where gun use is required: when the gun is the only available weapon, and when a target of opportu-

nity (inside the missile minimum range/angle envelopes, but within gun parameters) presents itself. Gun solutions, especially in a dense air-threat environment, are fleeting in nature. You must see the situation approaching, react quickly to “fine tune” the gun solution, then kill or damage on the first attempt. Think twice about the time and energy dissipation required to generate such a situation if it does not already exist.

4.4.14.2 Combat Gunshot Opportunities. Apparent LOS relative to the shooter and the defender's turn rate capability dictate which type of shot (medium/high angle or low angle) is available; tactical considerations dictate which is the most feasible. Gunshot opportunities in combat are rare, so do not save rounds for other bandits, fire a lethal burst (generally 1 to 2 seconds). Then, immediately reposition to avoid the resulting fireball. Once separating, assume you have been targeted by a new threat (you have been very predictable and not checking six while getting your guns kill) and maneuver the aircraft accordingly.

4.4.14.3 Gunsights. The gun cross and the enhanced envelope gunsight (EEGS) are the two sights used in the F-16. The primary F-16 gunsight is the EEGS.

4.4.14.3.1 Gun Cross. The gun cross is always available. Basically, the gun cross is where the gun barrels are pointed. Proper aim is achieved by positioning the gun cross in the targets POM with the proper amount of lead. The gun cross is a very good reference to initially establish the aircraft in the target POM with some amount of lead. Without EEGS, the gun cross is the only usable reference during very dynamic, high AA shot attempts.

4.4.14.3.2 EEGS. The EEGS sight is a director gunsight. It provides the capability to accurately employ the gun at all aspects, with or without a radar lock, against either an evasive or predictable target, and out to maximum gun effective range. The EEGS consists of five levels of displays, each providing an increasing level of capability depending upon the system's knowledge of fighter and target parameters (range, velocity, and acceleration). As the radar locks on to the target, the sight symbology smoothly transitions from Level II to Level V.

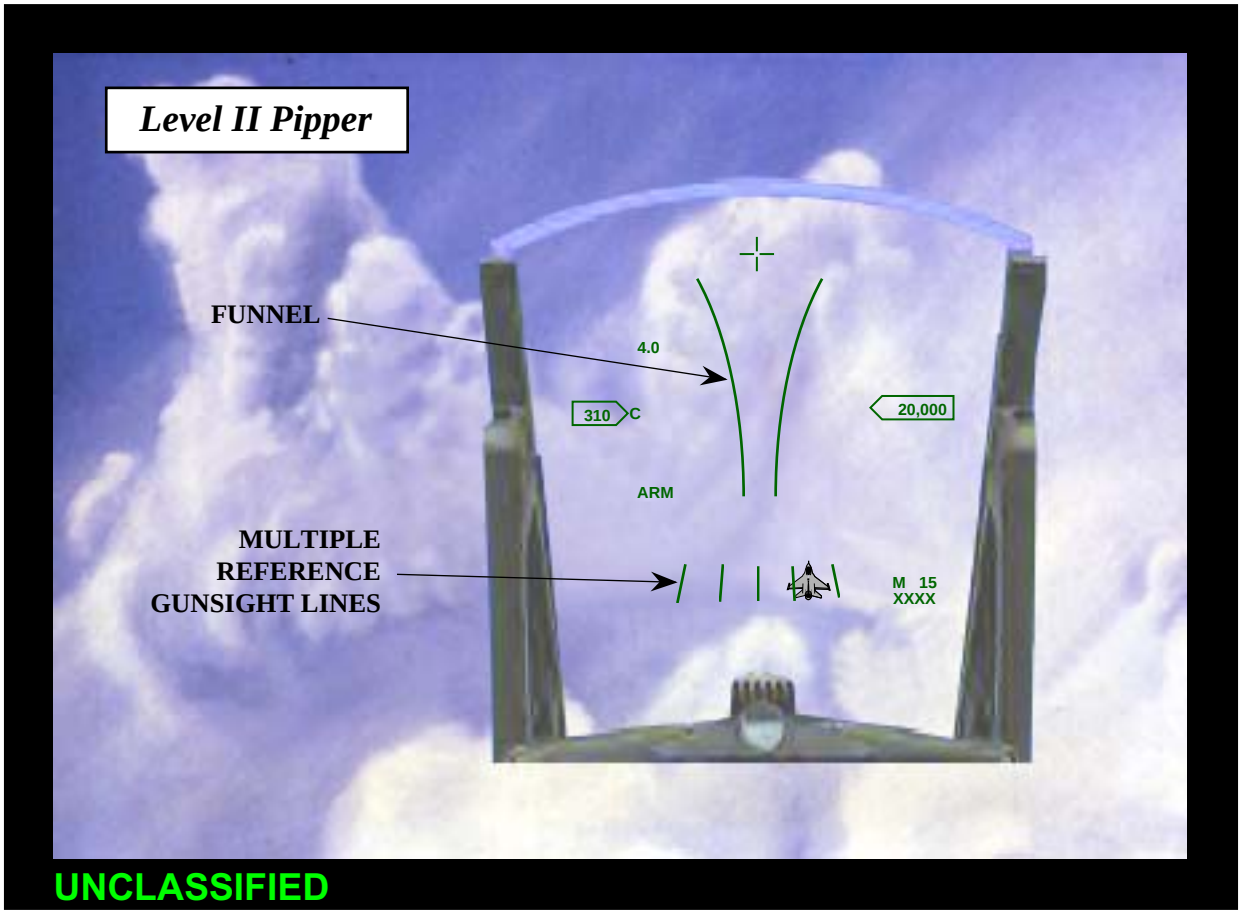
4.4.14.3.2.1 EEGS Level I. The lowest level of symbology, Level I, consists of the gun cross and is used in the event of HUD or system failure. (See **Figure 4.20**, Level I Pipper.)

Figure 4.20 Level I Pipper.

4.4.14.3.2.2 EEGS Level II. Level II is the basic no-lock symbology. (See **Figure 4.21**, Level II Pipper.) It consists of the funnel and the multiple reference gunsight (MRGS) lines. Ranging can be obtained from wingspan matching. The funnel is used in low aspect (up to 50 degrees) or high-aspect (130 to 180 degrees) shots to establish the aircraft in the proper POM and to track the target. The top of the funnel is 600 feet range and the bottom is between 2,500 and 4,000 feet, depending upon altitude, bullet type, and the level of the lock. An accurate aiming solution exists when: (1) the target is being tracked at the point in the funnel where the wingspan is equal to the funnel width (assuming the proper wingspan is set); and (2) the shooter rate of turn approaches that of the LOS to the target. The only assumption here is that the target is turning into the attack. You are thereby provided a sight with a good estimation of proper lead angle out to approximately 1,500 feet, where the width and slope of the funnel decreases to the point where wingspan matching is no longer accurate. The MRGS lines are used in high LOS rate attacks (such as beam aspect against a high-speed target) to establish you in the targets POM with excess lead. Finally, Level II symbology includes the firing evaluation display system (FEDS). These are simulated rounds that are fired at the rate of five per second while the trigger is depressed and are displayed on the HUD as dot pairs. The dot pairs move downward across the HUD in the same way that trac-

ers would move had they been fired, and their width corresponds to their current range in mils (based on the entered wingspan).

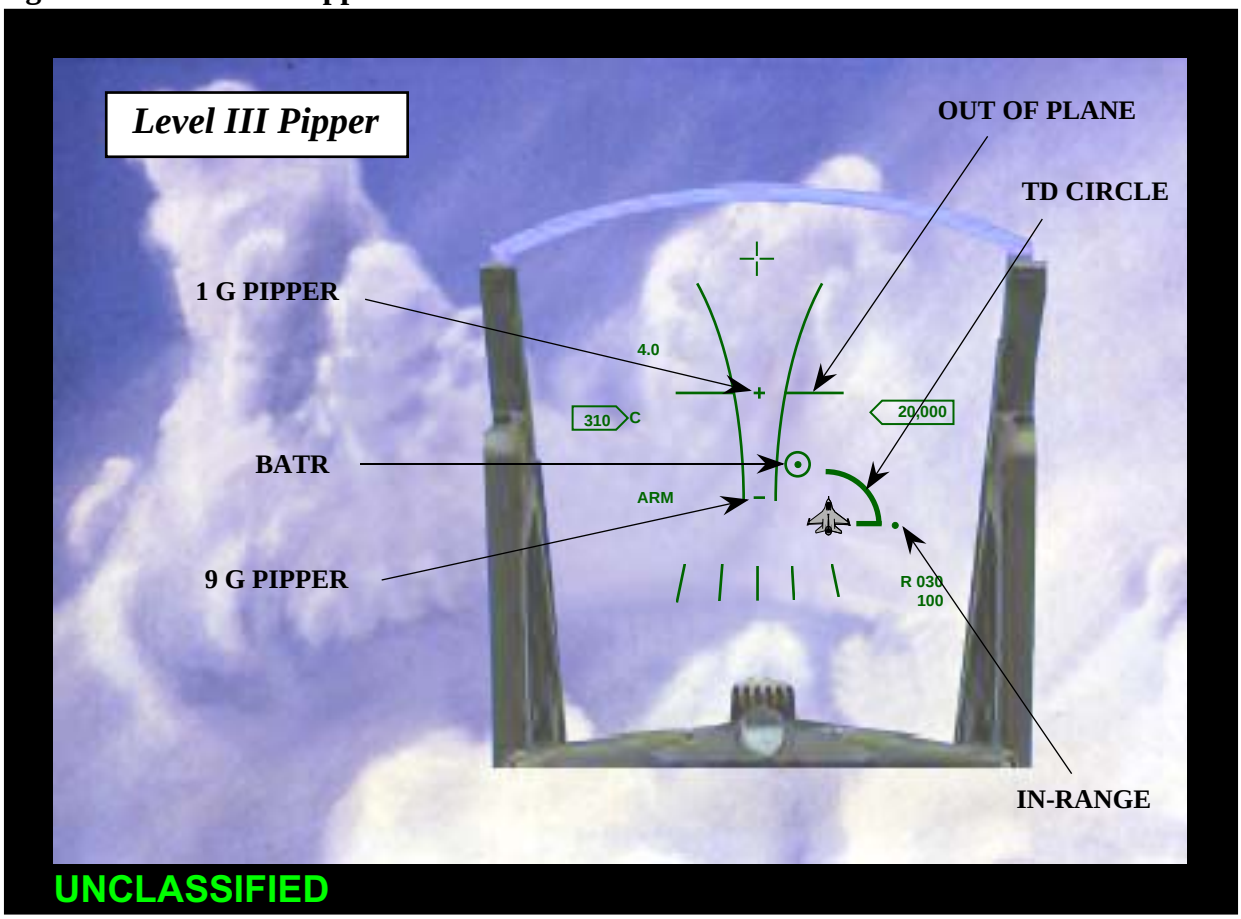
Figure 4.21 Level II Pipper.



4.4.14.3.2.3 EEGS Level III. When radar lock-on occurs, target range is the first information available and is the only information needed for the system to smoothly transition to Level III. (See **Figure 4.22**, Level III Pipper.) The funnel and MRGS lines are retained and function as in Level II. Four additional references are also displayed: (1) A target designator circle (instead of the TD box) is centered on the target and displays a clock analog of target range; (2) A maximum range cue is displayed as a dot on the periphery. It shows the range that indicates effective range (this ensures the proper bullet impact velocity needed for high explosive incendiary (HEI) fuze function); (3) Three aiming references are displayed. The small cross is the 1-G pipper and indicates proper lead angle for a constant velocity (straight and level) target. The 9-G pipper is the in-plane maneuver potential line and shows proper lead angle for a target turning at maximum instantaneous rate. This reference (the bar) gives you a well-defined lead angle boundary to use as a reference in estimating the correct lead angle. Abeam the 1-G pipper is the out-of-plane maneuver potential line that provides an aiming reference for an evasive target. The end of these lines indicates the potential movement by the target in one bullet TOF. Here the algorithm assumes a maximum sustained turn rate of 20

degrees per second at sea level. This turn rate decreases with increases in altitude and airspeed; (4) To assist in shot evaluation, a 6-mil circle (corresponding to the gun dispersion) is displayed after squeezing the trigger and showing the location of the bullets as they go through the target's range. This bullet at target range (BATR) symbol is used instead of the FEDS whenever valid target range is available and is displayed on the HUD from one TOF after opening fire to one TOF after releasing the trigger.

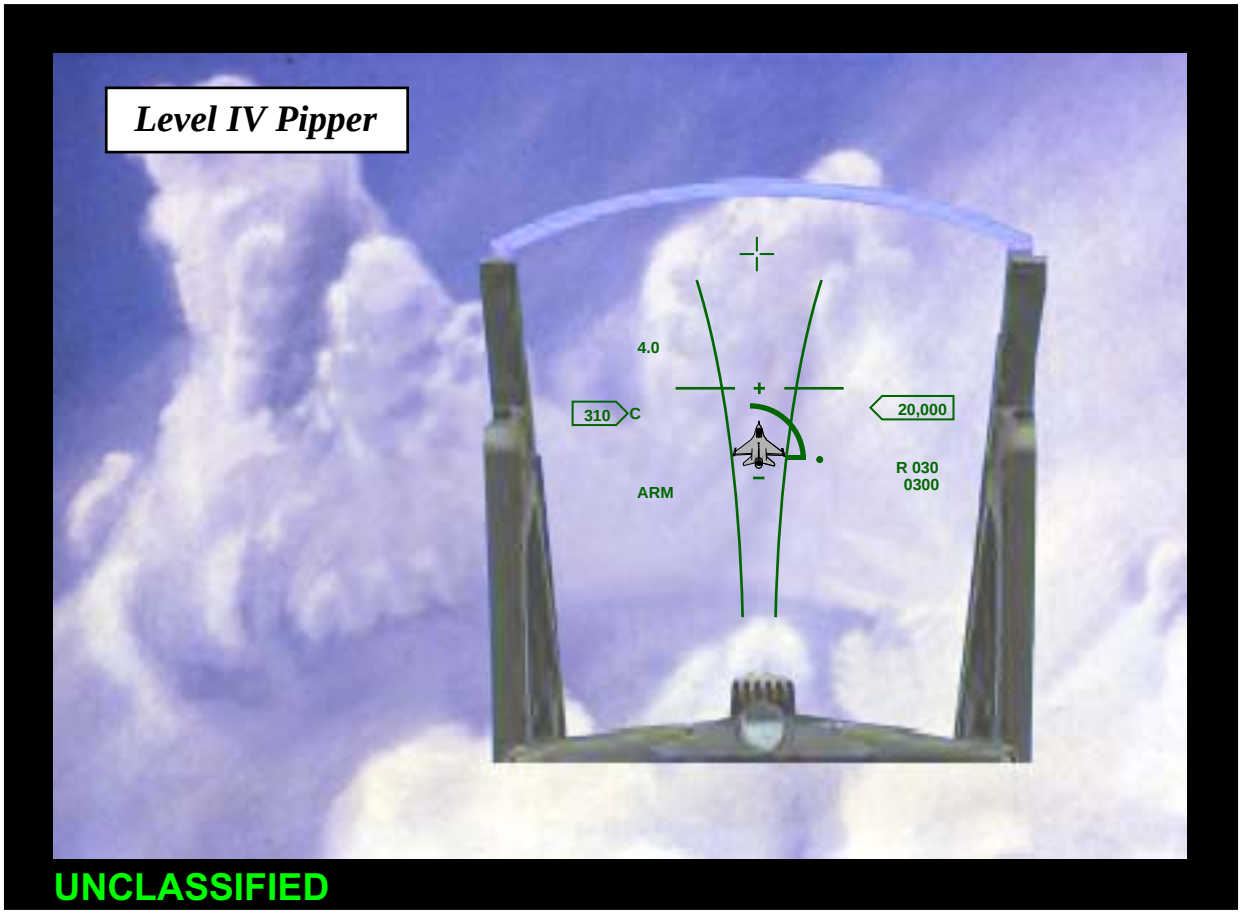
Figure 4.22 Level III Pipper.



4.4.14.3.2.4 EEGS Level IV. Shortly after lock-on, the radar obtains target velocity and the sight transitions to Level IV. (See **Figure 4.23**, Level IV Pipper.) The sighting references now transitions from more of a pure lead computing optical sight (LCOS) to a blended LCOS and director sight. A pure director sight is not feasible because at short ranges, radar-tracking errors cause the sight to jump around with a random, noisy motion, and making it unusable. To smooth out the sight, the system behaves as an LCOS system inside 500 feet and a combination of LCOS and director systems outside 500 feet. What this filtering means is the pilot must track the target for about 0.25 second before shooting, or shoot about 0.25 second before the pipper is on the target. The funnel retains its original shape but now responds to target maneuvers and is parallel to the target's POM. The MRGS lines are removed because the funnel now extends to the bottom of the HUD and can be used as an

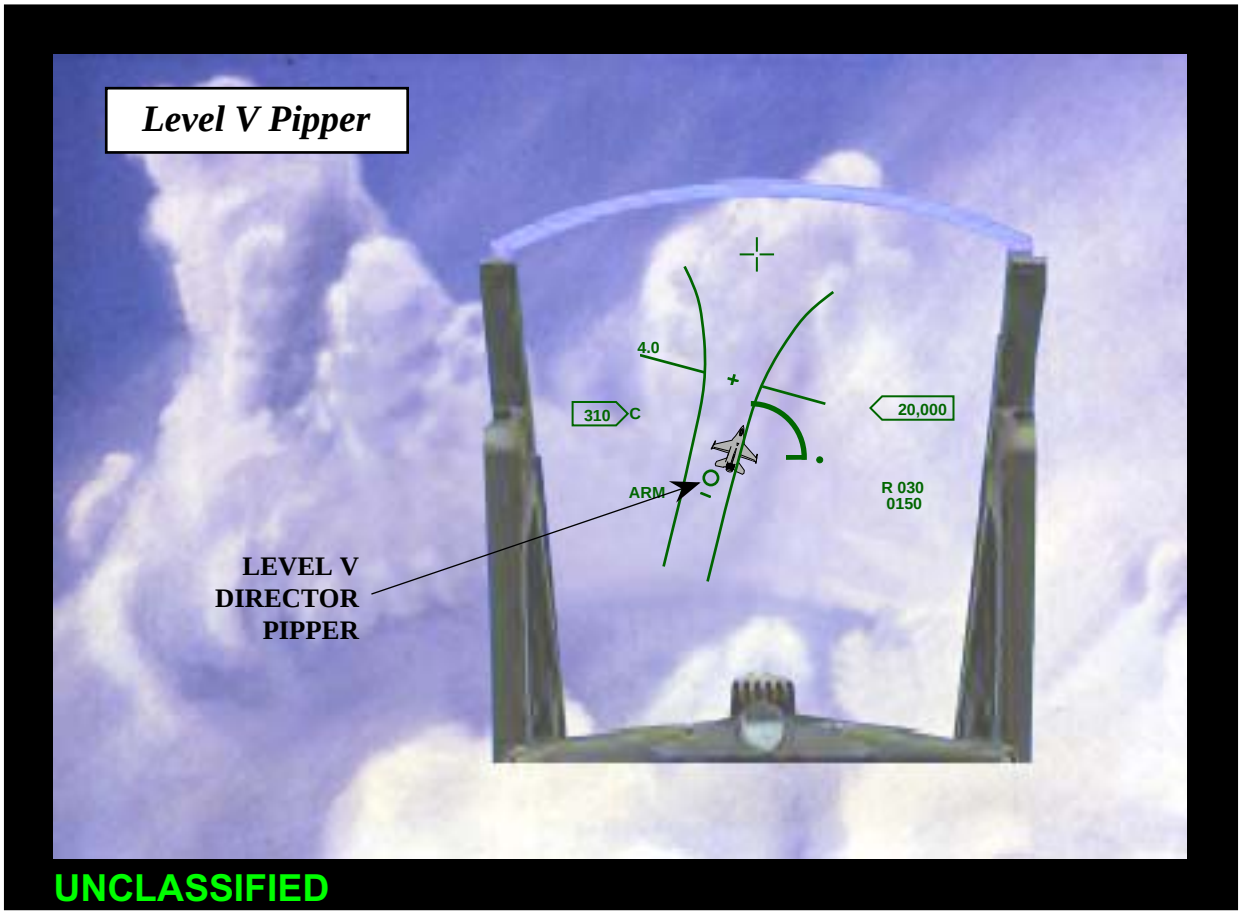
aiming reference at all target aspects. All remaining symbology is the same as in Level III.

Figure 4.23 Level IV Pipper.



4.4.14.3.2.5 EEGS Level V. Several seconds after lock-on, the radar can determine target acceleration and the sight transitions to Level V. (See **Figure 4.24**, Level V Pipper.) Once range is inside the computed maximum range, a 4-mil Level V pipper appears in the funnel. The Level V pipper uses the radar's estimate of target acceleration and the same LCOS/director blending as the funnel (LCOS lateral aiming error has been eliminated). The Level V pipper is a true “death dot” only in a stabilized solution (remember the 0.25 second settling time) against a target on a predictable flight path (constant POM, velocity, and G). The funnel and the other symbology remain and are the same as in Level IV.

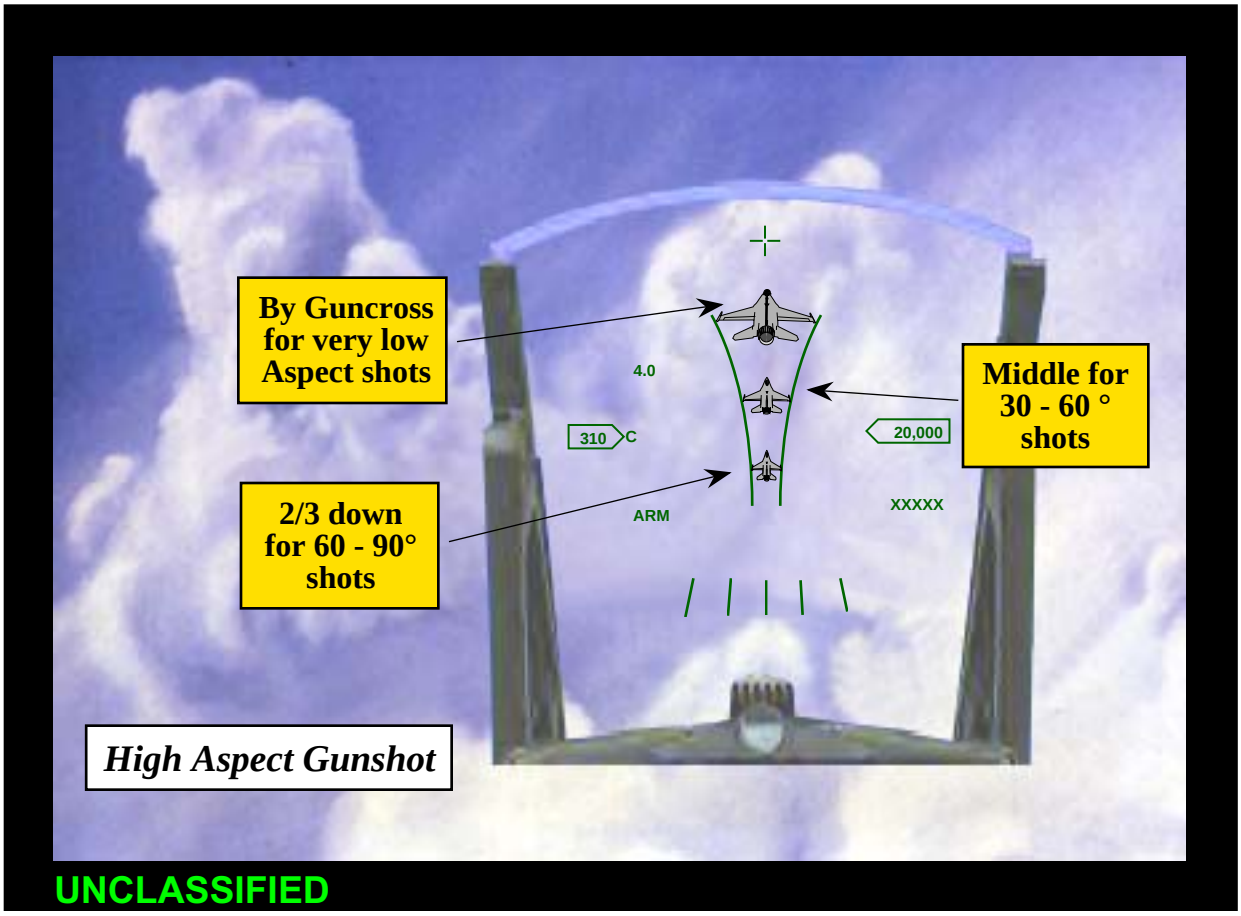
Figure 4.24 Level V Pipper.



4.4.15 High-Aspect Gunshot. The high-aspect gunshot enables the pilot to get quicker kills, more shot opportunities, and intimidation moves by defenders are easily solved. The key to building this skill is practice in a controlled environment such as exercises. The skill must be well-honed or it turns the move into a risky proposition. (See **Figure 4.25**, High-Aspect Gunshot.)

4.4.15.1 The first step is to recognize when a high-aspect WEZ exists. This varies based on the pilot's proficiency. Typically, a high-aspect shooter wants to open fire around 4,000 feet to 5,000 feet with aspects up to 90 degrees. Decreasing range and increasing aspect while transitioning to the shot are the primary considerations in WEZ recognition. Aspect will increase based on the turn rate the defender can generate while you are converting to guns. As a ROT use 20 to 40 degrees higher aspect than you currently see. Plan on losing about 2,000 feet in range in the conversion to lead (assuming you are at a good instantaneous turn and using altitude to decrease your radius). If you are comfortable with that aspect and corresponding range, then continue in for the shot. If not, then solve for aspect until it is acceptable. Keep in mind that the slower the defender, the less aspect he can generate to spoil your attack. The defender may be holding airspeed in reserve (instantaneous rate) and the offender needs to counter this by driving him lower on airspeed or being ready to reposition if the adversary increases aspect to an unacceptable level.

Figure 4.25 High-Aspect Gunshot.



4.4.15.2 The Transition. Rotate Lv low in lead using some of the altitude you have above the adversary. Power AB until pulling target to the HUD is assured, then idle and speed brakes. Attain fire-control radar (FCR) lock if needed with slewable / 10x 60 / 20x30. Use boresight once target in HUD. Listen for missile growl and check DLZ. Look for any available missile Wez on the way in for guns.

4.4.15.3 Gun sight mechanics. Place the gun cross in front of the defender's nose. Place defender between your feet to get your jet in the same POM. Avoid over-lead error by placing the target in the center of the HUD. As pipper catches up, reference director pipper for aiming on the target.

4.4.15.4 Repositions and jinking adversary. If the adversary jinks poorly or you are outside your own personal minimum approach range, reposition the guncross in the new POM and continue the shot. When the defender jinks aggressively or presses your personal comfort level for when to come off, it is time to reposition. Proficient high-aspect shooters can probably press into 2,000 to 3,000 feet before coming off the shot (if it is not going to be successful). 3,000 to 4,000 feet is a good range for marginal shooters (again, for a high-aspect gun shot.) The earlier the offender comes off, the sooner the defender can get his lift vector back towards you. The bottom line is the offender's proficiency level dictates the range at which he needs to come off. The longer the offender can press the attack, the longer the defender needs to defend against the shot—typically keeping the adversary pre-

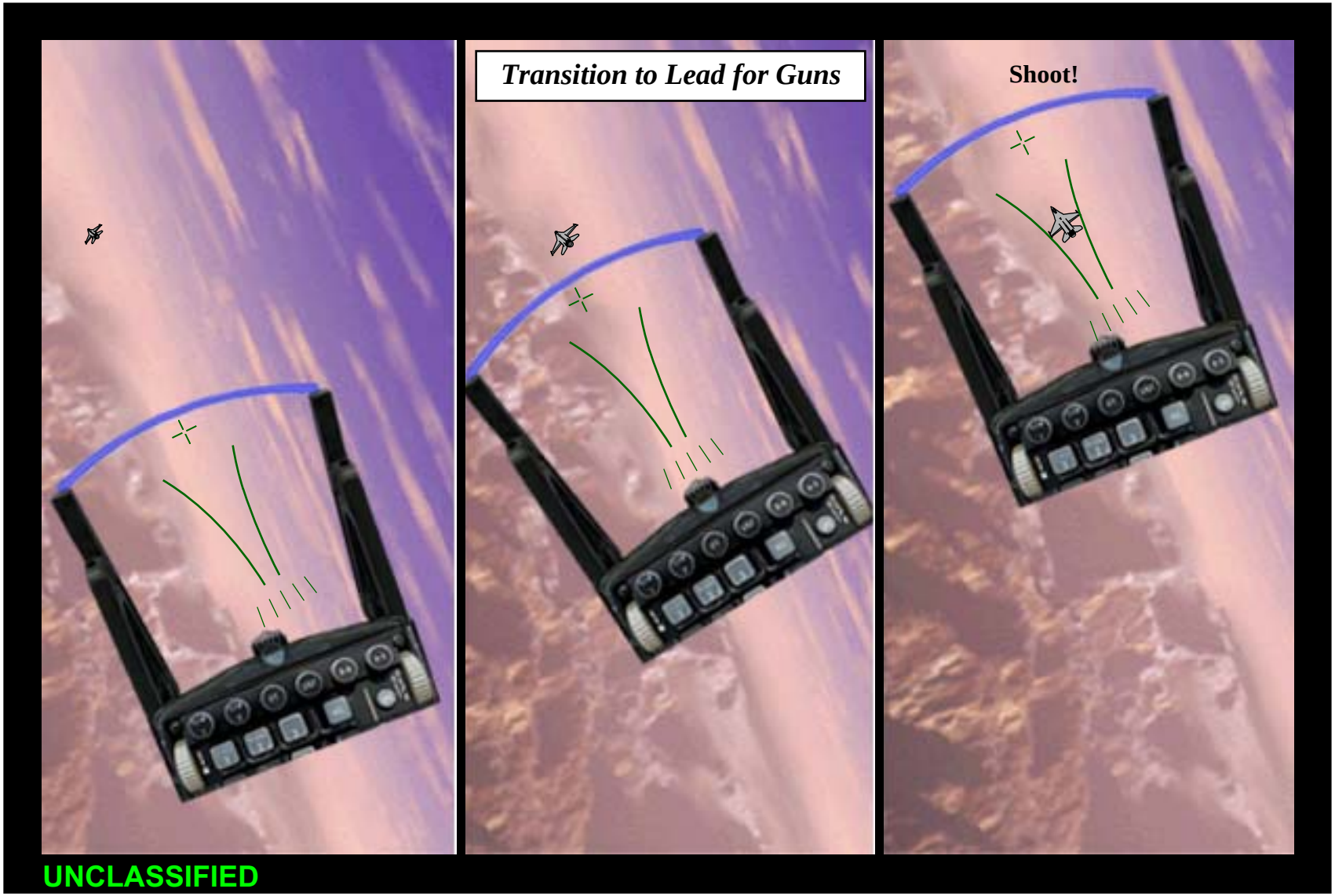
dictable and giving the offender the necessary turning room to continue the attack from an offensive, low-aspect position. The reposition mechanics are often misunderstood and misapplied. Think of the reposition from a high-aspect gunshot in terms of a bump and slide while pulling power and extending the speed brakes. Back off the G and let the defender slide 1 to 2 o'clock positions away from the HUD, and then pull to square the corner to decrease the HCA and aspect angle. The offender's goal now is to arrive at 2,000 to 3,000 feet back with 0 aspect and minimal HCA. Ideally, within 20 to 30 degrees 1 clock position off the offender's nose.

4.4.15.5 Should you find yourself losing control of 3/9, then a maximum G quarter plane towards the adversary's 6 o'clock may be warranted. A stack may result, which we'll cover in the defensive BFM section.

4.4.16 Low-Aspect Gunshot. Once you determine the aspect (45 to 55 degrees) and range is acceptable (3,500 to 4,500 feet), a transition to lead in order to use the gun is the next step. Rotate LV in lead to use the vertical that you have preserved to tighten your turn circle and bring the nose to bear with a full aft stick limiter pull. Pull power to idle and extend speed brakes once lead is assured. With crisp, rapid LOS to the HUD (energy advantage) select idle and boards with the defender 30 to 40 degrees out the top of the HUD. With slower LOS (closer to defender in airspeed) select idle and boards as the defender hits the top of the HUD. Get a lock on the defender, using 10x 60 or slewable until the defender is in the HUD, then use boresight as you continue to pull the appropriate lead for the shot. Do not pull excess lead, it only wastes time, and allow the defender more time to generate angles. Initially place the gun cross in the defender's POM. Once the proper lead and plane are established, finesse the final solution by using the director pipper. Fire a lethal burst as the pipper approaches the defender's aircraft, about one aircraft length away. If able continue to shoot and kill the defender, if you miss reposition and prepare to reestablish the gunshot if the defender is still alive. Think shoot-lag-shoot to preserve your offensive position. Unless the offender is slower than the defender, every bid to lead causes closure.

4.4.16.1 The defender may react to your gunshot attempt, and you must be ready for this. The soon-to-be extinct defender will typically pull hard into you providing a slightly higher aspect picture which may require a little more lead but is easily solved with a lethal burst. A smart defender will attempt to spoil your shot through a change in POM/out of plane jink. The defender may unload/bunt at your shot which is neither a common or smart reaction. The difficulty in shooting the unloaded defender is the smaller cross-section of the aircraft due to near zero aspect (think WW II gun footage). The unload makes the gun shot tricky but decreases Vc, aspect and opens up a missile WEZ. Changing POM is the most common defender reaction. (See **Figure 4.26**, Transition to Lead for Guns.)

Figure 4.26 Transition to Lead for Guns.



4.4.16.2 Typically any time you take a gun shot you will accept some closure. Don't accept closure unless you're getting something in return: BATR frames on the hostile. If the defender jinks but the jink is so slight or ineffective that you can track the defender through it, then press the attack. If the defenders jink spoils your gun shot (at roll rates of 10 degrees/second the pipper will lag the true solution), then you need to stop the closure and reposition for another shot in the new POM. If closure is not a problem, it may be as simple as coming off the trigger, predicting the defender's new POM and placing your gun cross in lead for the next shot. As an ROT, never let the closure rate get higher than 1/2 of your range; i.e., 150 knots closing velocity (Vc) at 3,000 feet, 100 knots at 2,000 feet and 50 knots at 1,000 feet, unless you are committed to your last shot. If closure isn't under control or you're getting closer than you'd like (1,000 to 2,000 feet is a comfortable, lethal range, with the defender +20 degrees of the nose) then use his jink as an opportunity to decrease Vc or increase range.

4.4.16.3 Enhanced Envelope Gunsight Employment Considerations. For low-aspect shots with a radar lock on, a simple technique is to use the 1-G pipper to track the target when outside maximum range. This will establish the POM and solve the majority of the lead angle requirements (remember from basic gun theory that of the total lead angle, about 85 percent is lead for target velocity and 15 percent for target acceleration). Using the 1-G pipper initially makes it easy to transition to either the in-plane or out-of-plane maneuver lines once in range. You then open fire and strafes the target along its LV, using either the in-plane maneuver bar or the out-of-plane maneuver lines as a reference for the lead angle boundary.

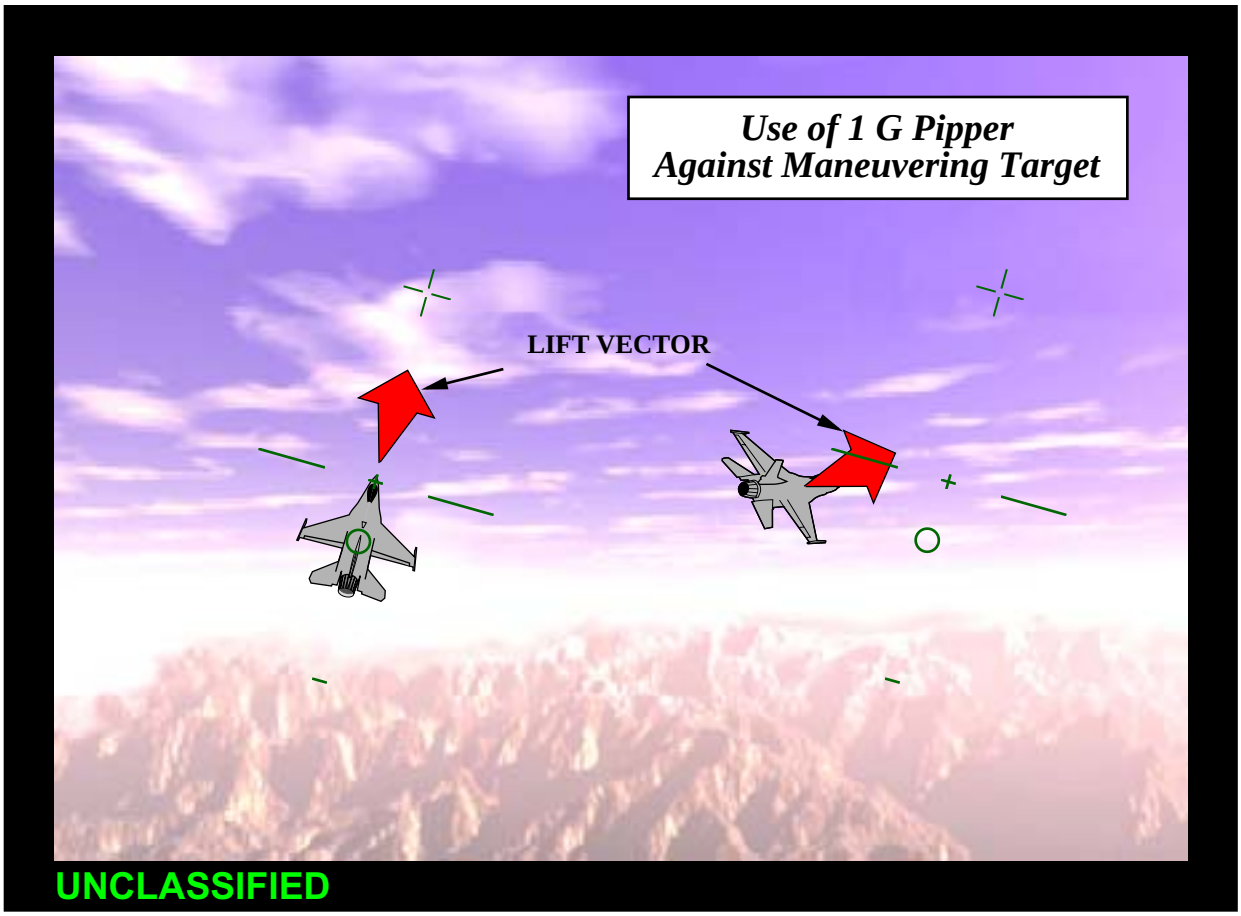
4.4.16.3.1 Maneuvering Targets. By using the technique shown in **Figure 4.27**, Use of 1-G Pipper Against Maneuvering Target, the attacker is using the best qualities of each part of the system. The radar can get a quick, accurate measurement of target range and velocity but lags in its estimation of acceleration. You are a poor estimator of target range and velocity, but you can very quickly perceive a change in acceleration by watching the target's planform and motion. Therefore, by using range and velocity inputs from the radar and acceleration and POM from your perception, and strafing the target over the area of uncertainty, you can shoot and hit targets.

4.4.16.3.2 Using the Director Pipper. With a full system lock and the Level V pipper displayed, the above technique is still valid. The 1-G pipper is less noisy than the Level V pipper and is much easier to track the target (ECM, chaff, and/or large target size can cause noise that results in pinpoint track confusion). Once in range, if the attacker sees the target remaining predictable, then transition to using the Level V pipper. Open fire about 0.25 second before the pipper is on the target and then increase G to strafe it from tail to nose (tail aspect).

4.4.16.3.3 No-Lock Employment. Without a lock, you must use funnel width in relation to the target's wingspan to determine the proper lead angle. An accurate firing burst can be obtained by first centering the target in the funnel. Next, open fire with the wingspan slightly larger or smaller than the funnel and let the target slowly track up or down the funnel. Cease fire when the wingspan is equal to the width of the funnel. It is important to remember that whenever relative motion exists between the funnel and the

target, the gun is properly aimed before the target wingspan reaches the width of the funnel due to the filtering properties.

Figure 4.27 Use of 1-G Pipper Against Maneuvering Target.



4.4.16.3.4 Beam Aspect Employment. The dynamics of beam shots require large lead angles and are difficult because the required turn rate to track the target exceeds the aircraft's turn capability at short ranges. In the 1v1 engagement, a beam shot could result in an exchange of the 3/9 line if the shot is missed. However, in a multibogey environment, it may not be sound to slow down and anchor in an attempt to achieve a low-aspect shot. Against a bomber with a tail gun, a beam/front aspect shot is the best option. A beam aspect shot requires that you establish the aircraft in plane with excess lead angle early on. In Level II and III, the MRGS lines are used initially to accomplish this by tracking the target on or between any of the MRGS lines. This puts the gun in lead and eliminates lateral error as you close. In Level IV and V, the funnel extends to the bottom of the HUD and is easily used to accomplish this initial lead requirement. This lead angle is maintained until range has decreased to the point where G forces are as high as you are willing to accept or until lateral control is too difficult. Aircraft G is then held constant as the gun is fired and the target moves up in the HUD. In this way, bullets are passing from in front of the target to behind it. Controlling lateral error (keeping the target centered in the funnel) becomes the critical factor, not lead angle.

4.4.16.3.5 High-Aspect Employment. High-aspect shots are very fleeting in nature and are currently not permitted above 135 degrees AA. However, in a multibogey environment, a high-aspect shot and a separation may be the best alternative if you are unable to get a missile shot and are merging at high-aspect. Employing the gun in a high-aspect attack first requires that you recognize the opportunity for such a shot early on. A pursuit course with the target near the top of the funnel should be initiated so that the shot does not take place with insufficient HCA for a separation during the disengagement. As you approach maximum range, establish the required lead and open fire. Open fire with the pipper (either Level V pipper or 1-G pipper) coming up from behind the target, pull the pipper through the target, then relax the Gs and let the target track back through the pipper. This will create a burst pattern from behind to ahead to behind the target. This technique compensates for any lead angle errors and makes lateral control critical. Without a radar lock, you must now analyze range to determine when to open fire. Keeping the target near the lower third of the funnel until the wingspan approaches the size of the bottom of the funnel (approximately 3,000 feet) can approximate this. Now open fire and track the target until the wingspan is larger than the funnel, then relax the G and let the target track up the funnel to ensure sufficient separation.

4.4.16.4 Gunnery Errors. Gunnery errors can be separated into three categories: dispersion, systemic, and pilot-controlled errors.

4.4.16.4.1 Dispersion. Dispersion is different for each bullet and accounts for the shotgun-type pattern. The dispersion for F-16 gun is 6 mils; meaning 80 percent of the bullets can be expected to hit inside of 6 mils.

4.4.16.4.2 System Errors. Systemic errors result from boresight inaccuracies, radar angle tracking inaccuracies, or any other non-pilot errors. These errors vary from day-to-day and from aircraft-to-aircraft and result in a movement of the burst center, some unknown distance from the aimpoint. In the F-16, the dominant systemic errors come from boresight and radar tracking errors. Boresight errors can be reduced to less than the 6-mil dispersion with a good boresight program. Radar tracking errors arise from the radar tracking different parts of the aircraft, which induces errors in its estimate of velocity and acceleration. However, these errors typically lie along the target's flight path, producing a miss in front of or behind the target. Therefore, the best shooting technique to ensure at least some hits is to strafe the target along its flight path.

4.4.16.4.3 Pilot-Controlled Errors. The final type of error concerns the pipper position relative to the target, the pilot-controlled errors. It is obvious that the pipper must be near the target to get a hit. The bottomline is that regardless of the source of error, you must strafe the target along its flight path and fire a lethal burst to compensate for errors. This will result in a higher probability of hitting and killing the target.

4.4.16.5 Summary. The gun is an effective, short-range, all-aspect weapon if properly used. Target aspect and geometry are prime players—be mentally aware of what you want to see in terms of gunshot opportunities and take advantage of them as they arise or when you make them happen. Know the logic and inherent errors of the gunsight and where to aim for maximum effectiveness. Effective gun employment requires practice and, most of

all, mental preparation. The gun must be in the target's POM, gun cross in lead, and in range. Instead of trying to fly the pipper to the target, concentrate on establishing the gun cross in front of the target and in the target's POM. Then, using the EEGS pipper (lock) or funnel (no-lock) as an indicator of the proper lead angle, make small plane and lead angle changes to superimpose the pipper on the target. Open fire before the pipper reaches the target, and then strafe the target from one end to the other. If the variables change, reposition and shoot again if the situation allows.

4.4.17 Reposition mechanics. An adversary who performs a 360-degree loaded rolling out-of-plane jink will generate closure and decrease available range for the attacker if left uncountered. Two ways of controlling range and closure in this instance is a lag roll (aka co-roll) or a counter roll. Both are fairly effective when executed correctly. The key is not to let the defender get too far away from the nose (1 clock position, no more than 25 degrees on locator line).

4.4.17.1 The lag roll is performed in the same direction as the adversary. If the fight were a right-hand turn, the lag-roll direction would be to the right. Conversely, the counter roll is performed opposite the adversary's jink direction. Perform both basically the same way. Pull with maximum G in idle, speed brakes extended. Pull to place the defender no further than the intersection of the glare shield and canopy or approximately 25 degrees on the locator line. The key is to keep the maneuver loaded the entire time. The idea is to fly a bigger circle than the defender. Failure to keep the roll loaded results in a bigger altitude delta and less slant range to the defender. Finally, flying a bigger circle doesn't mean rolling slower. The longer your nose is off the adversary, the longer he has to set up his next move—forcing you to react to him. Beat the adversary to the punch by predicting where his nose will go, assessing your range and closure and establishing lead before he finishes off his jink. You drive the fight, which will soon be over. Remember that a heater WEZ is usually available when the adversary jinks underneath.

4.4.17.2 As the fight gets closer to the floor, the attacker and the adversary lose the ability to use loaded 360-degree rolls due to ground clobber. As an ROT, 1,500 to 2,000 feet above the floor gives enough for one last loaded underneath roll. The defender is then forced into a nose counter defense. The key here is to avoid getting noses out-of-synch, and fix range and closure problems first. Then proceed with the gun. Loaded rolls over the top are still available to the attacker to stop closure. The key is to keep the defender out of the HUD until ready to shoot. Also, don't try to fix a problem that isn't there. If the range is snug (approximately 1500 to 1200 feet), but the closure is zero or in the negative numbers, pull lead and kill.

4.4.17.3 The ultimate objective is to preserve your range and take lethal shots until you kill. If unable and it becomes apparent that you will no longer stay in your desired shoot window, it is time to take the last shot and transition to a stack where you will regain the offensive position. Push the power up to AB as you take a final shot (watch the training rules) and reposition by setting the wings and pulling up into the vertical. Hopefully, the final shot is lethal, and no follow-on maneuvering is required. If the shot isn't lethal, you will find yourself in a winning stack due to the reaction the defender accomplished to spoil your last shot, and the lower energy you have forced upon the defender. If this isn't the

case, you may find yourself in a neutral/defensive position, which is most undesirable and will be covered in the defensive BFM section.

4.5 Defensive Basic Fighter Maneuvers.

4.5.1 Mindset. Survive for as long as possible. Reverse or neutralize if able. Never give up.

4.5.2 Gameplan. Prevent the attacker from employing ordnance, and force attacker to make mistakes. Continuously create problems for the adversary. If the adversary solves the first problem, create another one. Look for weaknesses such as airframe/ordnance limitations or errors such as poor pursuit course selection and exploit them to your advantage.

4.5.3 Objectives.

- Survive from a Position of Disadvantage
- Negate the Initial Attack
- Keep Tally
- Create maximum geometry problems for attacker.
- Recognize/exploit errors/weaknesses
- Perform effective jinks/infrared countermeasures (IRCM).

4.5.4 The Threat.

4.5.4.1 Today's air-combat environment is extremely lethal and unforgiving. Practically all modern fighters have advanced radar and infrared- (IR) guided missiles, and all but a few carry internal guns. Radar missiles typically have long effective ranges that preclude being able to run away (bug out/blow through) from a visual encounter. Even from a high speed, 180-degree AA pass, the least capable medium-range missiles (MRM) usually provide the adversary a shot opportunity at the fleeing fighter. IR-guided missiles get more lethal every year as new types are developed, and older models are upgraded. Whereas second and third generation IR missiles not only had small WEZs, but could also be reliably defeated by flares, newer short-range missiles (SRM) have large off-boresight slave angles and robust counter countermeasures (CCM). These advances in SRM technologies have made the old check and extend defense and to some extent the constant turn rate defense largely obsolete.

4.5.4.2 Today, about the only sanctuary left in the visual arena is in close, inside the minimum range for the missiles, and/or outside their slaving limits, while avoiding the adversary's nose (the gun WEZ). Our gameplan will focus on rapidly getting to and maintaining this sanctuary, while carefully watching for an exploitable adversary error.

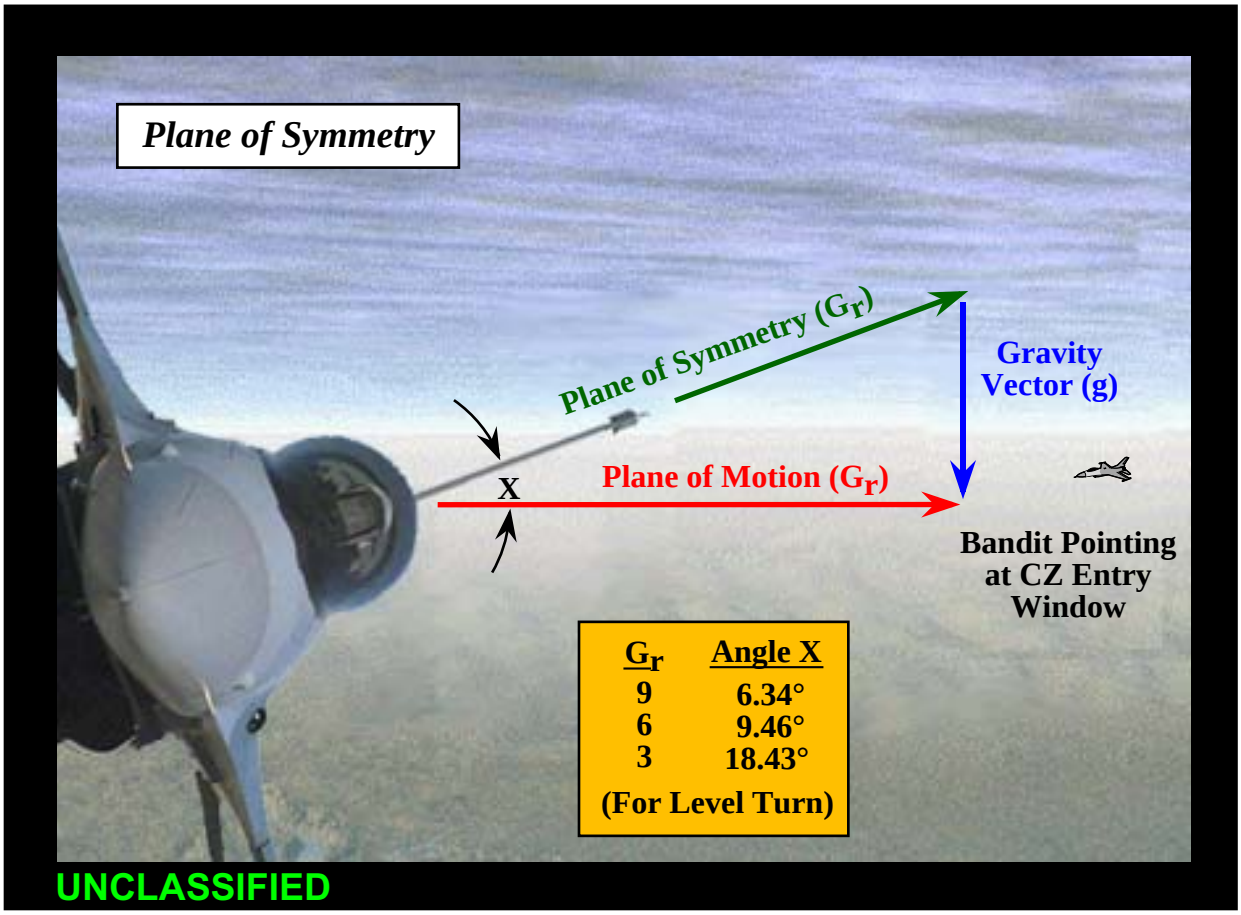
4.5.5 Initial Reaction. As previously stated, survival is the most important priority in defensive BFM. Recognizing and exploiting attacker errors is the next priority. Next, if the attacker isn't making any errors on his own; i.e., he has solved the long-range problems and achieves a gun WEZ; effective jinks are the last line-of-defense. Fully understanding this priority hierarchy can help simplify your defensive decision-making. For example: An AB initial break turn would significantly increase the angles turned over time by the defender, and complicate the adversary's follow-on maneuvering. However, that AB break would nullify any IRCM efforts and allow a quick IR missile kill by the adversary with no follow-on

maneuvering required. Therefore, do not break in AB. Also, gun's defense frequently suffers when defenders are reluctant to give up the turning room required to effectively get out-of plane for a medium-aspect guns jink. Jinking helps solve the adversary's closure and angles, but not jinking means you die. Remember, dead men don't reverse.

4.5.6 Follow-On Maneuvering. Creating BFM problems at the expense of airspeed and potential energy (altitude) is valid. Continuing to bleed-off airspeed in a limiter pull, while a well-flown adversary roots around in to deep 6o'clock for a heater, is dumb. Continuing a limiter pull that is effectively moving the adversary forward on your canopy is smart. If using up all your knots will pull him all the way into the HUD, then use all your knots (and gun him). It is a simple matter of priorities.

4.5.7 Lift Vector (LV) Control. Lv control is critical to effective defensive maneuvering. For typical break turns of 7 G to 9 G your Lv is no more than 10 degrees off the canopy reference line (even for a worst case level break). An initial break turn, where you put the adversary right on the reference line and pull, will be close enough. This will actually result in a slight descent relative to the adversary, which, as we will shortly see, is not at all a bad thing. (See **Figure 4.28**, Plane of Symmetry.)

Figure 4.28 Plane of Symmetry.



4.5.8 Plane of Motion (POM). At lower G loads your POM will be displaced significantly further from your plane-of-symmetry (POS). The main visual cue here becomes adversary

position relative to the horizon. If the adversary is not making any big out-of-plane maneuvers, an Lv on/slightly low turn should hold him in the same relative position with reference to the horizon. Lv below the adversary will cause him to move higher relative to the horizon. Lv above the adversary will cause him to appear to move lower relative to the horizon. These same concepts apply to high G turns as well. However, just pulling him straight down the canopy line may be easier to visualize at higher G. (See **Figure 4.28**, Plane of Symmetry.)

4.5.9 Head Positioning.

4.5.9.1 Improper head position during high G defensive turns is a common error. The first instinct is to attempt to support the weight of your head and helmet using your neck muscles alone. This is basically impossible, and can lead to serious muscle injury at high G levels. Equally unacceptable is the practice of looking at the adversary under low G, then looking forward during the break turn (High G), then looking back to reacquire the adversary after the speed and G bleed down. You cannot exploit a pursuit error you do not see.

4.5.9.2 The best technique is to use the seat headrest to support your helmet during the turn. The following example is for a right turning break:

4.5.9.2.1 As you begin the roll to Lv on/slightly low, rotate your upper torso about 45 degrees to the right, and lean your upper body slightly to the right. Turn your head to the right another 45 degrees or so and tilt it back just enough that you can see the adversary on the reference line with your eyeballs at their extreme upward and right slave limits. This position will place the right side of your helmet against the lower left side of the ejection seat headrest. Let the headrest support the weight of your helmet, and you will be able to turn very hard in relative comfort while watching the adversary. By rolling your helmet against the headrest and moving your eyes, you can follow the adversary through a wide range of flight paths. (See **Figure 4.29**, Head Positioning.)

4.5.10 Initial Break Turn. The initial break turn needs to optimize the defender's survival and be a combat-oriented habit pattern. With this in mind, the following four steps must be instinctively and simultaneously made.

4.5.11 Reduce power to sub-AB. There is some debate on MIL versus idle power breaks vs. specific IR threats. To keep this unclassified, the only in-all-cases habit should be an idle power break assuming the worst case scenario.

4.5.12 Lift vector slightly low. It is critical to get adverse background versus modern IR missiles. Although a low-lift vector will provide the attacker some turning room, it is imperative to survive. The defender can worry about the free turning room if he's still alive to be concerned about it! (See **Figure 4.30**, Adverse Background.)

4.5.13 Maximum G pull. Make it hard as body/stores limits allow. The body limits definition is staying awake and the ability to analyze the attacker's actions. One cannot effectively fight proper BFM if you see a black dot or end up G LOCed. You must see the pursuit course and ordnance shot to effectively defend yourself.

Figure 4.29 Head Positioning.

Head Positioning

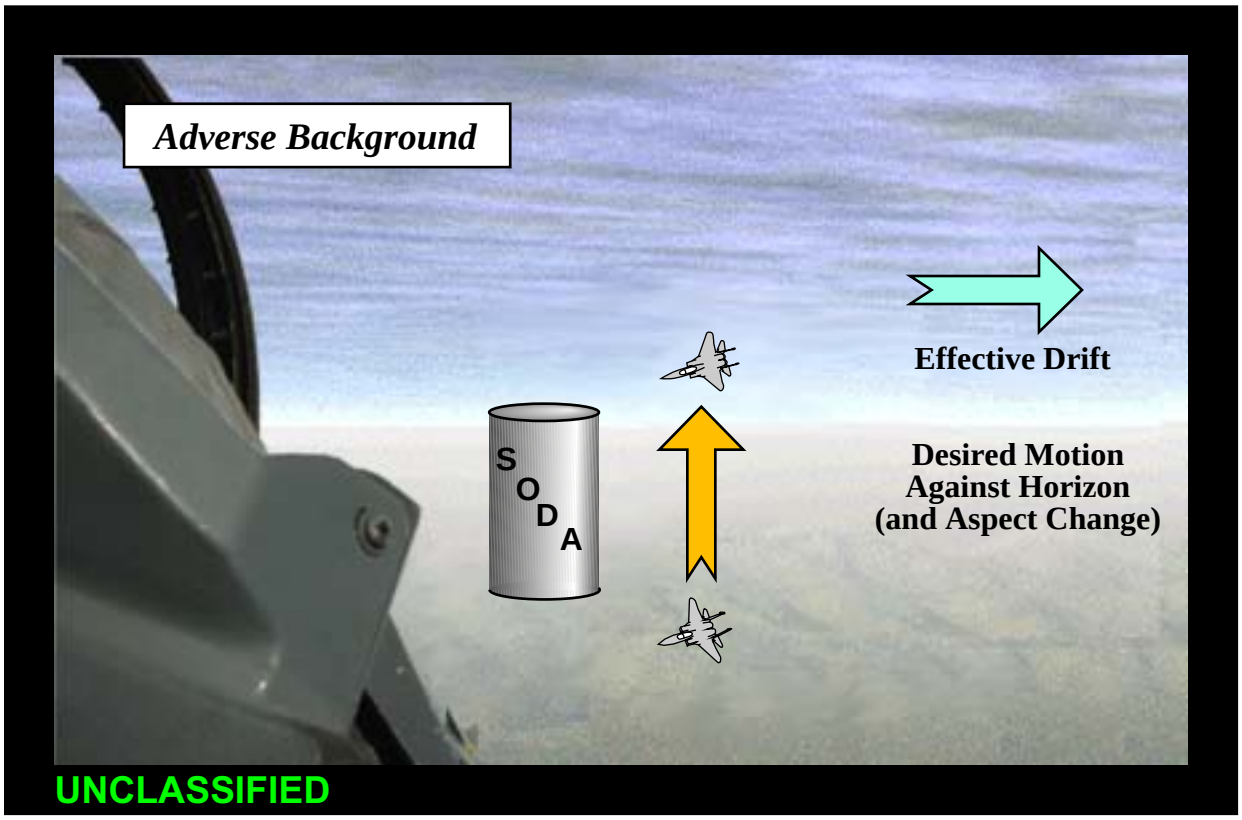
Prior to "fight's on"

In the LV-on break

- Other issues
  - Preflight stretching, practice at EOR, lap belt, kit straps

UNCLASSIFIED

Figure 4.30 Adverse Background.

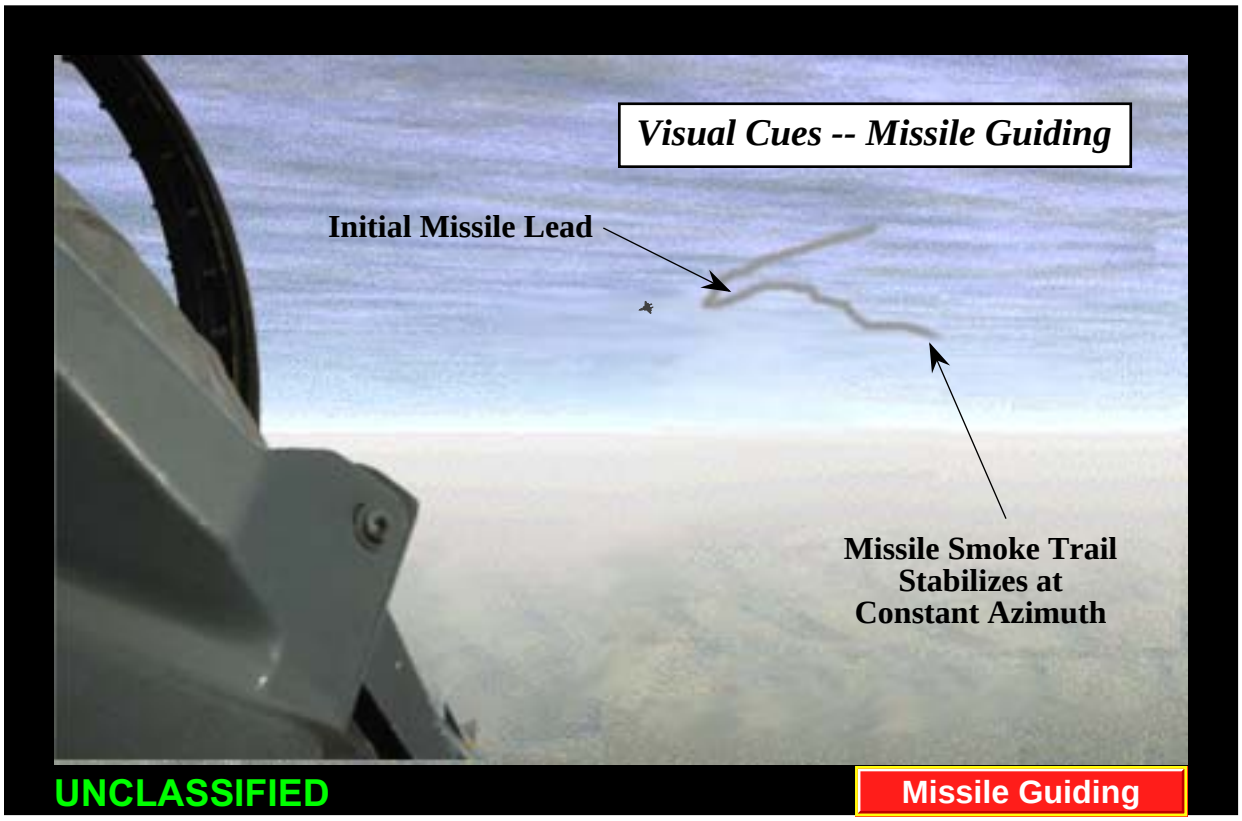


4.5.14 IRCM. Chaff and flares (in accordance with AEM guidance) are a must. Since one cannot always count on them dispensing and working 100 percent of the time, the idle break is critical.

4.5.15 Additional Considerations. The majority of F-16 combat-ordnance loads are CAT III. While most pilots have some established criteria for when they will jettison their external stores, discussion of the actual switch movements involved rarely includes references to the stores category switch. You need to realize that punching the emergency-stores jettison button alone will not provide the adversary with a face full of CAT I Viper. It will result in a CAT III Viper with no stores remaining unless the stores category switch is also moved to the CAT I position. This is a fairly involved series of switch changes to make while in a break turn. Also, when the Gs slam you back against the seat, it is a long reach for most pilots. You need to spend some time thinking about the impacts of this on your go-to-war switchology and habit patterns. With the foundation of defensive turn mechanics now built, we can continue into the actual techniques of defensive BFM.

4.5.16 Visual Cues: Missile Guiding. A guiding missile will rapidly move forward on your canopy and the horizon during the break turn, (probably to about your 3/9 line) then stabilize in one spot or slowly move forward as it zeros out its own LOS rates and guides to impact. If you see this, keep the power back (no higher than MIL), and repeat your optimum countermeasures (CM) sequence again, while ensuring you are getting dirt behind you in the missile field-of-view (FOV). Typical missile times-of-flight are short…this happens fast. (See **Figure 4.31**, Visual Cues—Missile Guiding.)

Figure 4.31 Visual Cues—Missile Guiding.



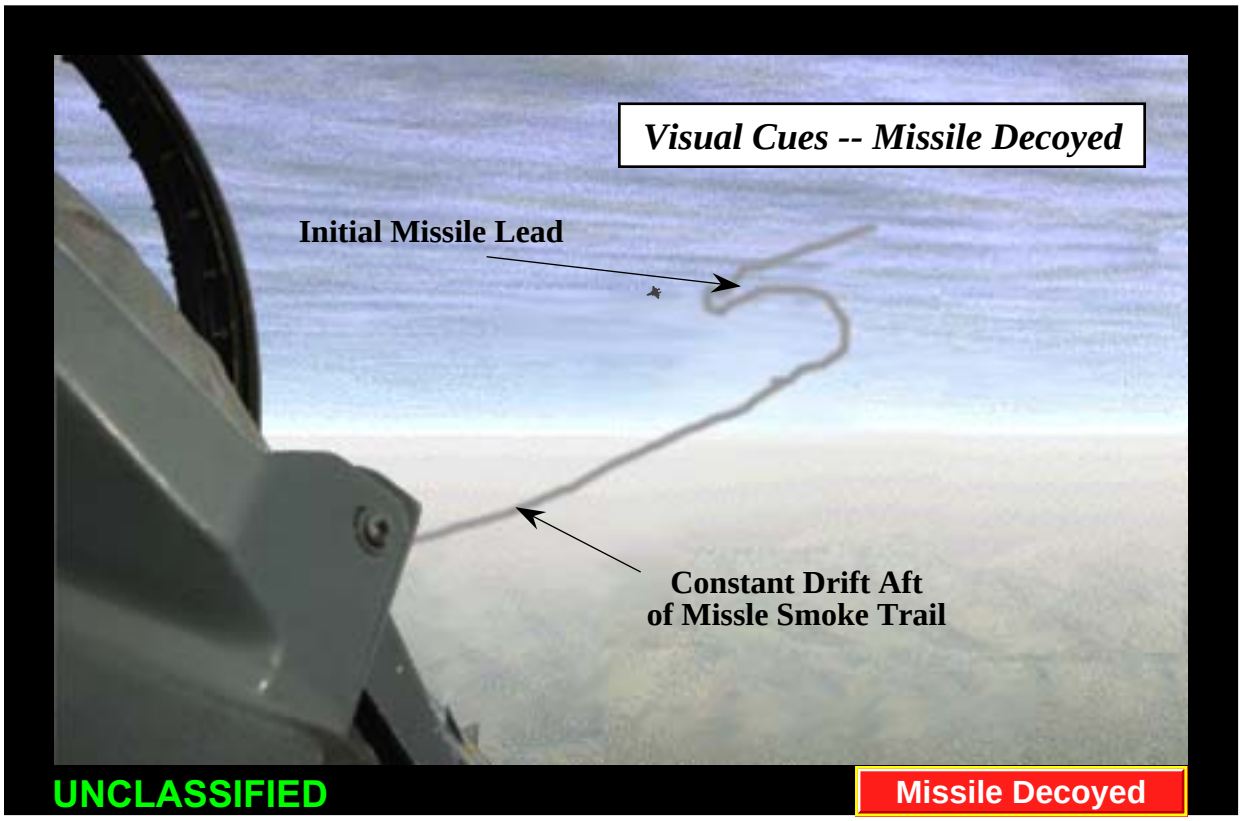
4.5.17 Visual Cues: Missile Decoyed. A decoying missile will make a clear move aft (relative to the horizon) as it guides to the CM behind you. It may not appear to move aft much on your canopy at first. However, as range decreases, it will appear to rapidly move aft on your canopy. As stated before, we are dealing with short times-of-flight. (See **Figure 4.32**, Visual Cues—Missile Decoyed.)

4.5.18 You Have Survived! What Next?

4.5.18.1 The process of defeating the initial missile attack will probably take at least 90 degrees of turn. By that point the adversary's chosen pursuit course should become evident. Regardless of the adversary's pursuit course, your LV on to slightly low turn will probably still work for at least another 90 degrees. Your turn is working if you are able to continue to move the adversary forward on your canopy LV line toward the HUD.

4.5.18.2 This brings up a basic simple truth of defensive BFM—if your turn is effectively moving the adversary forward or making him bigger, keep turning. You are creating an increasingly difficult BFM problem for the adversary, and the more your AA and HCA approach 180 degrees, the worse his problem becomes. The major question to answer as you continue through the first 90 degrees of break turn is what pursuit course is the attacker flying?

Figure 4.32 Visual Cues—Missile Decoyed.



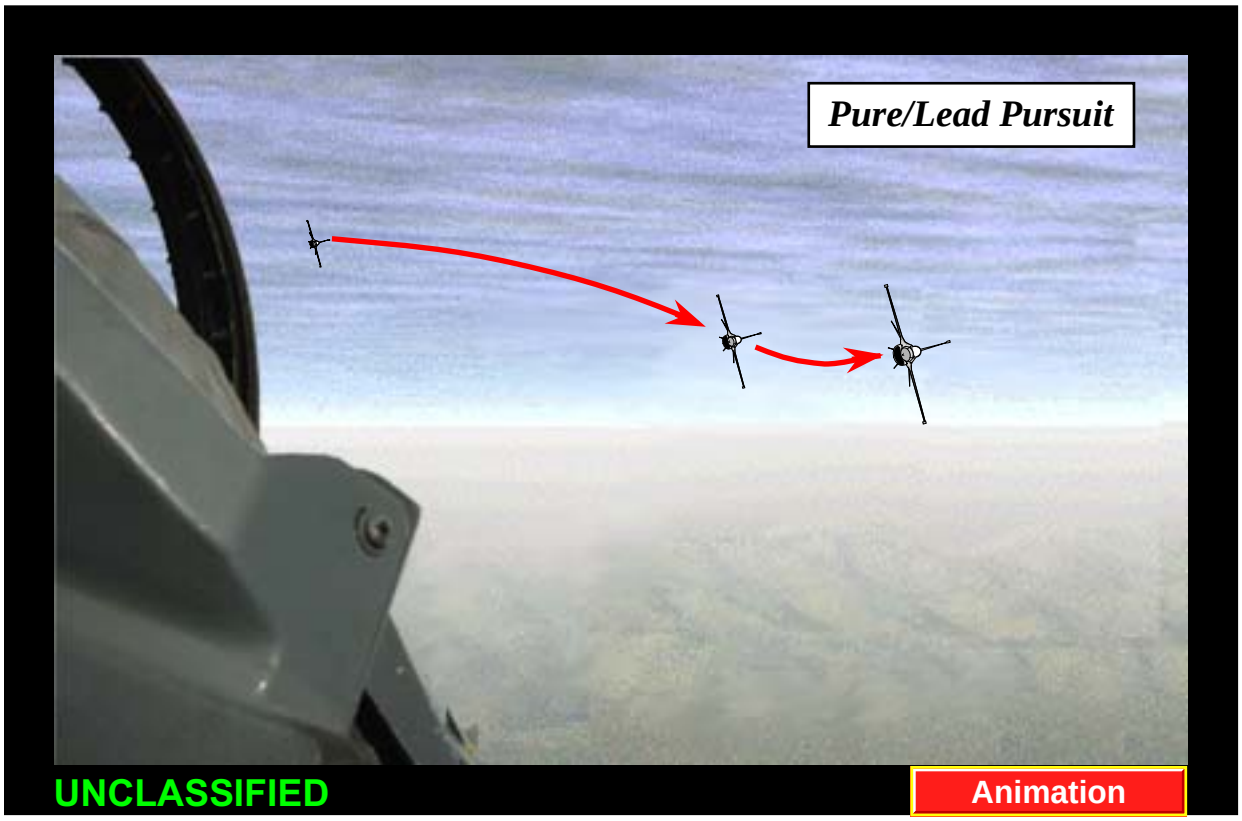
4.5.19 Pure and/or Lead Pursuit.

4.5.19.1 The visual cue for pure pursuit is obvious, the adversary remains in his initial nose-on pursuit course. Your hard turn will rapidly move a pure-pursuit adversary forward on the canopy, and for initial adversary ranges of greater than 2 NM you may actually get him to the HUD prior to merge. As range decreases with the adversary inside your turn circle, there will be some apparent aft movement. Although the adversary is in pure pursuit, his flight path is actually pointing behind you by an amount equal to his AOA. (See **Figure 4.33**, Pure/Lead Pursuit.)

4.5.19.2 An adversary who remains in pure pursuit may be either making a basic error, or pressing a missile attack in to minimum range and setting up for a separation to follow. Either of these could include a high-aspect gunshot attempt.

4.5.19.3 Your threat knowledge will pay off big here. What is the minimum range for his missiles at this aspect? Does he even have a gun? Can he fire it in this configuration? Is his gun canted up, down or aligned with aircraft boreline? What is its effective range? Get in the books.

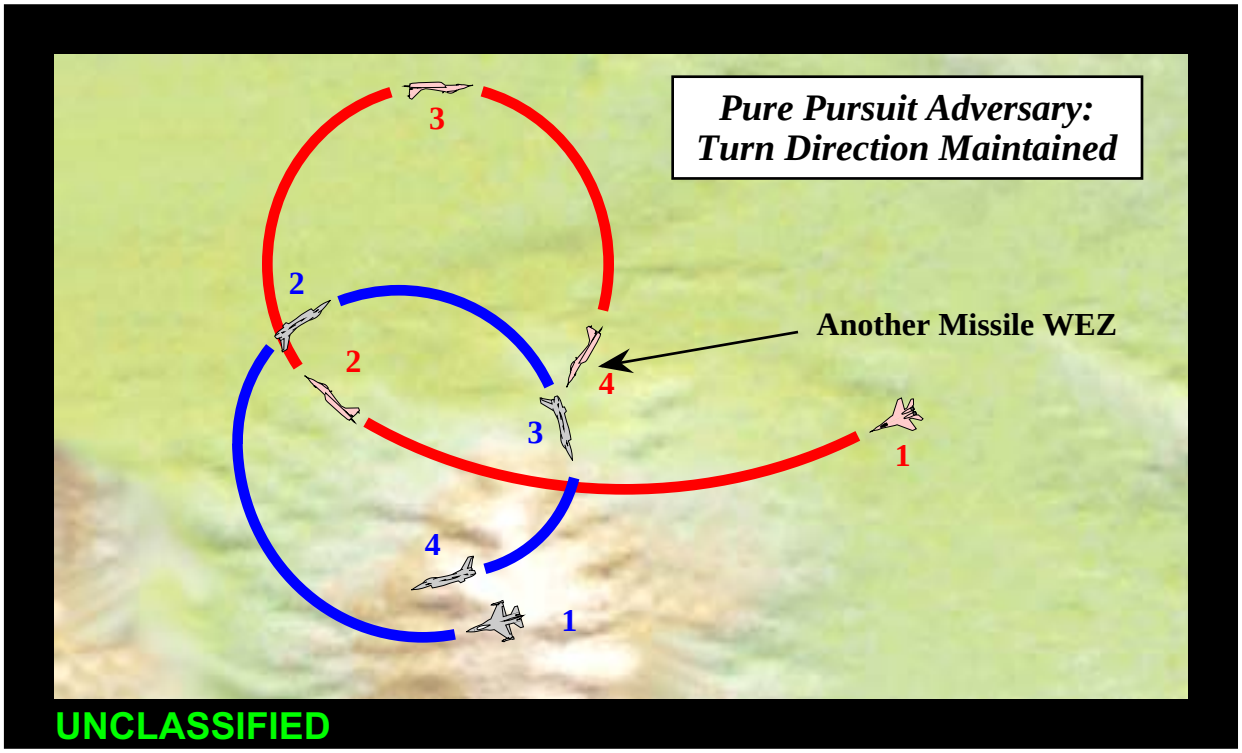
Figure 4.33 Pure/Lead Pursuit.



4.5.19.4 A pure-pursuit adversary presents a very straightforward application of the basic turning ROT presented so far—break LV on as described. Use CM and a reduced throttle setting. Select AB as soon as you are inside minimum range (Rmin) for his heater. Keep your LV on turn coming (since he will continue to move towards the HUD) unless he pulls lead for a gun attempt.

4.5.20 Pure Pursuit Adversary: Turn Direction Maintained. If, after the merge, you keep your turn going the same direction, the adversary can quickly use his turn rate advantage coupled with his larger radius to solve the HCA and AA problems and achieve at least a medium-aspect missile WEZ or even a sustainable CZ position. A better option is to choose a flight path that exploits the only real advantage you currently enjoy over the adversary. That advantage is your smaller turn radius; therefore, a reversal may be in order. (See **Figure 4.34**, Pure Pursuit Adversary: Turn Direction Maintained.)

Figure 4.34 Pure Pursuit Adversary: Turn Direction Maintained.



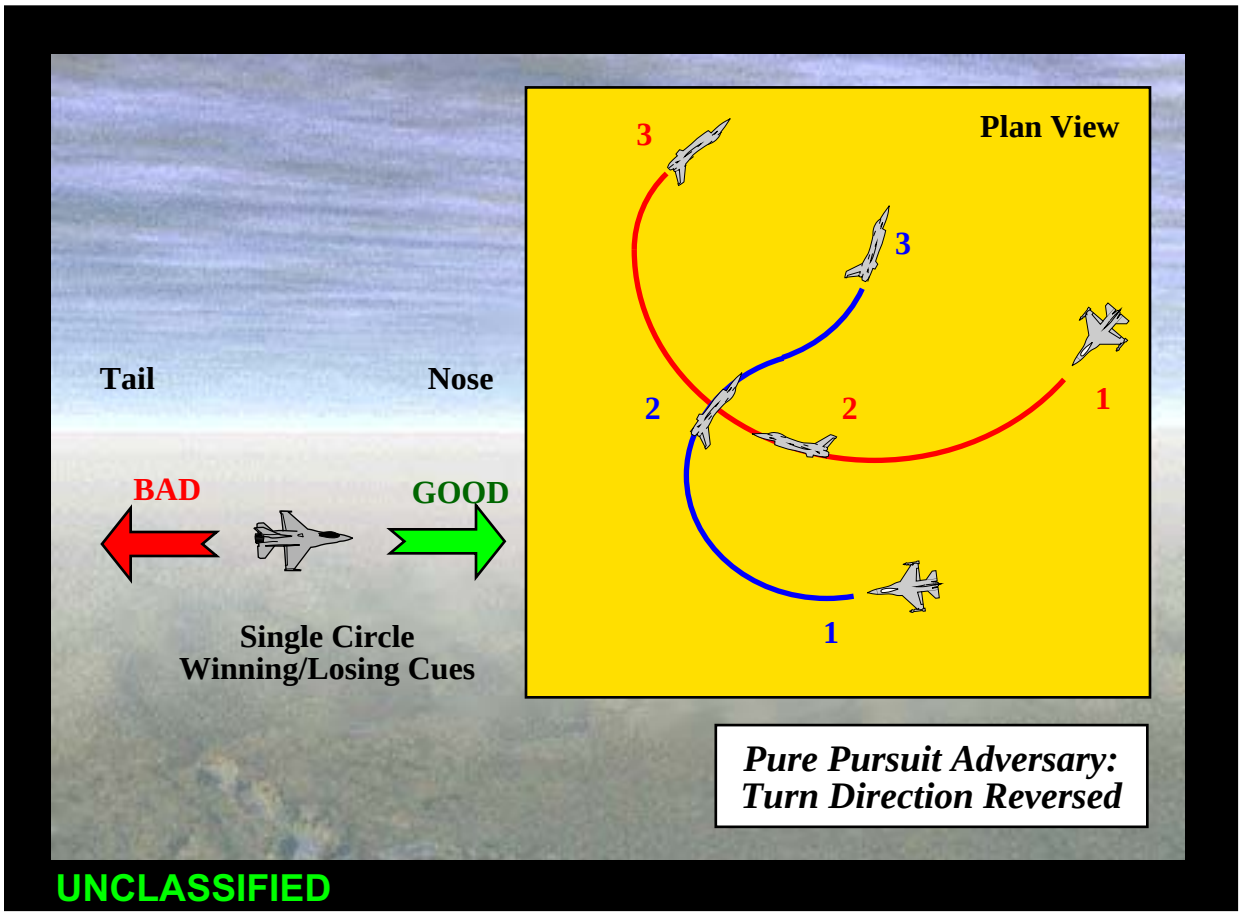
4.5.21 Pure Pursuit Adversary: Turn Direction Reversed.

4.5.21.1 Reversing your turn direction places the adversary in a position where he will quickly move forward of your 3/9 line. Executing the turn reversal involves nothing more than a quick unload, followed by a crisp 180-degree roll to place LV on the adversary, then resume the AB limiter turn, LV on. The adversary's larger turn radius will move him forward of your 3/9 line unless he makes an immediate power (airspeed) reduction. If he does this, he may avoid going defensive, but the fight is now rapidly neutralizing, which means you are doing great! (See **Figure 4.35**, Pure Pursuit Adversary: Turn Direction Reversed.)

4.5.21.2 If HCA was not too great at the merge or if the adversary's overshooting flight path was more than a couple thousand feet aft of your position, the turn reversal may not take you permanently out of the adversary's WEZs. It will, however, dramatically reduce his weapons employment opportunities and force him to reduce power to preserve 3/9.

4.5.21.3 The guns attack will be evident when some of the adversary's belly side becomes visible as he pulls lead. The lead required by the adversary for a 90-degree gunshot is significant, and his belly side should be clearly visible. However, as aspect increases beyond 90 degrees, lead required decreases. At higher aspects the minor differences between pure pursuit and gun's attack lead angle may be impossible to distinguish, especially under high G loads. When in doubt, execute high-aspect gun's defense.

Figure 4.35 Pure Pursuit Adversary: Turn Direction Reversed.



4.5.21.4 It is critical to realize that lead required is a very threat-specific quantity. Some aircraft, such as the F-16 have guns that are aligned with the aircraft boreline. Others, typically dedicated AA platforms, have guns canted up (reducing airframe lead required), and some A/G fighters have guns canted down (optimized for strafing). Different ammunition types have dramatically different muzzle velocities. What this means is that the visual picture you develop for jink timing against an F-16 adversary may not be the same for other threats.

4.5.22 High-Aspect Guns Defense.

4.5.22.1 Remember the three elements of an effective gunshot. The adversary must solve for lead, range and POM. A quick look at the high-aspect situation reveals that we cannot deny range; the adversary will close into lethal range regardless of anything we do. Likewise, since AA is at least 90 degrees, there is nothing further you can do to deny his achieving the required lead. Additional pulling actually reduces lead required. What you can deny very effectively in the high-aspect guns defense is POM.

4.5.22.2 You do this by momentarily rolling your lift vector off the adversary by 45 to 60 degrees and pulling until you have moved your current POM far enough outside the adversary's plane that he will not be able to solve the problem prior to the merge. Generally, this

roll and pull should be down (maximizing total G for a given available radial G) unless minimum altitude forces you to go up.

4.5.22.3 Only 1-2 seconds of downward pull is required to displace your POM adequately. You should then pull back up into the adversary to stop your descent and then establish a new POM parallel to, but below the adversary's. Obviously, timing is very critical here. If you begin your jink too early (and even worse, roll back LV on too early), the adversary has time to solve POM again prior to minimum range. If you begin your jink too late, the adversary has time to complete his guns attack (read: kill you) before POM has effectively changed.

4.5.22.4 A good ROT is to begin the roll as soon as you see a definite pull to lead pursuit by the adversary, or by 3,000 feet to 4,000 feet slant range if A/A is too high for reliable lead pursuit visual cues. Defeating a high aspect gun attempt at these ranges will often result in a reversal or opportunity to neutralize the adversary.

4.5.23 Deep Lag Pursuit. Late G onset or flying (way) out the back of the turn circle (greater than approximately 1 NM) results in deep lag pursuit. The adversary makes an initial move generally in the right direction, but instead of beginning a properly timed turn at the combat zone (CZ) entry window, he delays this turn too long. The adversary will move toward your 3/9 line during your break turn; but as he reaches the 3/9 line, you will see HCA stable or continue increasing. Also, the adversary's late turn will result in range increasing briefly (after about 180 degrees of break) as the adversary's late turn produces momentarily diverging flight paths.

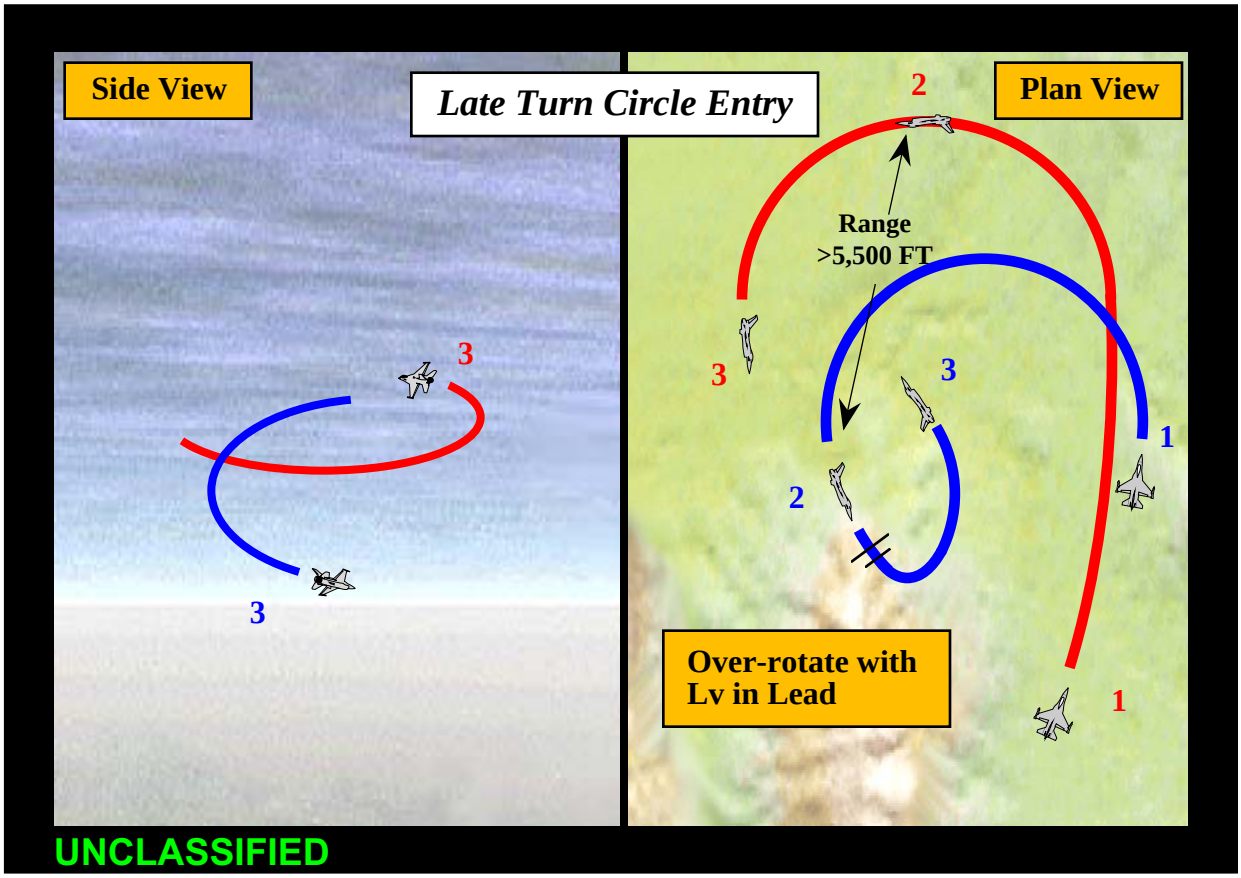
4.5.23.1 Defending Versus Deep Lag Pursuit. (See **Figure 4.36**, Late Turn Circle Entry)

4.5.23.1.1 Reversal into the previously discussed single-circle geometry is probably not a good option unless the slant range to the adversary at the pass is quite small, (no greater than one turn radius, approximately 3,000 feet). A pass this close typically results from an adversary flight path is essentially pure pursuit and is handled just as we discussed in that section.

4.5.23.1.2 Reversing with greater slant range will present the adversary with an available (all be it high aspect) gun WEZ, and possibly a WEZ for some advanced IR missiles. True, you know how to defend against these shots; but by keeping your turn going the same direction, you can probably deny any future WEZ.

4.5.23.1.3 Keep your hard turn coming at the pass and over rotate to increase your turn rate. The effect of the momentarily divergent flight paths will be that you can effectively move the adversary forward on the canopy. Keeping the turn tight will reduce range available to the adversary so that he probably cannot achieve nose-on/ lead for a gunshot at the next pass.

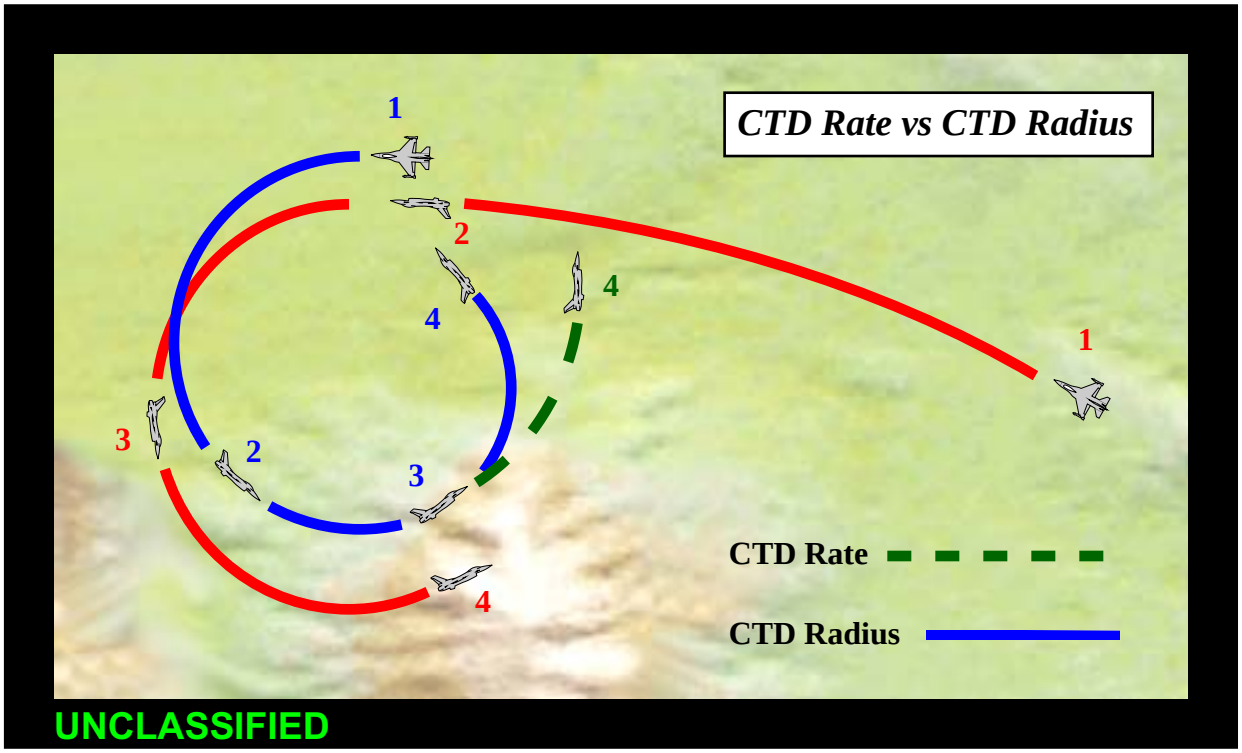
Figure 4.36 Late Turn Circle Entry.



4.5.24 CTD Radius Fight vs. Lag Pursuit Adversary.

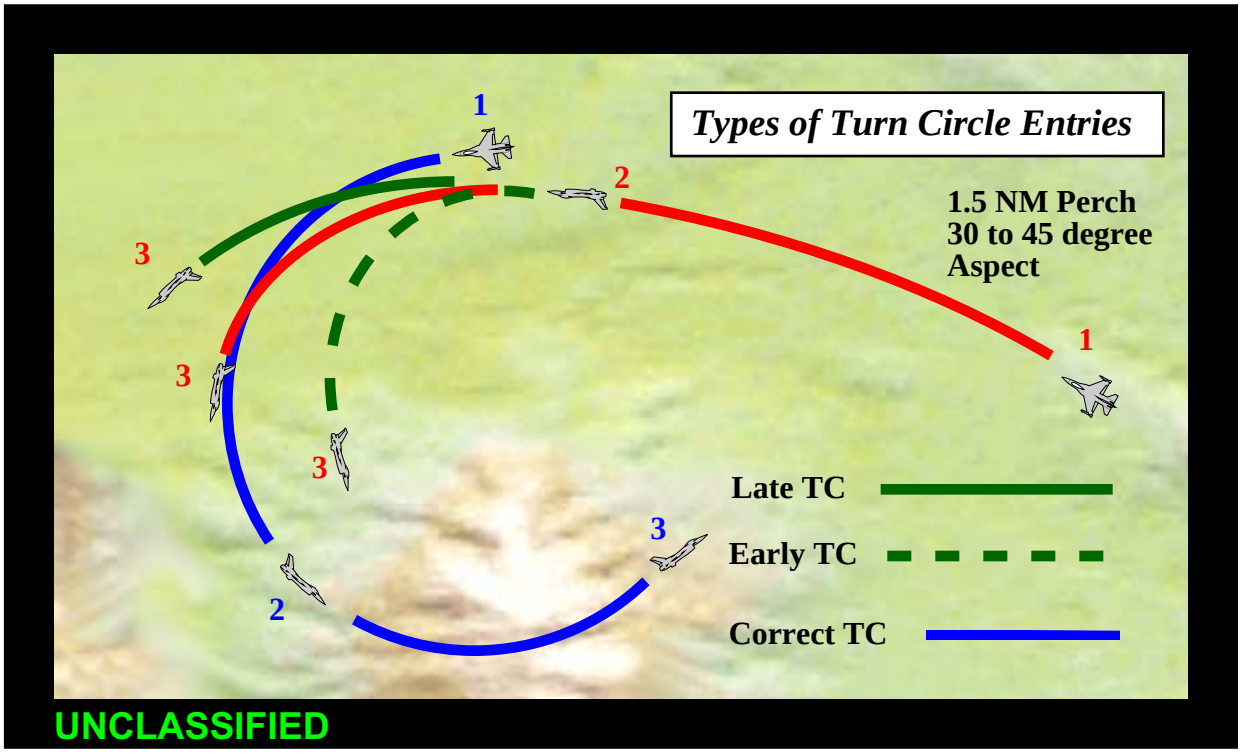
4.5.24.1 Initial Reaction. The initial break turn remains unchanged. Perform a maximum G break turn with infrared countermeasures (IRCM) or transition to a gun's defense depending on the offender's range and pursuit course. If the defender is able to generate forward line of sight (LOS) on his canopy then he should continue his limiter turn to maximize heading crossing angle and aspect for the offender. Rule number one in defensive BFM. When pulling results in LOS forward on the canopy, keep pulling. If the defender sees forward LOS slow and start drifting aft, then the defender utilizes range and aspect cues to analyze the offenders turn circle entry. If the offender makes no errors through the turn circle entry, it is time to readjust the problem and force the offender to react rather than prosecute. This transition takes the form of a radius fight by using vertical Tr to increase nose rate, decrease turn radius and add a new component for the offender to solve. The effect of the radius fight is to force the attacker to preserve range or accept a high aspect Gun/Missile shot. To preserve range the attacker must accept some lag pursuit typically resulting in ATA greater than 60 degrees which negates most off boresight shots. (See **Figure 4.37**, CTD Rate versus CTD Radius.)

Figure 4.37 CTD Rate versus CTD Radius.



4.5.24.2 Lag Pursuit Entries. Once established in the break turn the defender must recognize the offender's pursuit course. Recognition cues include range, aspect, line of sight, and nose rotation (i.e. pure to lead) in order to survive the threat and exploit offensive errors. Lead and pure pursuit courses have already been covered. We will focus on the offender that chooses a lag pursuit course. There are three types of Lag Turn Circle entries: 1) Late turn circle entry, 2). Early turn circle entry, 3) Correct turn circle entry. (See **Figure 4.38**, Types of Turn Circle Entries.)

Figure 4.38 Types of Turn Circle Entries.



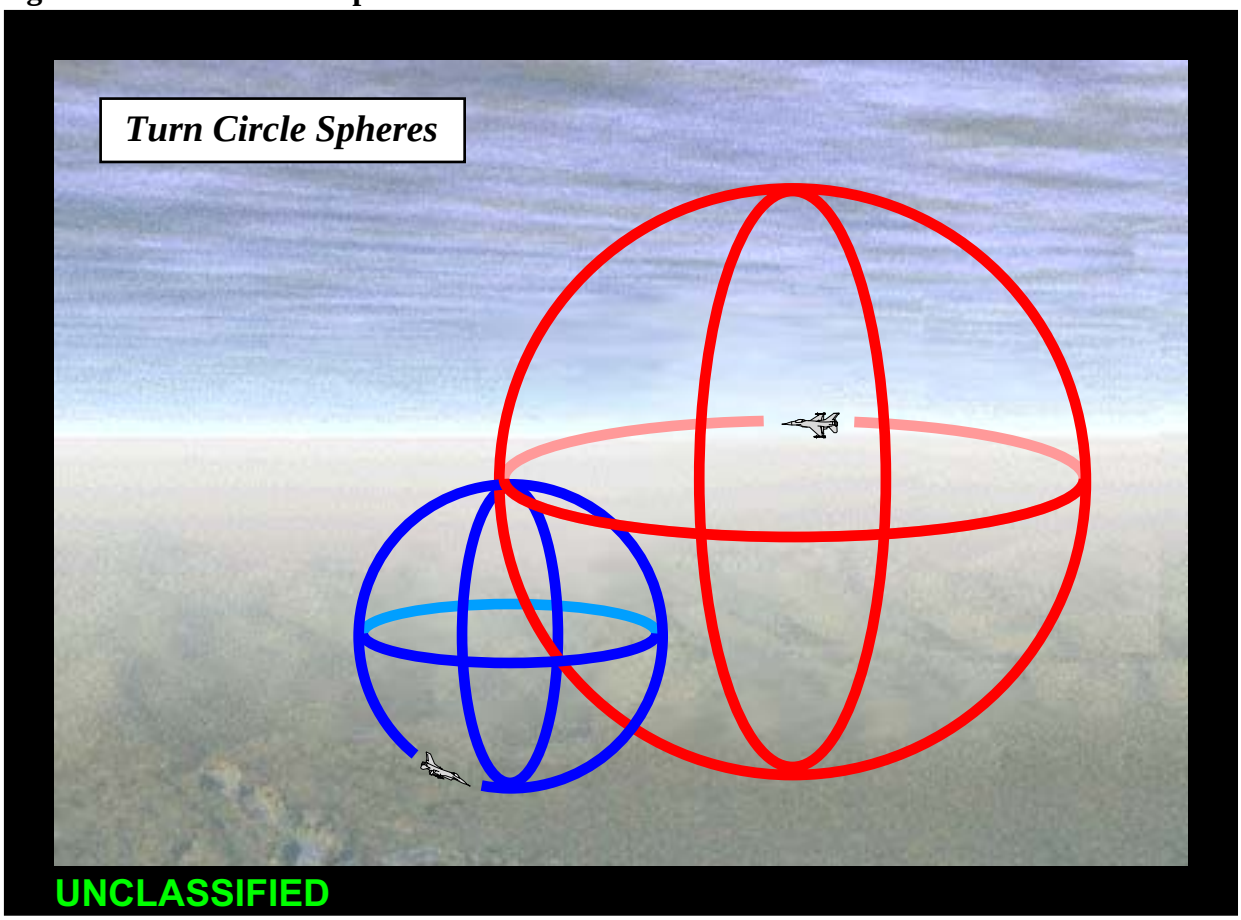
4.5.25 Late Turn Circle Entry:

4.5.25.1 Range assessment and LOS cues are two key indications of the offender that performs a late turn circle entry. (See **Figure 4.36**, Late Turn Circle Entries.) Recognition of the error is the key to success and a universal concept applicable to all BFM. As the defensive fighter, execute a break turn to pull the adversary forward on the canopy. The physics involved have to do with where the offender is in relation to the turn circle. The offender is outside of the defender's turn circle, which creates the forward LOS cue during the break turn. This forward line of sight (adversary tracking from the tail of your aircraft towards the 3/9) is exactly what the defensive fighter should see. This is creating angular problems for the attacker. Generate forward line of sight by continuing with break turn mechanics until the attacker reaches the turn circle. At the turn circle entry, the line of sight freezes or pauses momentarily. Continue to pull and analyze the attackers' pursuit course. If the offender flies out the back of the turn circle generate forward line of sight by continuing the limiter pull. If the attacker pointed to the correct spot (Reference OBFM) the defender saw forward line of sight a pause (at your turn circle) momentarily aft (while he slightly cuts your turn circle) followed by more forward LOS. This continuation of the forward line of sight occurs because the offender was late to turn and flew outside of the defender's turn sphere (see **Figure 4.39**, Turn Circle Spheres). As the defender assesses the late turn circle entry and recognizes the range to be greater than 5,500 feet to 1.0 NM, it is time to capitalize on this error.

4.5.25.2 The change in the apparent mil size of the aircraft can aid in the recognition of the opening range. Ranging exercise, dissimilar BFM and pure repetition are ways to learn the sight cues for range. The offender's mil size will initially increase as the defender per-

forms the break turn and the attacker gets closer. If the offender starts his turn after the line of sight on the canopy freezes (the offender's wings roll up assuming he is not in bank as he drives to the turn circle) and the mil size decreases, than the offender is late to enter the turn circle. This coupled with the assessment of the range opening up greater than 5500 feet are the two cues that illustrate the offender's error.

Figure 4.39 Turn Circle Spheres.



4.5.25.3 The execution of this radius fight is to simply over rotate the LV in lead and use vertical turning room to meet the offender across the circle. Once the defender is out of the missile WEZ, (threat dependent) move the left hand full forward into afterburner and stop flaring. The defender should never ease off the limiter turn as he simultaneously rolls his LV to fly a slice back type maneuver across the bottom of the offenders turn circle sphere (see **Figure 4.39**, Turn Circle Spheres). This is not a split-S. The key to executing this maneuver is to get the LV in lead pursuit. Accomplish this by placing the offender on the opposite side of the canopy as you roll through the vertical. For example, after the left break turn you roll, with a max G pull to place the offender off the right side of your canopy to freeze the LOS. Another technique is to visualize a line out the front of the offender's pitot boom about a turn radius in length and keep your LV on that point in the sky where the two aircraft will meet. Adjust LV to keep the LOS frozen on the canopy until the range is less than or equal to one turn radius (approximately 3,000 feet). Once inside 3,000 feet transition your LV to lag, look for aft LOS and a lead turn opportunity, should it

present itself. Ultimately you would like to merge directly under the adversary with no lateral turning room between you and as little altitude delta as possible (Training Rules allowing). From the offender's perspective this maneuver will look extremely intimidating, as the defender's aircraft may be able to point towards the offender first.

4.5.25.4 Typically, when given this vertical sight picture the offender will increase G to stop the increase in HCA and aspect. This will decrease the offender's weapon separation (range between the aircraft) as the offender trades off his rate advantage to gain angles. If the offender reacts in this manner, he is essentially cutting across the defender's turn sphere (see **Figure 4.39**, Turn Circle Spheres) and the defensive situation quickly becomes more neutral. One disadvantage is the defender will give up vertical TR (3,000 to 4,000 feet) to execute this maneuver. If the offender is unwise and continues to pull down to the defender's plane of motion, a low-to-high lead turn opportunity is available as the defensive fight transitions to a high aspect fight.

4.5.25.5 Another option for the offender is to point to where the defender started down and re-enter the defender's new POM. This may seem like the smart move for the offender, but as the offender drives to lag he is staying outside of the defender's turn circle sphere (the late turn circle entry caused the range to open up greater than5500 feet). Any amount of turn (just like the initial break turn) that the defender can generate will add to the amount of angles the offender will have to solve. Depending on the initial range that triggered this maneuver, it may be enough to neutralize the fight. In addition, this vertical maneuver continuously shifts the defender's turn circle in three dimensions and forces the offender to constantly readjust his own flight path in order to re-enter the defenders turn sphere (see **Figure 4.39**, Turn Circle Spheres). If the offender salvages the late entry and manages his Lv and energy correctly than, the defender sees aft line of sight with the offender stabilized 3500-5500 feet back in range. Do not continue the egg fight and blindly pull over the top. The defender will be in a look up blue-sky environment against a potential off-boresight threat. The defender must evaluate whether or not he can continue to generate a favorable LOS (forward LOS or slowing the aft LOS), asses the range (i.e. turning room) and over-the-top airspeed. Depending on the Block aircraft, configuration, altitude and type of motor, this could be anywhere from 225 to 275 KCAS. With over-the-top airspeed and a neutral cue (seeing the offender across the circle or approaching the horizon as the defender approaches the horizon) then transition to high aspect BFM using the best available gameplan.

4.5.26 Early Turn Circle Entry. The sight picture is the defender initially sees forward line of sight during the break turn. Prior to the LOS freezing the hostile aircraft rolls up and starts his turn; the LOS freeze transitions aft, with nose rotation as the aircraft size increases (see **Figure 4.40**, Adversary Planform Views). The offender is either pulling for a WEZ or making an offensive BFM error as described earlier in the pure/lead pursuit section. The defender is still in both the gun and IR missile WEZ and must continue the break turn with IRCM. Assuming the offender continues a pure pursuit course, the defender will continue to see the top of the aircraft with LOS and HCA building rapidly. High LOS, high HCA and close in range are the normal cues to reverse. If the offender is flying inside of your turn radius and there is a large difference between the two energy states, a reversal may turn this defensive fight into a neutral or offensive one. The decision to reverse should also depend on the AOA

limitations of the adversary. For example, an F-16 adversary approaching inside of 2,500 feet with high HCA and high LOS may trigger the reversal decision. However, if the adversary is an F-18, which can perform at higher AOA, the reversal may place the defender back inside of a WEZ. If the defender is unsure of the reversal cues (range, HCA, LOS) and continues his turn, he may lose sight momentarily as the attacker crosses outside the defender's turn circle (between points 1 and 2 in **Figure 4.41**, Early Turn Circle Entry). A natural reaction of the defender to maintain sight is to over rotate the LV just enough to stay on the limiter and keep sight of the offender while pulling to generate forward line of sight. Once the defender has min-ranged the missile, select full afterburner, stop flaring and keep the power up until you evaluate the offender's next WEZ. The defender's lift vector placement is dependent on the line of sight cues. A transition to high aspect BFM is possible if the defender can create forward LOS to the 3/9 position by over-rotating the lift vector with a limiter pull. If forward LOS stops and transitions to aft LOS, then stay in the radius fight to deny the offender room to point and range for weapons separation. This maneuver will increase angular and HCA problems for the offender and allows the defender to once again drive the fight and force an offensive error. If the offender eases off his turn to preserve range, and opens it back up to 5,500 to 6,000 feet then execute as described earlier in the Late Turn Circle entry section. If the offender stays within the 4,000 to 5,000 feet regime and is offsetting circles to point, continue your limiter pull with vertical to force a very fleeting front quarter shot by the offender. (See **Figure 4.41**, Early Turn Circle Entry.)

Figure 4.40 Adversary Planform Views.

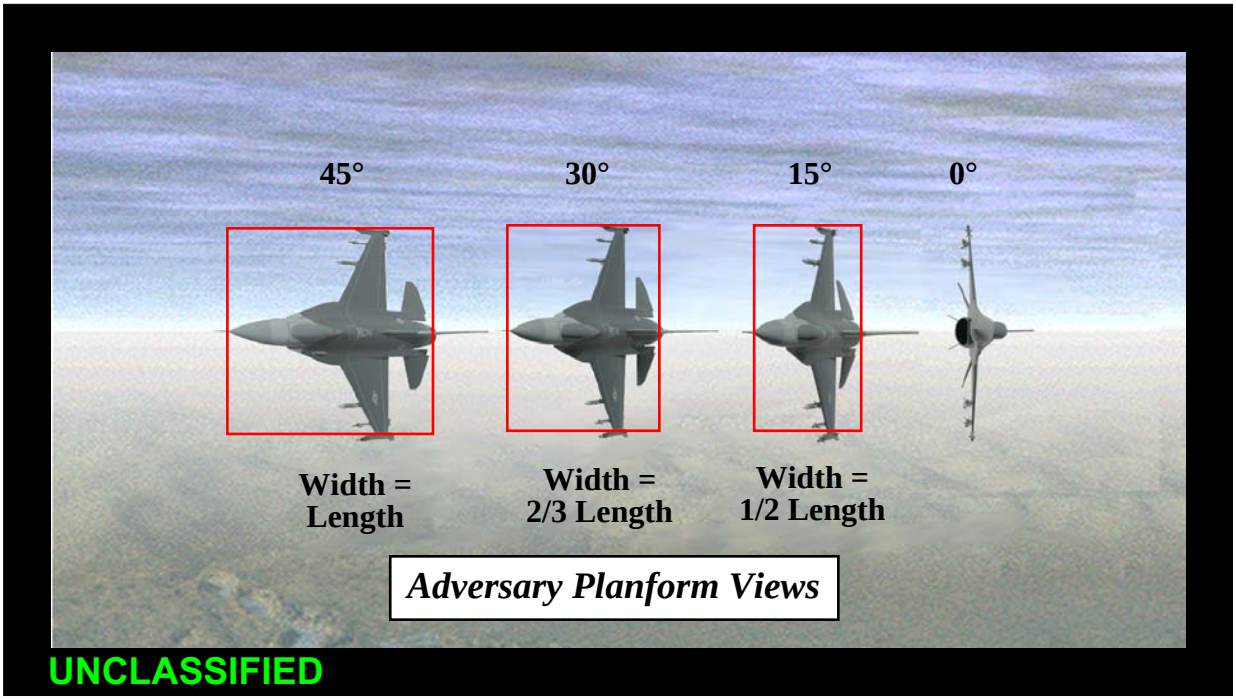
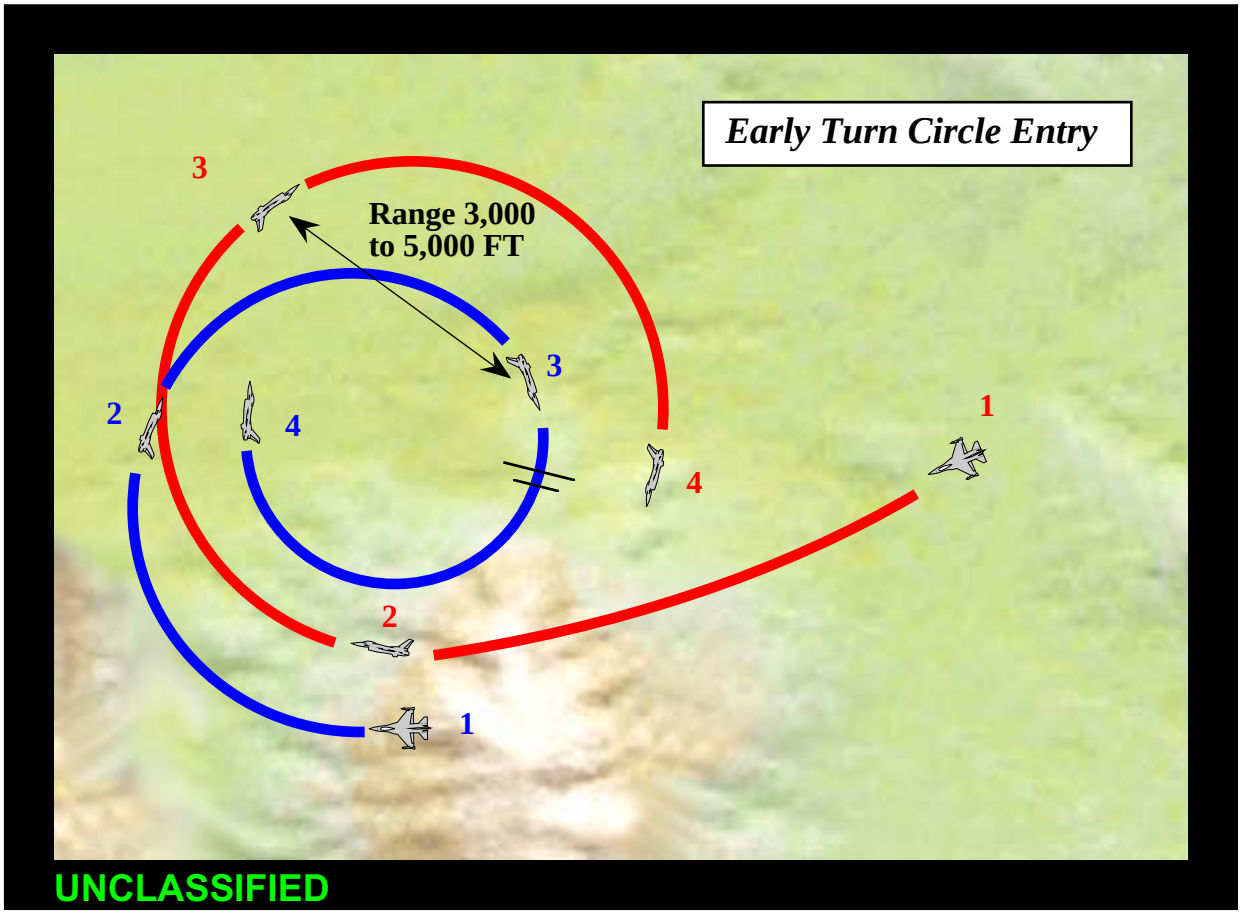


Figure 4.41 Early Turn Circle Entry.



4.5.27 Correct Turn Circle Entry:

4.5.27.1 The defender sees forward line of sight during the break turn, followed by the LOS pausing as the offender starts his turn (nose rotation at the pause) and then aft LOS as range decreases and settles to approximately 4,000 to 5,000 feet at the 5:30 to 7:30 clock position. If the offender makes no errors through the turn circle entry, it is time to readjust the problem and force the offender to react. Drive the Fight! The defender assesses the attacker's nose position and pursuit course during the initial break turn. While assessing the offender's nose outside of the missile WEZ, the defender needs to reorient the lift vector low and, stay on the limiter while reselecting full afterburner. The lift vector placement is done solely to create a favorable LOS cue (forward LOS which is optimal or a reduction in aft LOS). This is not an instrument maneuver where a pre-determined nose low attitude will work in all cases. There is a point when the defender may go too far downhill and open up lateral turning room for the offender to exploit. The defender can counter this from happening by continually readjusting the LV placement to create a favorable cue. If the over rotation of the LV is starting to increase the aft LOS or decrease the forward LOS then the defender must re-set and hold the previous LV placement. Obviously, increased proficiency makes adjustments easier to identify and execute. Typically, if the offender is flying good offense the defender is roughly 25 to 45 degrees nose low while staying on the limiter. Normally this places the offender about 2 to 3 beer cans above the horizon.

4.5.27.2 A common offensive mistake is to ease off the turn to preserve more range. The defender will see the forward line of sight increase as he continues his limiter turn which creates more angular problems for the offender. If the offender eases off too much, he may very well fly out the back of the turn circle and create another exploitable error (similar to the late turn circle entry picture). The offender will see HCA and aspect increase while the range between the two aircraft decreases (assuming he flew a correct turn circle entry maintains his current altitude and G). As the defender you will notice you can pull the offender forward of the 5:30-7:30 clock position (roughly looking over the back of your horizontal stabilizer) and more towards the 3/9 line. This is a tough BFM problem for the offender, as he must stay at or near the defenders turn circle sphere to not give up more angles (see **Figure 4.39**, Turn Circle Spheres). For example, if the offender stays in the horizontal and allows you to generate more than 2,000 to 2,500 feet in the vertical, he is flying BFM outside of your vertical sphere. Every angle the defender gains on the offender will not be solved until the offender either offsets the turn circle to point (In this case climbs up and have a very intimidating shot from above) or re-enters the defender's turn circle sphere (see **Figure 4.39**, Turn Circle Spheres.)

4.5.27.3 If the defender can continue the turn and force the offender forward of his 3/9 line, there can be a point where it is more advantageous to come off the limiter pull and out of the radius gameplan. Once the offender is across the circle forward of your 3/9 line the fighter is essentially transitioned to HABFM. At this point the defender cannot create any more forward line of sight, and is bleeding excessive energy by staying on the limiter. The defender should ease off the turn and try to freeze the offender at 3/9 while potentially gaining energy or at least achieve zero Ps if able. Take off the defensive BFM hat and put on your high aspect one to start this gameplan. You are neutral across the circle and the defender must recognize and adjust the gameplan accordingly.

4.5.27.4 If the defender is not able to neutralize the fight, then the defender can continue to survive until reaching the floor. In training, most BFM perch sets will start the fight 8,000 feet above the floor. If a defensive situation occurred in combat, the defender may have double or triple that altitude to survive (assuming a medium altitude war). At some point, if the offender never makes the errors described above, the defender will readjust his LV and roll out of bank to make a floor transition. In a real world situation, the defender can use the terrain below to try to mort the adversary and give as much clutter problems to the adversary's on board sensors and weapons. In the training environment, one technique is to set the LIS sky at 2,500 feet above the floor to aid in the floor transition. Some would argue that if the offender has not forced any errors up to the 2,500 feet above the floor, level out and save some altitude to jink with. Once again what is the threat? If the defender wants to maximize survivability against the missile and not the gun, the defender needs to keep the turn going all the way until the floor. To leave some margin for error, the defender can level out at 500 feet above the floor initially.

4.5.27.5 As proficiency advances, the defender can decrease the level off altitude as required to not hit the floor. By leveling off very close to the floor the defender does not allow the offender any turning room below him. When the defender levels out, the turn radius starts to open up and allows the offender potentially his first shot opportunity since the fights on. The defender will recognize the offender's energy state at the floor by watch-

ing the aft line of sight. If the defender sees aft LOS from the 3/9 back towards the horizontal stabilizer without seeing the nose carve towards the aircraft (i.e., continuing to see top of the offenders aircraft), the offender is trapped in lag. If the defender sees aft LOS with the nose carving (the jet seems to rotate and the defender sees top of the jet move towards pure pursuit) honor the WEZ, and use IRCM while transitioning to short range BFM.

4.5.27.6 The last problem you can potentially create for the offender is closure. It is a common mistake for the offender to leave the power in too long and grow impatient for the attack as the fight reaches the floor. This offensive error translates typically to 100 knots + Vc as he pulls for the attack. This enables the defender one last chance to neutralize the fight. Perform a solid nose counter defense or reverse to the stack if the defender can recognize and capitalize on the reversal cues.

4.5.27.7 A common question is why hurry to the floor where the defender can't perform a standard tuck-under guns defense? The answer is the defender has maximized his gameplan for survivability by denying a missile WEZ for as long as possible. More importantly, the defender has increased the chances of the offender making a mistake to capitalize on. Bottom line: to allow an adversary to achieve stern aspect guns parameters is to allow an adversary a missile WEZ, a WEZ you will not likely survive.

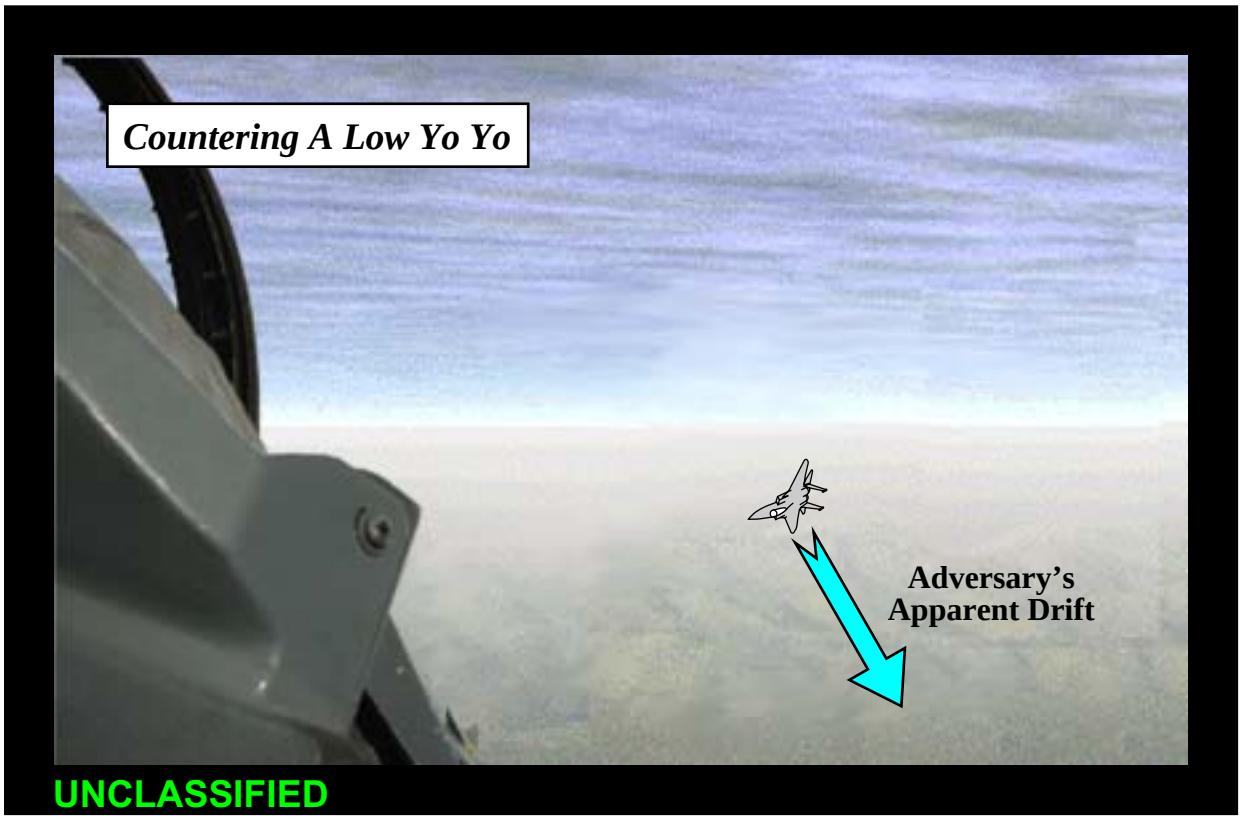
4.5.28 Additional Considerations and Situations.

4.5.28.1 Countering a Low Yo-Yo.

4.5.28.1.1 Visual cues for detecting a low yo-yo are adversary's nose and flight path dropping in relation to the horizon with his LV reorienting into lead. Countering a low yo-yo is fairly simple. Reset Lv enough to keep the adversary in the same position relative to the horizon, typically, Lv on to slightly below the adversary. This should keep his nose off your jet for now. The exception to this is the adversary that gets below your POM before you can react. In this case, do not mechanically pull down into the adversary (unless you think you can stuff him) because you may be putting yourself in back into a WEZ. As you approach the floor, a well-flown floor transition is critical. Remember, the Pk of the ground is almost 1.0.

4.5.28.1.2 The opportunity to take the offensive is important here. Sticking the adversary in lag only ensures temporary survival. The fight will be won or lost based on several factors. First, your fight is not being fought in a tactical vacuum. You both probably have supporting fighters somewhere in the vicinity. Who's supporting wingman arrives and fires first will determine the winner. Second, disengagement is probably suicide; so with no support available, you are locked together in combat until one or the other achieves a kill or runs out of fuel. (See **Figure 4.42**, Countering a Low Yo-Yo.)

Figure 4.42 Countering a Low Yo-Yo.



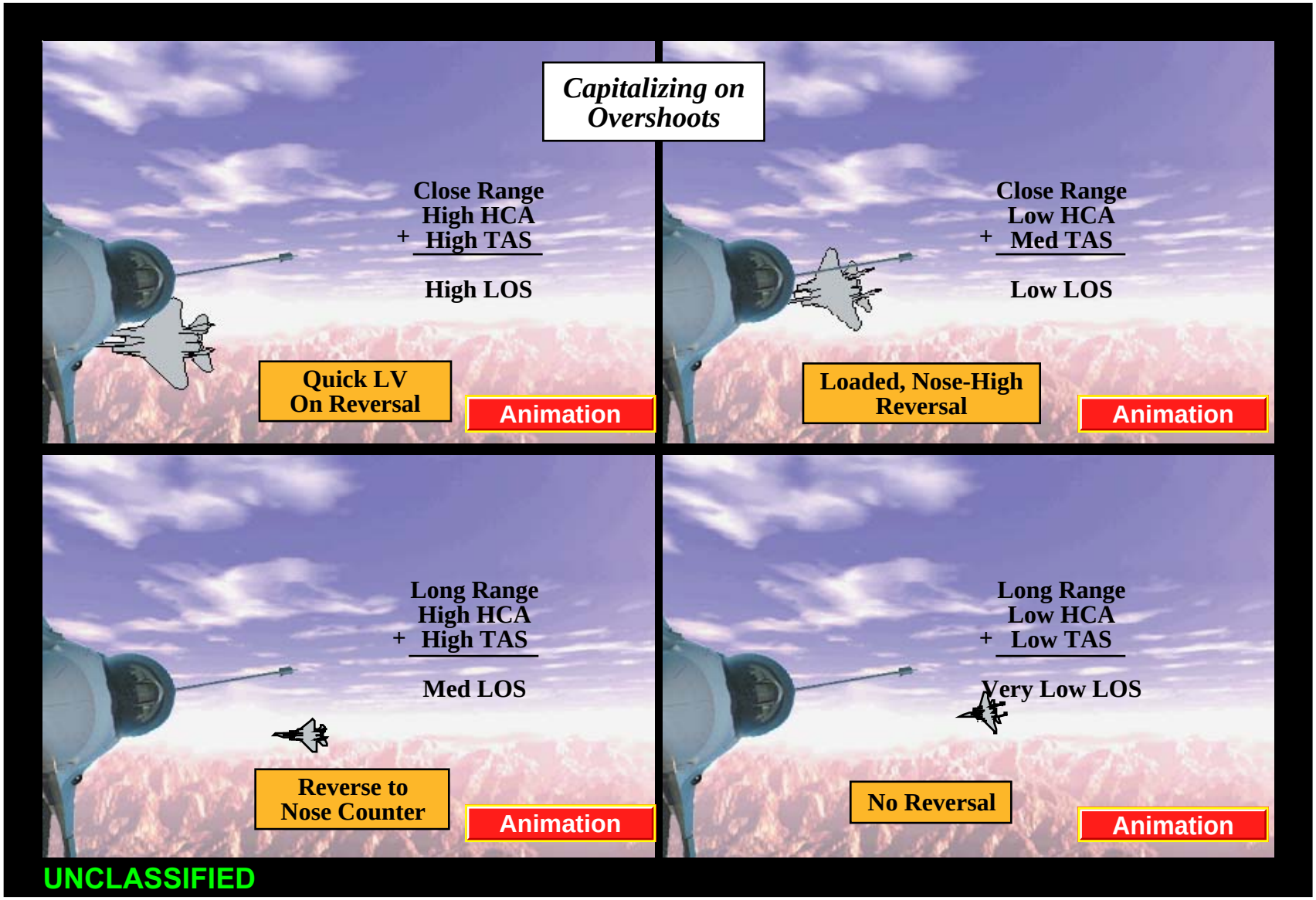
4.5.28.2 Capitalizing on Overshoots.

4.5.28.2.1 LOS rate is the main factor affecting your reaction to overshoots: The range of the 6 o'clock pass, HCA and adversary true airspeed produce the apparent LOS rate. Close range, high TAS, and high HCA produce the highest LOS rate. Generally, the higher the LOS rate of the overshoot, the more rapidly you should roll to put the LV on the adversary. For low LOS rate overshoots, you may need to try to slow your forward motion to increase the apparent LOS toward 3/9. (See **Figure 4.43**, Capitalizing on Overshoots.)

4.5.28.2.2 The basics of reversing against a high LOS flight-path overshoot were discussed previously. It is basically an unloaded roll to LV - on, reorienting the fight into single-circle geometry, with victory going to the fighter with the smallest turn radius. The contribution of rate is minimal once single circle geometry is established.

4.5.28.2.3 For a successful reversal you must exaggerate the LOS by slowing forward motion relative to the adversary. The best way to do this is to use maximum G to get the nose up as high as possible and pointing Lv on to behind the adversary's POM (point to his high 6). The altitude gained can become turning room available exclusively to the higher fighter. When combined with 3/9 advantage gained by slowing forward velocity, this may allow a reversal of roles.

Figure 4.43 Capitalizing on Overshoots.



4.5.28.2.4 For very low LOS overshoots with HCA and range largely under control, it is probably wiser to keep turning hard in the same direction. However, be cognizant of the threat by continuing the turn may trap the adversary in lag, but also allow for multiple off-bore shots if still inside a missile WEZ.

4.5.28.3 Low Line-of-Sight Reversal Execution.

4.5.28.3.1 As the adversary's flight path begins to slide past your 6 o'clock (due to closure/HCA problems your jinks generated), immediately begin a wings-level (relative to the horizon) pull while selecting full AB and closing the speed brakes. As your nose gets above the horizon, begin to lean your LV toward the adversary. If outside of a turn radius, pull Lv on the adversary till at one turn radius. If you are less than one turn radius, pull Lv to adversary's high 6 and assess LOS and 3/9 positions. If the adversary stays level, you will rapidly move behind his 3/9 line. A roll to LV in-lead should allow a quick transition to offensive. If the adversary also pulls vertical, it will result in either a scissors or a stack.

WARNING: If the adversary has adequate 6 o'clock range available, your roll to wings-level may be all that is needed to solve the adversary's problems. Make a careful prediction of the adversary's turn radius potential prior to initiating the reversal.

4.5.28.3.2 If in doubt as to the wisdom of reversing, do not do it. Keep your tight turn coming, realizing that the adversary will probably be back into guns in another 90 degrees of turn or so. That, however, will be 10 seconds more you have lived, and you have already proven that you can beat gun/missile attacks. Keep it up, keep sight and never give up!

4.5.28.3.3 Realize that many aircraft (F-15, F-18, MiG-29, etc.) can generate significantly more AOA than an F-16. This allows many of these airframes to stop their flight path overshoots a lot faster and under more severe conditions; i.e., closer, than an F-16. Keep this in mind when choosing the low-aspect reversal option.

4.5.29 Reversal Follow-Ons. The end result of a reversal will be a status quo (still defensive), an offensive advantage or lastly, a neutral position. The defensive and offensive positions have already been discussed; the neutral position is broken down into two broad categories: scissors and stacks.

4.5.29.1 Flat Scissors.

4.5.29.1.1 Scissors solves into two basic descriptions, flat or rolling. The general plan in handling a scissors situation is to be the first one to stop it and transition to a stack. A flat scissors is typically entered by the defender executing an in-plane pull towards the defender, and the attacker responds in kind. Initially, the room between the fighters is greater than 1 turning radius. An attempt to stack now results in an adversary with the ability to point and employ. The optimum execution to gain an offensive advantage is to decrease turning radius between the fighters with a Lv on pull until less than one turn radius; drive the adversary out front of the 3/9 line, then transition to a Lv up-pull in relation to the horizon.

4.5.29.1.2 If the defender executes an in-plane pull towards the attacker from an overshoot, and the attacker responds in kind the result is typically a flat scissors. The optimum execution to gain an offensive is to drive the adversary out front of the 3/9 line. The sight cue desired is seeing yourself get farther behind the adversaries 3/9 line, and the adversary getting farther away from your 3/9 line in each pass. LOS rate is not a good indication since the offensive adversary will stay behind your 3/9 line, the defensive adversary will remain close to your nose, and if neutral the adversary will transition down your 3/9 line from side-to-side. As the LOS rate stabilizes, unload, and use full aileron and rudder to reverse direction. At airspeeds below 330 KCAS, use full AB to generate the greatest rate (radius is essentially the same). Continue these turn reversals until there is less than a turn radius between the two aircraft (neither aircraft can point at the other). At each pass the HCA will probably decrease. As soon as you see that you do not have enough range to point and employ ordnance, even if the adversary rolled out, transition to the vertical.

4.5.29.1.3 Simply pull straight up instead of back at the adversary. This pull to the vertical is in full AB, wings-level, pulling to create a LOS forward now that you are not pulling towards the adversary. This will result in some kind of stack that is discussed in **paragraph 4.5.29.3**, Stacks.

4.5.29.2 Rolling Scissors. A reversal pulling to the high or low six of an attacker is the typical entry to a rolling scissors. In this case, a LOS rate toward your nose is an indication of this maneuver working; keep it going. If there is a LOS rate aft, change to an alternate plan quickly (prepare to jink). The situation where there is little to no LOS is the establishment of a rolling scissors. The key to winning in this situation is to be the first one out. Change the pull direction to straight up as your wings are coming level. Pull to the vertical as previously described. If this maneuver is properly executed with the adversary's nose low, the adversary will flush out front. If you wait even one extra roll, the adversary could stop it when his nose high. A stack will normally result.

4.5.29.3 Stacks. Stacks are a result of some type of reversal and an important component of defensive BFM. Keep in mind slow-speed fighting may be a required skill to kill and survive. The uneducated in slow-speed fighting may not live long enough to have a second chance. A stack is a risky and vulnerable location in a multibogey environment or against an adversary with off-boresight capability. The key elements to wining the stacked fight are: winning 3/9, not altitude; taking away the turning room available; flying an optimum jet to maximize altitude and minimize forward movement over the ground.

4.5.29.3.1 Side-Side Stacks. Side-side stacks typically result from a flat scissors or a gunshot overshoot, where the adversary has already closed the range to less than a turn radius as the defender starts the reversal. The desired result is to see forward LOS from the adversary and gain an offensive advantage. Resist the urge to pull toward the adversary, unless necessary to close the range and get inside minimum range for off-boresight ordnance. If necessary to close the distance, tap the rudder slightly to get the nose tracking in the desired direction. Any dipping of the wings will lose lift, and generate a faster rate along the ground, which pushes you forward on the 3/9 line. As the adversary floats out front, use a power reduction, dip the nose to employ ordnance, and complete the offensive transition. If the adversary gets behind you, then a transition back to

your defense. Otherwise this side-side stack will remain until one aircraft runs out of fuel, a supporting fighter decides the fight, or someone mismanages the aircraft and fall off first and turn the fight into a vertical stack.

4.5.29.3.2 Vertical Stack—Low Man. Being the low man in a high-low stack is a very desirable position if you started out defensive. Minimize the altitude difference between the two aircraft. Attempt to get directly below and out of sight of the adversary. Any attempt by the adversary to check on your position will result in wing dips, losing lift and generating forward LOS. Staying within 1,000 to 1,500 feet vertically is generally a safe place to deny the necessary turning room to an adversary. If unable to get that close and the adversary attempts to roll down towards you; there are several steps to take. First, pull to the adversary's belly side to make it dump the nose as much as possible. Second, get out of the way of any bullets coming your way. Third, after you have survived this attack, analyze how the adversary is falling off. If the adversary is attempting to leave or keeps falling away, a quick transition to the offensive is available. If the adversary is stacking below you, the high ground is now owned by you, which may be a good thing.

4.5.29.3.3 Vertical Stack—High Man.

4.5.29.3.3.1 Being the high man in a vertical stack is a desirable position as long as you can survive there! Typically a full AB, slow LOS, and rate platform is the target presented to the adversary. If you get within the off-boresight/missile capability, you may be a sitting duck! Assuming the aircraft is not in a WEZ, the optimum plan is to get enough turning room to covert to an offensive position. If you find yourself out of a WEZ, and neutral, you have achieved a temporary objective of immediate survival. Work to get 2,000 to 3,000 feet of altitude difference directly above or behind the adversary. There are a variety of ways to transition to a WEZ: a barrel roll, slide down with a power reduction, and lastly a nose pushover.

4.5.29.3.3.2 The barrel roll and power reduction are the easiest to execute but require slightly more altitude advantage than the nose over. Simply fly to a position where you can employ ordnance, typically the gun. Ensure you have enough range to shoot and avoid the fireball or bubble. The nose over is slightly more complicated and should not be attempted for the first time in the middle of a BFM training sortie. From a nose high position with lateral separation, just above the low-speed warning horn airspeed, pull power to idle while pushing forward on the stick. The aircraft will pitch over rapidly with a minimal loss of altitude. Set the gun cross in lead (not much is required at slow LOS rate), take the shot and ensure you will avoid the fireball or bubble.

4.5.30 Vertical Transitions In-Close.

4.5.30.1 Proper WEZ recognition and execution in the extremely dynamic vertical fight is another critical element of slow speed fighting. As the high fighter coming down correct power selection is critical. If you force the adversary to fall off, then idle/speed brakes is the best. If the adversary is staying in the nose-high position an AB setting allows for resetting the stack after your attack. The low man needs to determine how best to take advantage of the high man falling off. This concept also comes into play in the vertical fight

when one aircraft is overshooting in the vertical. At the pass, determine if the adversary is falling away and start a vertical lead turn as LOS rate passes your nose (the adversary is giving you the necessary range to prosecute an attack). If the adversary is attempting to keep the range close by rolling underneath you, a continued nose-high position to get range is the optimum plan.

4.5.30.2 Therefore, since the following gameplan is inherently risky, proximity of supporting fighters, as well as fuel and ordnance remaining must be taken into consideration when deciding whether to attempt to improve the present situation.

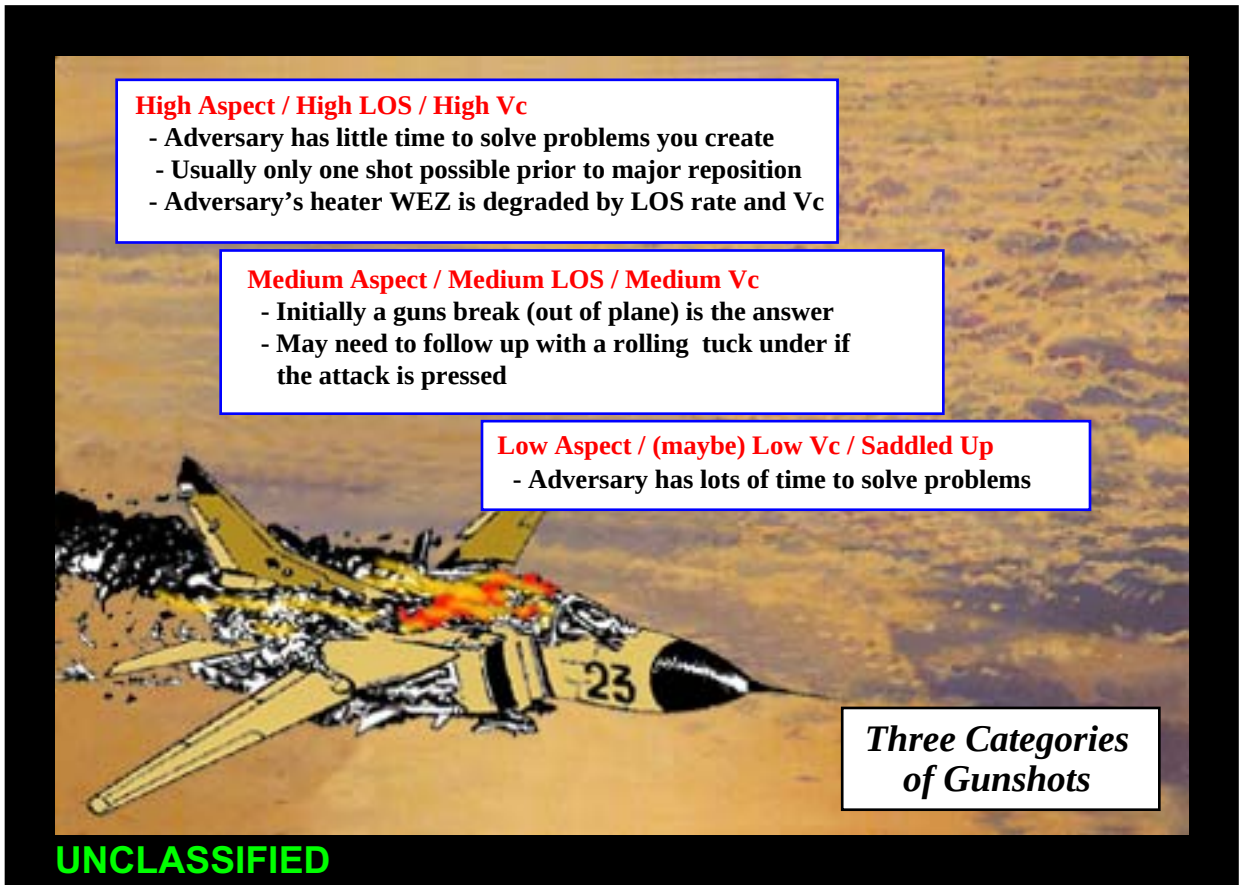
4.5.31 Categories of Gunshots. Gunshots are broken down into three categories: (1) high-aspect shots are those attacks occurring at aspects of equal to or greater than 70 degrees, (2) medium-aspect shots are from 30 to 70 degrees, and (3) low-aspect shots are those at less than 30 degrees. This breakdown of gunshots is oversimplified, since they occur over a wide aspect and Vc regime. Also, as you will remember from offensive BFM, a valid gunshot has three components; it must be in lead, in range, and in the POM. Your defensive strategy versus various gunshots will generally break down into one of two categories: (1) attempt to deny POM (an out-of-plane move) versus a medium- to high-aspect shot or, (2) attempt to deny lead (an unload) versus a low- to medium-aspect shot. (See **Figure 4.44**, Three categories of gunshots.)

4.5.32 High-Aspect Guns Defense.

4.5.32.1 Variables. A quick look at the high-aspect situation reveals that range cannot be denied; the adversary will close into lethal range regardless of anything you do. Likewise, since the adversary is coming at you least 60 degrees off your tail, there is nothing further you can do to deny the adversary at the required lead. What you can deny very effectively in the high-aspect guns defense is POM.

4.5.32.2 Defensive Maneuver. Roll your LV off the adversary by 45 to 60 degrees and pull until current the POM is moved far enough outside the adversary's plane. The idea is to prevent the adversary from getting its gunsight on you prior to overshooting. Generally, this roll and pull should be down (maximizing total G for a given available radial G) unless already at minimum altitude. Only 1 or 2 seconds of downward pull is required to displace a POM adequately. Pull back up with your LV below the adversary to stop your descent and establish a new POM below the adversary's and build HCA. Timing is critical here! If you begin your jink too early (and even worse, roll back LV-on too early), the adversary has time to solve POM again prior to minimum range. If you begin your jink too late, the adversary has time to complete the gun attack (i.e., kill you!) before a POM has effectively changed. A good guideline is to begin the roll as soon as you see a definite pull to lead pursuit by the adversary, or by 3,000 to 4,000 feet slant range if the angle is too high for reliable lead pursuit visual cues. After surviving this gunshot, you need to transition to a follow-on game plan as discussed in **paragraph 4.5.28.2**, Capitalizing on Overshoots, or **paragraph 4.5.29**, Reversal Follow-Ons.

Figure 4.44 Three Categories of Gunshots.



4.5.32.3 Medium- and Low-Aspect Guns Defense. If the attacker (through pure skill, cunning, or luck) has arrived in a gun and missile WEZ and has not made any exploitable errors, you must now give the attacker another series of problems to deal with. The idea now is for you to force the adversary close and get into a "knife fight" to create a closure/range problem. Typically, when you are in a gun WEZ, a missile WEZ is not far away. Keeping the power in idle, with speed brakes extended will cause the most airspeed closure problems for the attacker. Unless you are able to prevent the attacker from pulling the required lead (you have the adversary trapped in lag), the power should be in idle to present the toughest problem to solve (closure/range). Three examples of when to close the speed brakes and push up the power (Mil or AB situation dependent) are:

- Approaching the floor.
- Getting too slow (less than 175 knots), thus losing the ability to properly jink at this airspeed.
- Ability to trap the attacker in lag and out of both WEZ's.

4.5.33 Medium-Aspect Combined Defense. The two most common errors pilots commit with medium-aspect guns defense are (1) failure to recognize the adversary's WEZ transition and (2) effectively timing jinks. An adversary prosecuting a medium-aspect attack will probably overshoot. It may be a planned overshoot or an attempt to force the defender to react, not necessarily an offensive error. Many defenders get enamored with trying to pull LV-on to

exacerbate the overshoot. This LV-on pull may force the attacker to overshoot after you blow up. Remember to spoil the lethal gunshot first with proper jink timing. An early jink won't cause enough closure and aspect problem for the offender, while a late jink is self explanatory. Jink timing is frequently too late. The high Vc of this gunshot effectively increases the maximum range available to the adversary. Also, since only one opportunity will occur (it is a known overshoot situation for the offender); most proponents of this type of shot start shooting early and continue to minimum range. A good "no-later-than" timing cue is when the adversary's nose passes through pure pursuit. A significant amount of the aircraft "belly" or intake for a Viper is visible at the open fire point because of the aspect of the shot. The offender needs more lead for high aspect and longer range gun shots. Establish the maneuver before the bullets are on the way. The execution is either an out-of-plane jink (the higher the aspect/Vc/LOS) or right into a POM spoiling jink (a rolling tuck under if altitude allows) if closer to low aspect. (See **Figure 4.45**, Follow-On to Medium Aspect Angle Defense.)

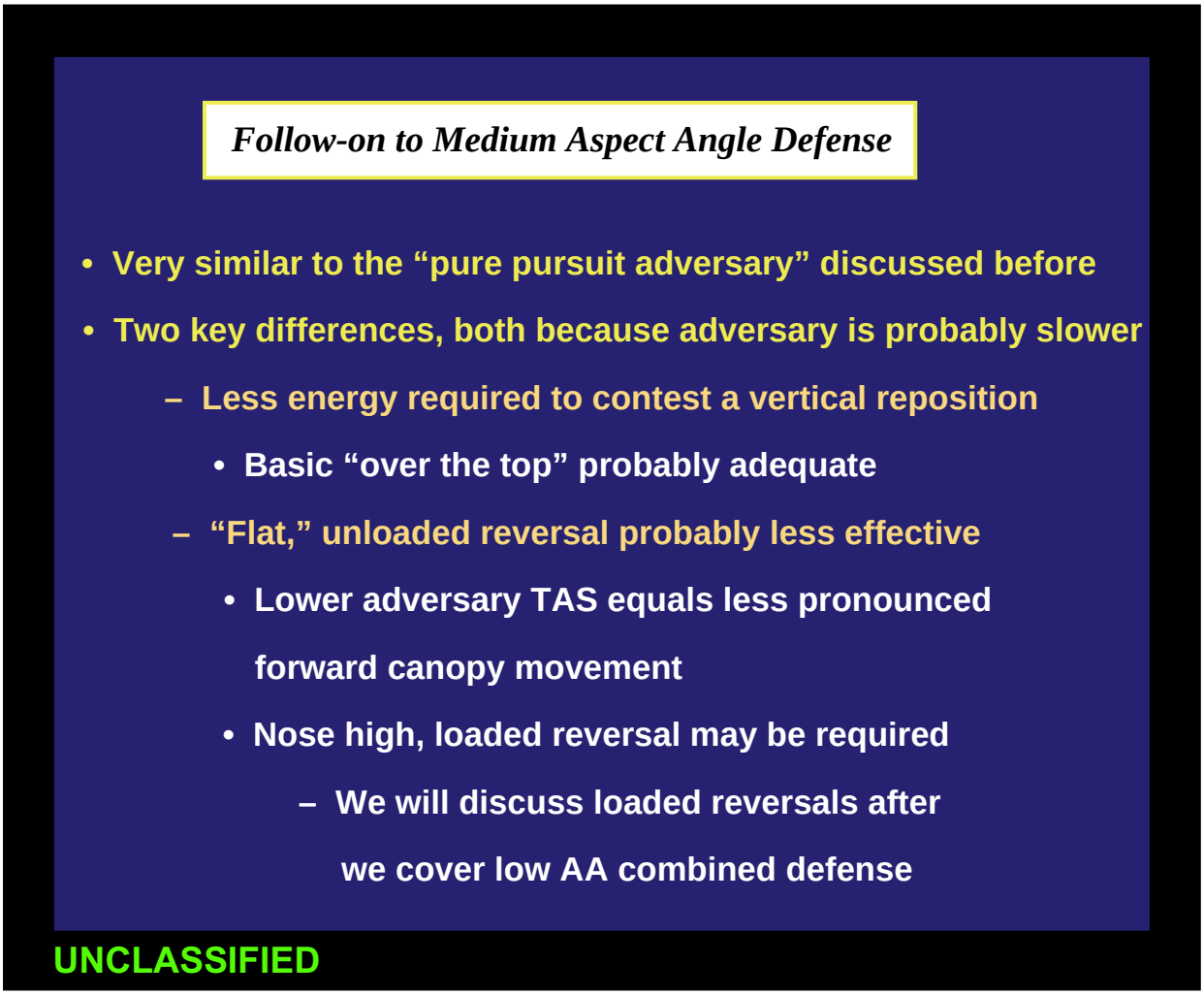
4.5.34 Follow-On to Medium Air-to-Air Defense. Follow-on moves to the medium-aspect shot are much the same as those discussed in **paragraph 4.5.20**, Pure Pursuit Adversary—Turn Direction Maintained and **paragraph 4.5.20**, Pure Pursuit Adversary—Turn Direction Reversed. The one significant difference is that since the adversary came from the CZ into a medium-aspect shot, the adversary is probably going slower than if the adversary pulled for lead during your initial break turn. As shown in **Figure 4.45**., Follow-On to Medium Aspect Angle Defense, this impact your follow-on moves in two ways.

4.5.34.1 First, it reduces the amount of energy you need to contest a vertical reposition by the adversary. If the adversary begins a vertical pull while still inside your turn, you should have enough airspeed to go over-the-top with the ability to pull your nose up after the adversary. If you are below over-the-top airspeed, extend briefly to get it. If you start up with less energy, the adversary will almost certainly achieve enough 3/9 line and vertical separation to remain offensive during the ensuing stack.

4.5.34.2 Second, a slower adversary makes an unloaded reversal into single-circle geometry less effective. The forward canopy movement cues is less dramatic (possibly nonexistent) than those for a higher-speed adversary. If you do not see adequate LOS cues as the adversary crosses your flight path, execute a loaded roll towards the adversary's high 6 o'clock position to exaggerate forward movement. If the adversary stays level, quickly reorient your LV into lead for an offensive position. If the adversary counters with a late pull into the vertical after you have already begun a nose-high reversal, you will probably achieve a low position in a stack (see **paragraph 4.5.29.3**, Stacks) with some possible 3/9 line advantage (neutral).

4.5.35 Low-Aspect Combined Defense. At zero aspect angle any attempt to reorient POM by the defender can be immediately solved by the adversary simply rolling his LV into the new POM. As the angle off your tail increases out to 40 to 50 degrees, this gets slightly more challenging for the adversary but is still solvable. You cannot do much about range other than light the AB and unload, and since this is a combined guns/IR missile defense, that is not an option. Therefore, lead angle becomes the most exploitable component of the low-aspect attack. Remember, "dead pilots do not reverse," always optimize your defense to defeating ordnance. Fortunately, the strategy presented here also provides a significant closure problem, and if the adversary tries to solve closure, it will create a HCA/AA problem as well.

Figure 4.45 Follow-on to Medium Aspect Angle Defense.



4.5.36 Low-Aspect Defense Execution: Gun Jinks. There are two basic types of jinks that are effective in the low-aspect defensive situation, the rolling tuck under and the nose counter. Since it is impossible to account for every situation as to which one to perform, we'll cover some basic execution mechanics and sight pictures that should help the decision process.

4.5.36.1 Rolling tuck under.

4.5.36.1.1 The preferred jink, if altitude allows, is a three-dimensional rolling tuck under, (typically 1,500 feet to 2,000 feet above the floor required at 10,000 feet mean sea level (MSL) in a clean jet). Continue the rolling tuck under until there is no altitude left to accomplish it or you either force a reversal or trap the attacker in lag and out of a Wez (you are now driving the fight). The purpose of the rolling tuck under is to defeat a gunshot by continuously changing your POM and creating closure problems for the adversary. If executed properly, the offender will disengage due to range and/or HCA problems, unloaded rolls to give the attacker lead (out-of-plane), will further complicate the attack and force a reversal opportunity. These maneuvers should manifest into a neutral or offensive position which meets the defensive BFM objectives.

4.5.36.1.2 This violent out-of-plane maneuver generates maximum HCA and closure problems for the adversary. It is executed by rolling underneath in the direction you are currently turning. As the attacker pulls the appropriate amount of lead and is establishing the proper POM, simply roll your aircraft while maximizing stick pressure. As the aircraft approaches upside down, (approximately 135 degrees), relax the pull, keeping the maximum roll input until the aircraft is about 90 degrees of bank on the other side of the turn. Decide whether to come out of the jink and pull in the new direction or continue the roll coming all the way around to the original direction. If the jink is continued to the original direction, simply add full back stick pressure from the 90 degrees point all the way over the top to the original direction. Lv placement in either case is crucial to survival. Avoid pulling in-plane with the attacker by putting Lv above or below his jet while his gun WEZ is still a factor. IRCM with idle, chaff and flares is a must for the IR threat during all jinks.

4.5.37 Post Jink: Which way to go?

4.5.37.1 The adversary's reposition determines which way to come out of the jink. Since this jink is designed to create closure problems, an evaluation of the attacker's range and Lv highlights the cues on which way to go. A tally-ho during this jink is mandatory to capitalize on adversary errors and create closure problems. One very aggressive option is to turn in the direction that will put the attacker in lead, while staying out-of-plane. This will maximize the attacker's closure problem but, may place you back into a gun WEZ. If you can cause some closure by pulling Lv on without getting shot at, do it. This aggressive option attempts to get the defender in the driver's seat as quickly as possible. It also forces the attacker to either bid to lag, allowing the defender to reset his Lv and start forcing the attacker out of sync, or the attacker pulls for lead, creating closure and range problems. An attacker that counter rolls while you jink may warrant a return to the same direction the jink was started.

CAUTION: An attacker on his game will try to be in lead and firing before you can establish a new POM. If it looks like he's in the gun WEZ, immediately go into another jink.

4.5.37.2 The second option is to come out in the direction that will put the attacker in lag. This option forces the attacker to pull lead to attempt a gunshot, but doesn't create as many closure problems while staying in an IR missile WEZ. If the attacker has performed a large, exaggerated reposition (ATA outside of missile slave limits), you may be able to select AB and trap the attacker in Lag, out of a WEZ. Regardless of the direction the defender rolls out of the jink, tally-ho must be maintained to capitalize on errors and determine adversary intentions. The defender needs to watch the attacker's nose ideally throughout the entire jink and immediately reorient his Lv based on the adversary actions. The transition to a floor defense is a time to roll out in the opposite direction of the initial jink. Without the altitude available for another tuck under, rollout opposite of the adversary's nose (and bullets) in order to maximize survivability and transition to a nose counter defense.

4.5.38 Nose Counter Jink.

4.5.38.1 This maneuver complicates the adversary's problem by giving the adversary lag when desiring lead. It is a rapid, unloaded 180-degree turn reversal. Maneuver timing cues

are different from medium-aspect defense since the adversary requires much less lead. You need to initiate the unload maneuver just prior to the adversary's nose approaching pure pursuit. When you see the adversary's nose approaching pure (en route to lead) push forward on the stick, breaking AOA, and roll the aircraft with full aileron to the opposite direction. Pull in the opposite direction, out-of-plane, to spoil the shot. The roll should happen just as the adversary reaches pure, and finish before the originally predicted lead point is achieved. The idea is to move as far as possible from the piece of sky the adversary thought you were heading for, without giving enough reaction time to correct for a new lead point. The nose counter can also be used against the offender that is out of sync and therefore unable to put his nose in plan for a gun shot. If using this to force closure problems, simply match the attacker's nose direction. Continue to give the attacker lead, out-of-plane, using the same fight technique.

4.5.38.2 The most vulnerable point of this maneuver to a missile attack is while the jet is unloaded. If the adversary has not shot an IR missile at you during the initial gun attack, it is probably because your LOS rate was too high for missile guidance. When you go into your unloaded reversal, you spend about 2 to 3 seconds with no appreciable LOS rate at all. Modern IR missiles can be fired from very close range, especially with zero LOS during a gun jink. TOF is short, and it will happen during the time that you briefly lose sight in the roll. If your adversary is IR missile-capable, you must assume a missile is coming when you jink—have the power back and expend flares.

4.5.39 Follow-On to Low Air-to-Air Defense.

4.5.39.1 Follow-on maneuvering will work best with about a 10- to 15-degree nose-low attitude. The defender must keep tally-ho (or immediately reacquire) the adversary and assess his intentions. Your power should be back at idle, with speed brakes optional. Some pilots like to leave the boards in to avoid alerting the adversary of upcoming closure problems. The sight of the boards is often the first reminder to the adversary to analyze closure. Maintain 160 to 180 knots (based on aircraft configuration). This regime gives the optimum trade off between retaining roll/turn rate authority and creating closure problems. As the adversary's nose prosecutes, immediately repeat the maneuver (with flares) in the opposite direction. At this point the adversary may be somewhat "on to" your plan, avoid making your second turn reversal exactly 180 degrees. You do not want the adversary to be able to simply roll out and let you fly through the bullet stream. The adversary's HUD BFM is producing a lot of closure. By the third or fourth jink (assuming the adversary stays pure/lead in order to prosecute), the adversary will have to make a large reposition to preserve 3/9 line. If the adversary recognizes closure problems early on in the attack, and elects to lag off for closure control, you can immediately postpone "Priority One" and concentrate purely on creating BFM problems. The strategy here is very basic—when the adversary wanted lead; you maneuvered to turn it into lag. Now, when the adversary wants lag, you turn it into lead. As soon as you see the adversary reversing to put his nose back into lag, immediately roll and pull into the adversary to make it lead. Most of the time, having decided the adversary really wanted lag, the adversary will reverse again back to the new lag direction. Turn this into lead also. Usually only a couple of these will provide a neutralization opportunity.

4.5.39.2 It is critical to realize that lead required is a very threat-specific quantity. Some aircraft, such as the F-16, have guns that are aligned with the aircraft boreline. Others, typically dedicated A/A platforms, have guns canted up (reducing airframe lead required), and some A/G fighters have guns canted down (optimized for strafing). Different ammunition types have dramatically different muzzle velocities. This means is that the visual picture developed for jink timing against an F-16 adversary may not be the same for other threats.

4.5.39.3 The concepts of offensive and defensive BFM are intertwined in the complex scenario of high aspect BFM. So, without any further delay, let's get into high-aspect concepts.

4.6 High-Aspect Basic Fighter Maneuvers.

4.6.1 Mindset: Gain the offensive advantage and convert to a kill or hold the advantaged fighter off as long as possible.

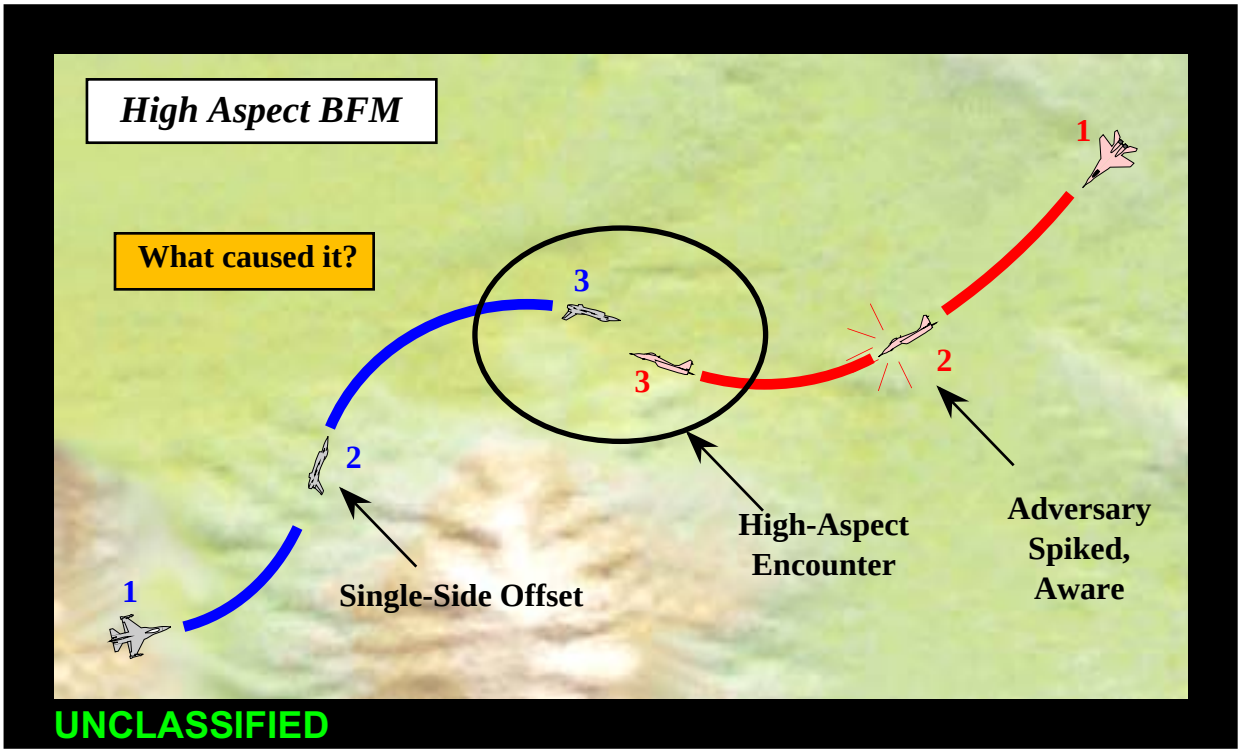
4.6.2 Gameplan: Recognize advantages and use those to gain the offensive advantage. Influence the fight, one-circle or two-circle to optimize your advantage.

4.6.3 Objectives.

- Recognize and execute lead turns.
- Manage Em with LV and Power
- Recognize and exploit Hostile Errors and Limitations
- Proper Transition to Offensive or Defensive BFM
- No missed shot opportunities, 100 percent valid shots.

4.6.3.1 How do we get to a high-aspect situation? The answer is the same as the offensive situation—we closed for an intercept. The difference is that somewhere before you got inside a controllable fight range, the adversary detected you and turned to counterattack. This is not an unusual situation in the fourth-generation fighter environment. With increasing SA capabilities, you are more likely to meet high aspect than any other way. (See **Figure 4.46**, High-Aspect Basic Fighter Maneuvers.)

Figure 4.46 High-Aspect Basic Fighter Maneuvers.



4.6.4 High-Aspect Basic Fighter Maneuvers Essentials. High-aspect encounters seem to be the largest source of energy-management misconceptions. To fully appreciate the role of energy in one-circle and two-circle fights, we will discuss some basic flight physics. Then we'll define the pictures you would see in a fight where both contestants match each other foot-for-foot in altitude and degree-for-degree in angle. Finally, we'll discuss some basic gameplan selection and execution.

4.6.5 Turning Room and Lead Turns (Prior to 3/9 Passage).

4.6.5.1 In high-aspect confrontations we generally look at the area forward of the 3/9 line as a place to find turning room. Turning room is the distance between the fighters that is outside of their respective turn radii. It is available in the lateral or vertical POM or a combination of the two. Prior to 3/9 passage, turning room available to one fighter is available to the other. If two aircraft merge with each other at 180 HCA with only enough room between them to avoid hitting each other, then no turning room exists. In a training environment, the bubble (500 feet for continuation training; 1,000 feet at the FTU and 1,500 feet below 5,000 feet AGL) defines the minimum spacing between the aircraft at the pass.

4.6.5.2 Turning room is generally gained under two conditions. The adversary either lets you have it because he is unaware of your presence [single-side offset (SSO) intercept], or is ignorant of the visual fight basics. If you try to get turning room prior to the merge by holding offset until the pass while the adversary continues to point, you are giving up angles at the pass and will have, in effect, given the adversary a lead turn opportunity. Generally, if you have two smart pilots with fairly equal aircraft there will be no turning room at the first pass. (See **Figure 4.47**, Turning Room Prior to 3/9 Pass.)

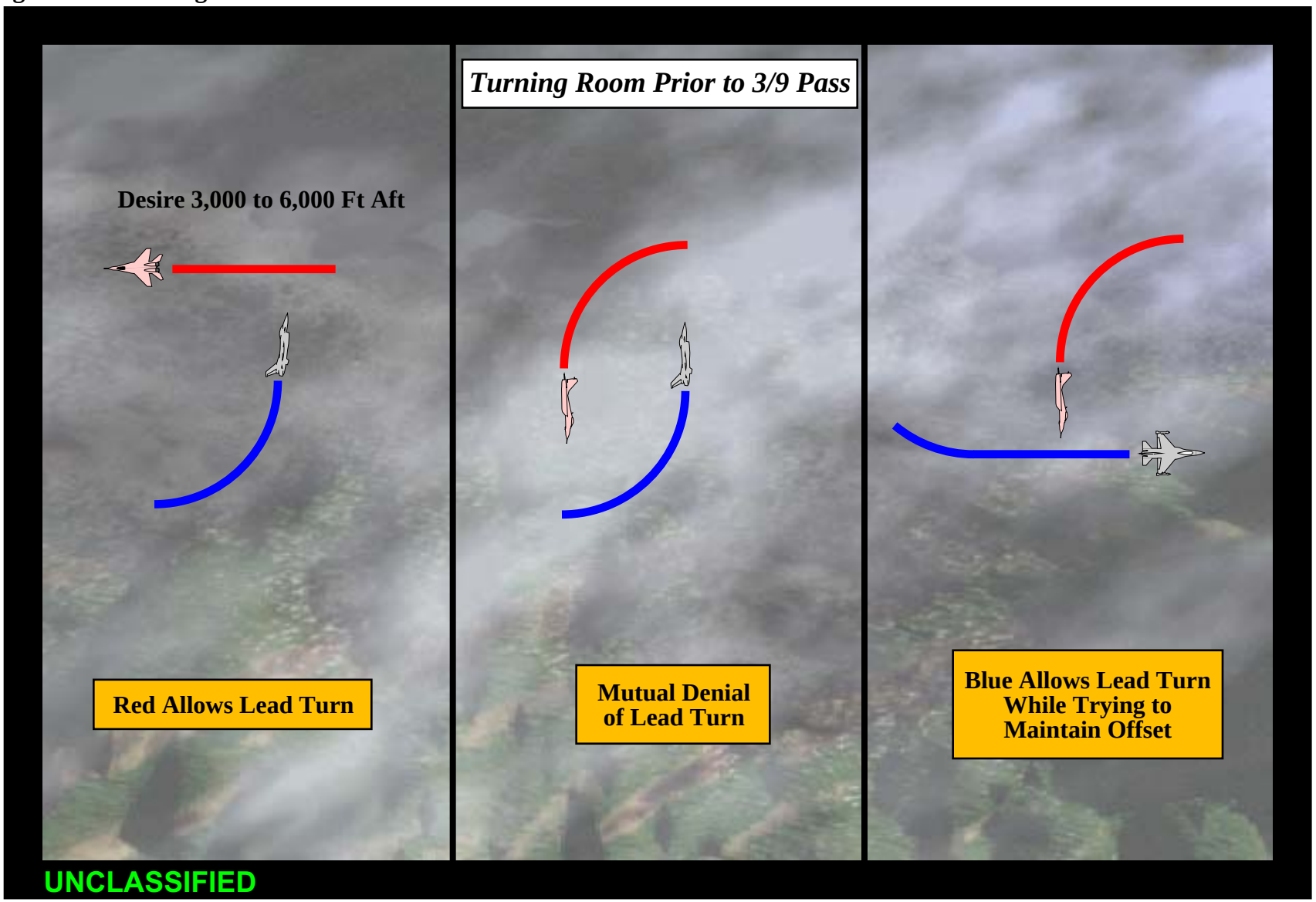
4.6.5.3 A lead turn by definition is using any turning room prior to passing the adversary's 3/9 Line for the purpose of decreasing aspect and heading crossing angle. If available, the lead turn allows an angular advantage which may make the difference between a quick kill and a prolonged engagement. The amount of turn you are able to complete is affected by the amount of lateral/vertical offset; i.e., turning room, available prior to starting the turn. In the initial two passes of a high-aspect fight there are usually few opportunities to get a classic lead turn. Typically, the first turn and second pass are evened out by turn-circle shrink and average turn rate in hard maneuvers, and the fighter who seeks to win it all in the first two turns is going to be in for a big disappointment. Unilateral turning room for your lead turn comes later in the fight when the adversary arrives at a performance limit.

4.6.5.4 Adversary LOS rate on the canopy and an aspect less than 180 are two site cues that show when a lead turn is available. If the adversary is not pulling for pure pursuit (due to BFM skills or at a performance limit) the aspect will decrease to less than 180. Execute the lead turn as adversary LOS rate begins to traverse down the canopy. The greater the distance between the two fighters, the LOS cue develops earlier and at a slower rate. The closer the distance between the two fighters, the LOS cue develops later and at a much higher rate.

4.6.6 Influencing and Controlling Merges.

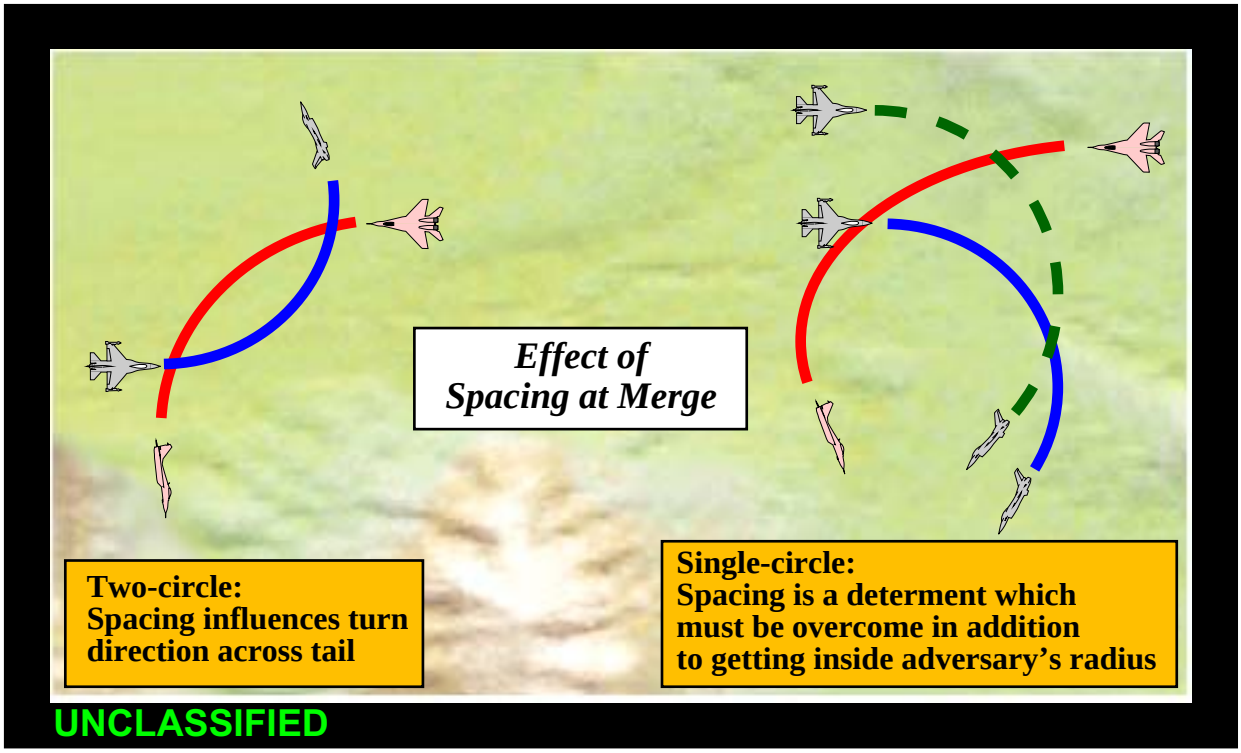
4.6.6.1 The fighter who correctly positions himself for the desired fight type will have the upper hand at the merge. Positioning for the merge is an often-overlooked area of high-aspect fights. Merges generally develop in one of two options: (1) the two players will arrive level at the merge and 180 degrees HCA, and as close in lateral distance as the training rules will allow or (2) one player will begin what appears to be a lead turn prior to the pass. Adversaries that can actively maneuver premerge will force option number one. Constrained or unaware adversaries will allow you option number two. The spacing and angles at the merge will influence the adversary's turn direction. In addition, each subsequent pass requires the fighter to use spacing, angles or a combination of both to continuously influence the adversary to turn the direction you want him to.

Figure 4.47 Turning Room Prior to 3/9 Pass.



4.6.6.2 When two fighters pass 180 degrees out, the horizontal distance between them is a piece of the turn radius of both adversaries in the next turn. If both turn toward each other (two-circle), the distance is inconsequential. If one fighter chooses to turn away from the other (one-circle), the distance becomes an additional radius that must be overcome in the 180 degrees to the next pass to avoid being defensive. A fighter who wants a two-circle fight should seek as much horizontal offset as possible to drive the adversary to turn two-circle. Conversely, a fighter desiring a one-circle fight should seek to minimize horizontal distance between the fighters at the pass, ideally passing just underneath the adversary. Turning single-circle when there is significant lateral distance at the merge (greater than 500 feet) will give the edge to the fighter that turned two-circle. (See **Figure 4.48**, Effect of Spacing at the Merge.)

Figure 4.48 Effect of Spacing at the Merge.



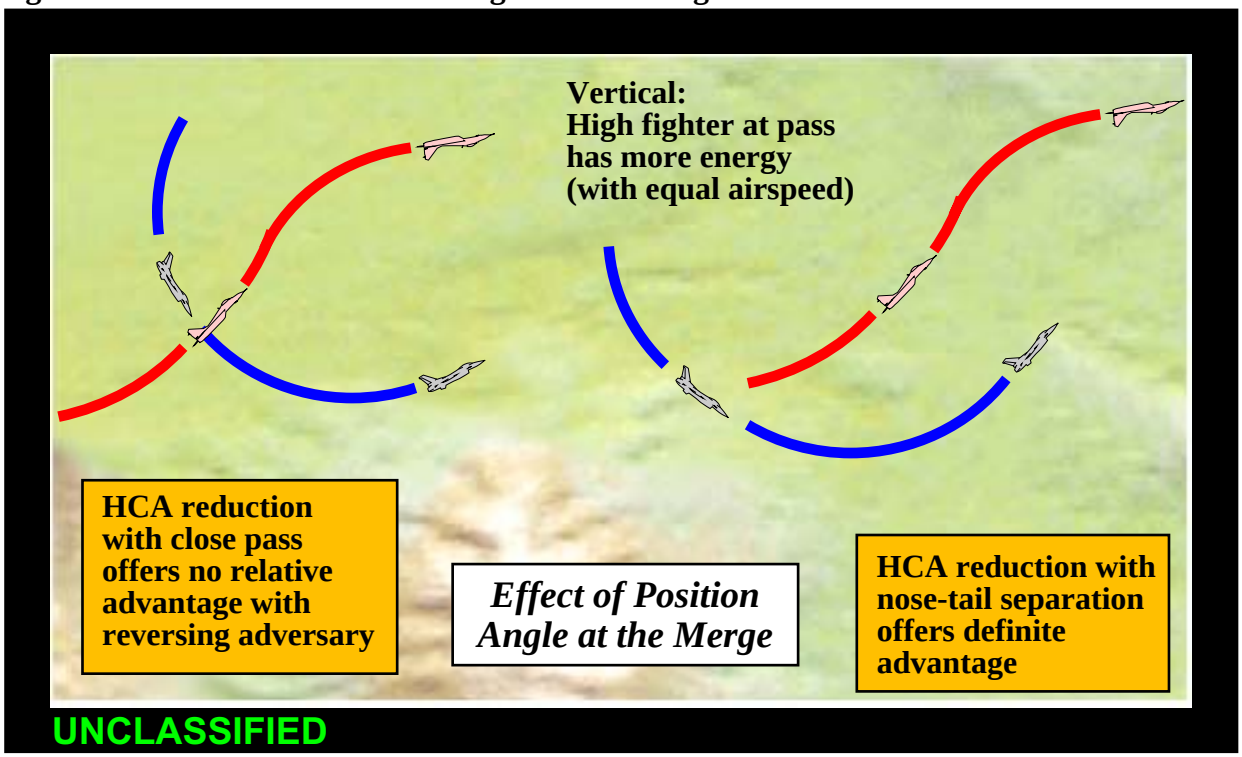
4.6.6.3 The concept stems from a belief that the other aircraft cannot turn well. Examples of poor turning aircraft include airspeed and vertical factors, such as a turn that would cause ground impact or the effect of God's G. An example of the premerge lead turn that works is shown here; however, the concept requires maneuver against an adversary that is on a performance limit. Assessing where the limit may exist and therefore is exploitable requires careful intelligence study and absolutely solid knowledge of energy physics.

4.6.7 Altitude Delta at the Merge. An altitude difference at the pass means the higher fighter has an energy advantage. This is usable as extra Ps against the lower fighter. In terms of energy, the only altitude that matters is that between the adversaries.

4.6.8 Angles Effects at the Merge. A fighter with advantage in angles at the pass also influences the adversary to turn toward him to negate it. The difference is that if the adversary

chooses to reverse direction, the amount of offensive potential the fighter sees will be a direct function of how far aft of the adversary the fighter crosses the extended 6 o'clock. The closer you cross the adversary's 6 o'clock, the less offensive advantage you will have if the adversary reverses. Pass at one turn radius or greater (nominally 3,000 to 5,000 feet) behind the adversary, to maximize your potential to counter an adversary reversal. Remember, offset is meaningless prior to the pass against an aware adversary. (See **Figure 4.49**, Effect of Position on Angles at the Merge.)

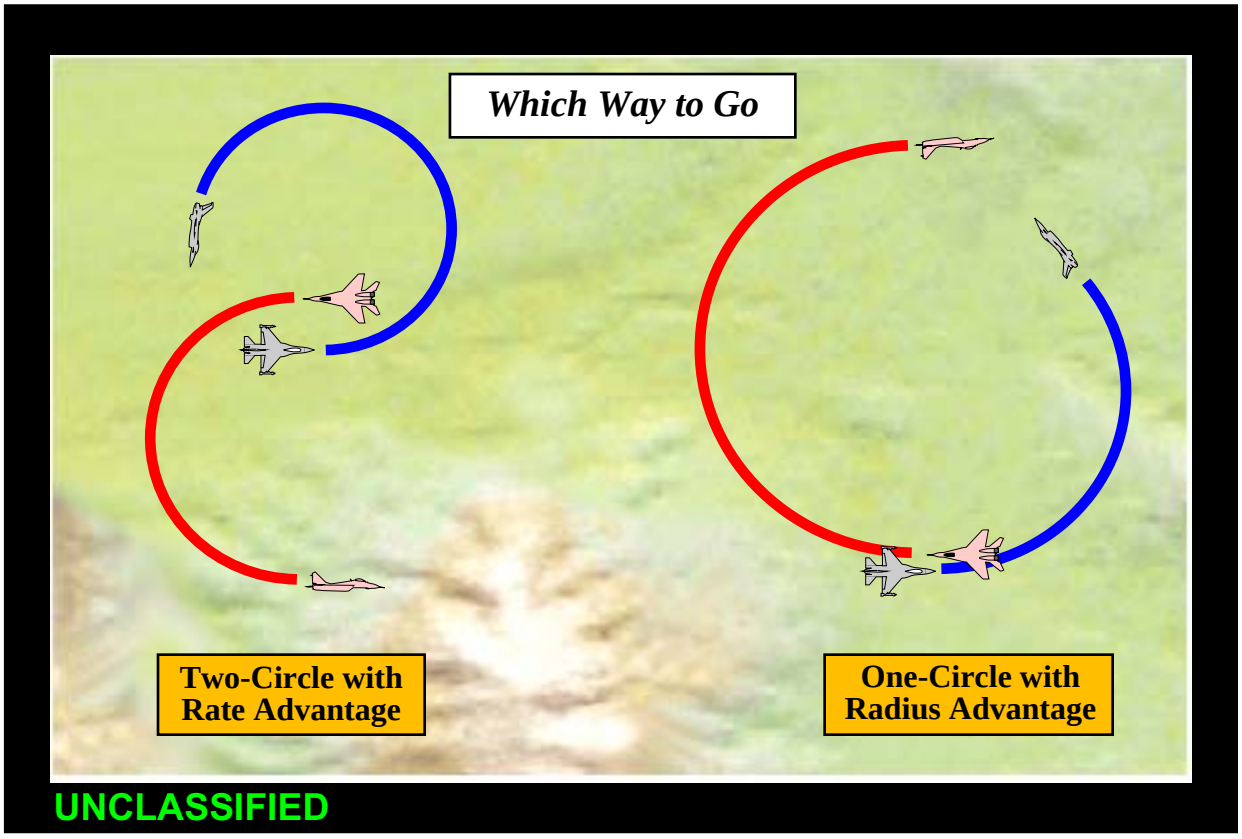
Figure 4.49 Effect of Position on Angles at the Merge.



4.6.9 Which Way to Go.

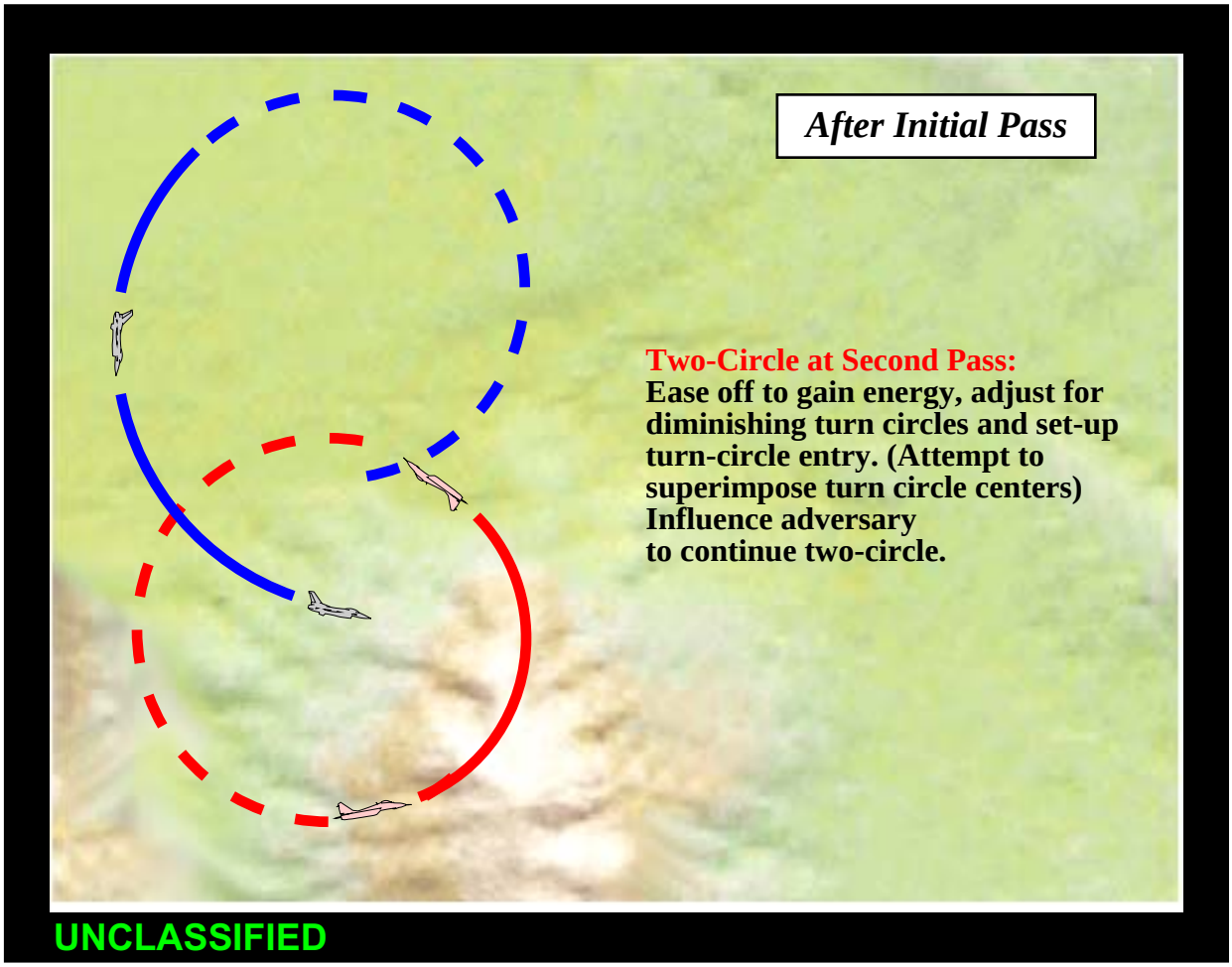
4.6.9.1 The direction of the turn at the pass sets the gameplan in motion and defines what advantages the fighter will seek to exploit in the ensuring turn. For a two-circle turn (adversary and fighter turn across each other's tails) the primary advantage is turn rate. A rate advantage over the adversary will allow angles that reduce HCA and increase offensive posture at each pass for the fighter. However, rate alone does not win the war. As you recall from offense, turn rate for the Viper is highest when crossing over the hump (330-440 regime) on the turn performance chart. It would seem logical that this is where you would want the fight to occur. The real answer though is that you want excess turn rate available in relation to the adversary and apply it throughout the airspeed regime. To accomplish that, you want to drive the adversary down the lift limit line first, and then follow him down while reducing AA and HCA, just like offense. This is where some Em diagram study will reveal your advantages and the adversary's weaknesses. (See **Figure 4.50**, Which Way to Go.)

Figure 4.50 Which Way to Go.



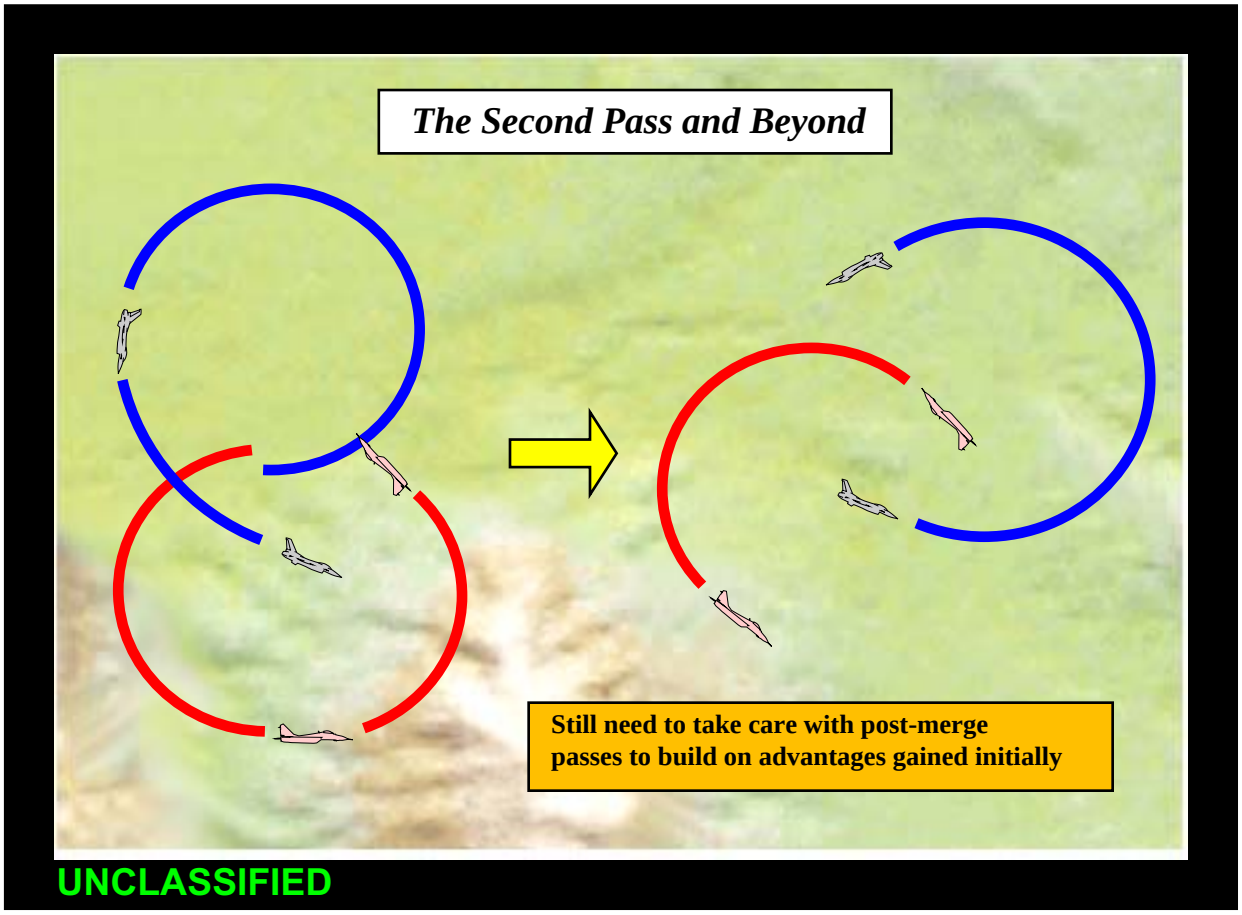
4.6.9.2 In this case, the second fighter turns away from the other's tail. In the single-circle fight, turn rate advantages are nearly inconsequential. The deciding advantage in the follow-on pass will be based on turn radius. The aircraft with a smaller radius can point sooner and will generate an advantage in HCA at the next pass. If at this next pass, you saw a HCA advantage and reversed the turn (a lead turn), then you have now transitioned to a two-circle fight (assuming the adversary continued his turn direction). This transition to a Two Circle fight forces the fighter to reestablish a positive rate advantage to transition to an offensive advantage or use range aft of the adversary 3/9 line to prosecute if the adversary reverses his turn direction. On the other hand, if the fighter chooses to keep the turn going in the same direction at the pass (continuing the single-circle fight) after gaining advantage, that fighter will likely see the advantage disappear. A Good time to utilize a single-circle fights are when your airspeed at the merge is low (e.g., sub-400 knots) or when the adversary is rate limited (a poor turning aircraft like a FLOGGER). Another good time to go one-circle is when you hit the merge with an adversary that may have a significant off-boresight capability (FULCRUM with helmet-mounted sights and capable missiles). (See **Figure 4.51**, After the Initial Pass.)

Figure 4.51 After the Initial Pass.



4.6.10 The Second Pass and Beyond. If there is any discussion at all about merge position entry, it certainly never gets applied to the later passes in the fight where it is even more critical. (See **Figure 4.52**, The Second Pass and Beyond.) Each pass in the fight is an opportunity for the players to switch the character of the fight from one- to two-circle or vice versa. For a fighter trying to force a particular fight (one or two circle), subsequent passes are where the plan will likely fail. At the merge, put some influence on the adversary to turn in the desired direction. Each subsequent pass becomes a new merge. Set objectives to be achieved prior to the next pass and set up the adversary to turn the way you want. The same principle for influencing one- and two-circle fights applies regardless of energy state. It will be of utmost importance to understand the boundaries when switching the game plan.

Figure 4.52 The Second Pass and Beyond.

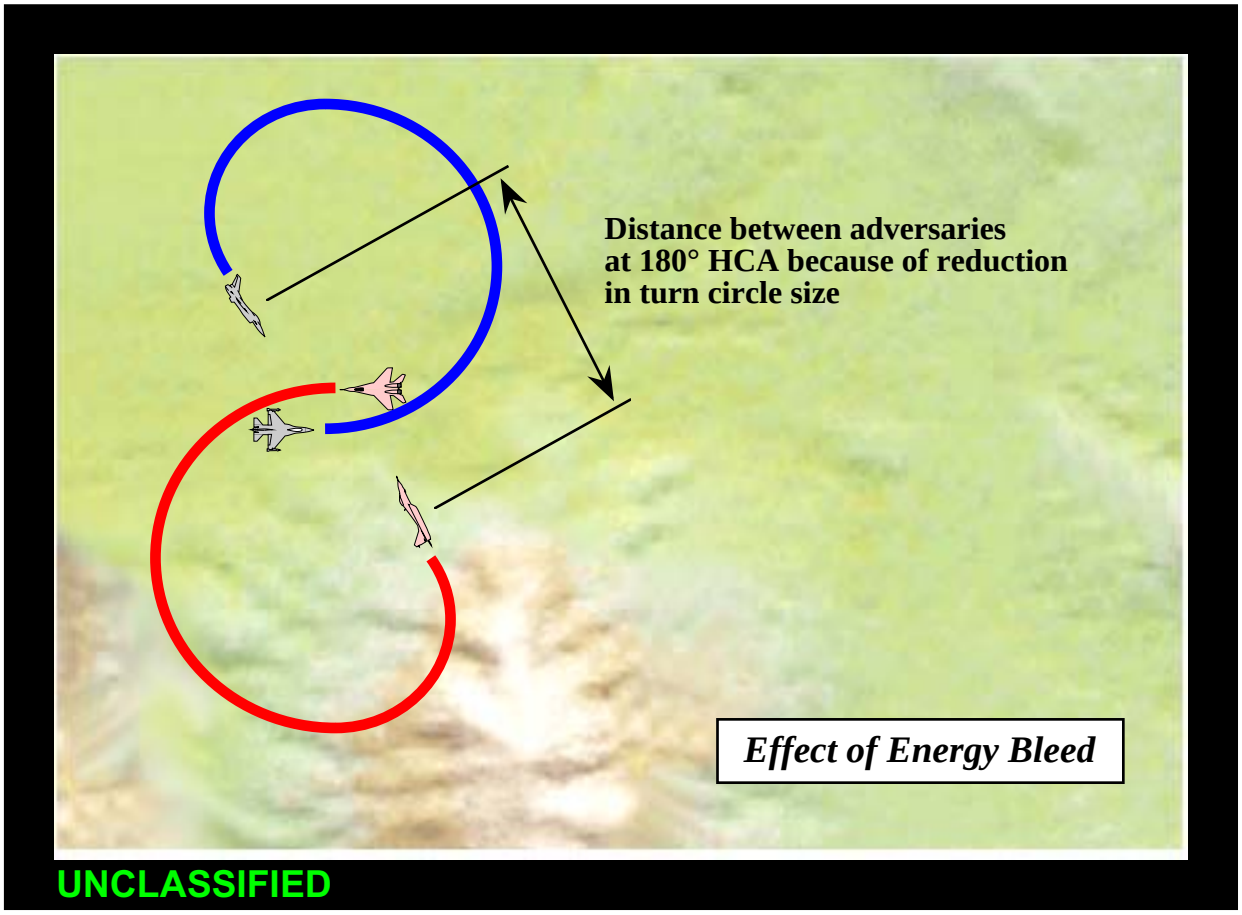


4.6.11 Effect of Energy Bleed Off on Turn Radii in Two-Circle Fight.

4.6.11.1 The radius effect of hard maneuvering from a high initial energy state as fighter's turn to gain advantage is termed “TC shrink.” As an aircraft turns 180 degrees on the aft limit and goes from 450 to 250 KCAS the radius starts at 3,200 feet (450 KCAS at 9 Gs), and 45 degrees of turn later is at 2,500 feet (400 KCAS at 8.3 Gs). The aircraft does not turn around the same point throughout the turn. The center moves away from the starting point towards the aircraft. Halfway around the turn the radius is 2,200 feet (7.7 Gs at 350 KCAS). At the completion of the 180 degrees, the aircraft is pulling 4.3 Gs at 250 KCAS with a radius of 1,800 feet. In the turn, the aircraft reduces to 55 percent of the original speed and 59 percent of the original radius.

4.6.11.2 Radius Effect During Two-Circle Fight. Put an adversary doing the opposite in a two-circle fight and it becomes apparent that you must ease off and drive to the adversary when coming out of the first turn. This may not be the way to fly the turn, it is only a discussion of limiter turn physics. An example is shown in **Figure 4.53**, Effect of Energy Bleed-Off on Turn Radii in Two-Circle Fight.

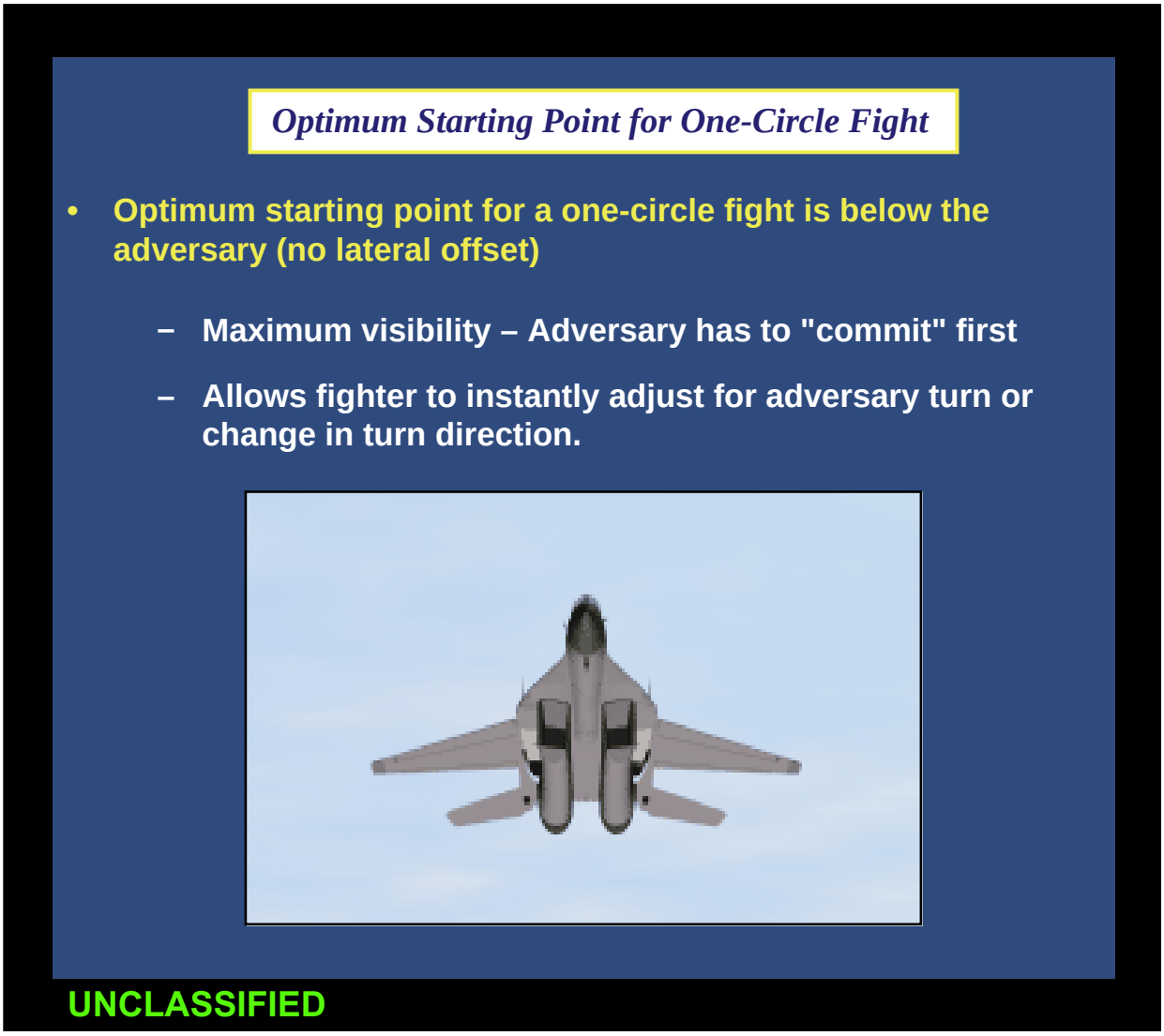
Figure 4.53 Effect of Energy Bleed-Off on Turn Radii in Two-Circle Fight.



4.6.12 Rate versus Radius. As discussed earlier, where you fly the jet on the Em diagram will provide varying turn rates and turn radius. For a clean configuration, 330 KCAS to 440 KCAS generally yields the best turn rate. Airspeeds between 130 KCAS to 329 KCAS gives us the tightest turn radius. When choosing and executing a gameplan, utilizing these airspeed windows is generally a feasible plan. However, blindly flying airspeed with no regard for adversary maneuvers is one easy way to end up defensive. Therefore, there are times when the fighter should allow airspeed excursions outside of these two general windows: (1) to deny a WEZ; (2) To create or deny turning room; and (3) to employ ordnance and/or kill the adversary.

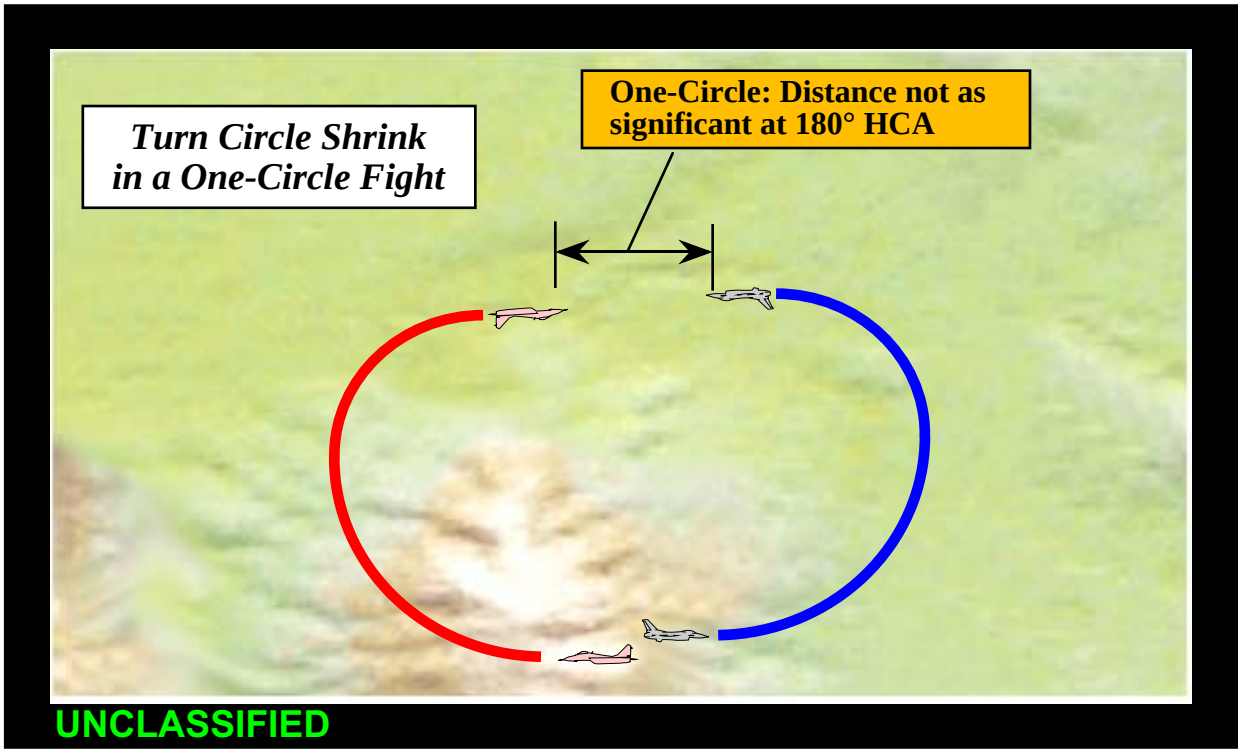
4.6.13 Optimum Starting Point for One-Circle Fight. The turn you cannot influence by position is the one-circle fight. (See **Figure 4.54**, Optimum Starting Point for One-Circle Fight.) The best you can do is negating any radius offset by zeroing it out with a close pass; this does not mean scraping paint. In training you have a bubble to avoid, but you can pass directly above or below the adversary (still outside the bubble) and then start turning in the horizontal. If you want a one-circle fight, arrive at the pass from below. This affords maximum visibility while forcing a LOS for the adversary at the pass. At the 3/9 line, the adversary can turn either way (so can you) with negligible effect. Influence the adversary to start the turn early to keep sight, and have the last word by staying visual throughout the pass. The last one to turn sets the one-circle or two-circle geometry.

Figure 4.54 Optimum Starting Point for One-Circle Fight.



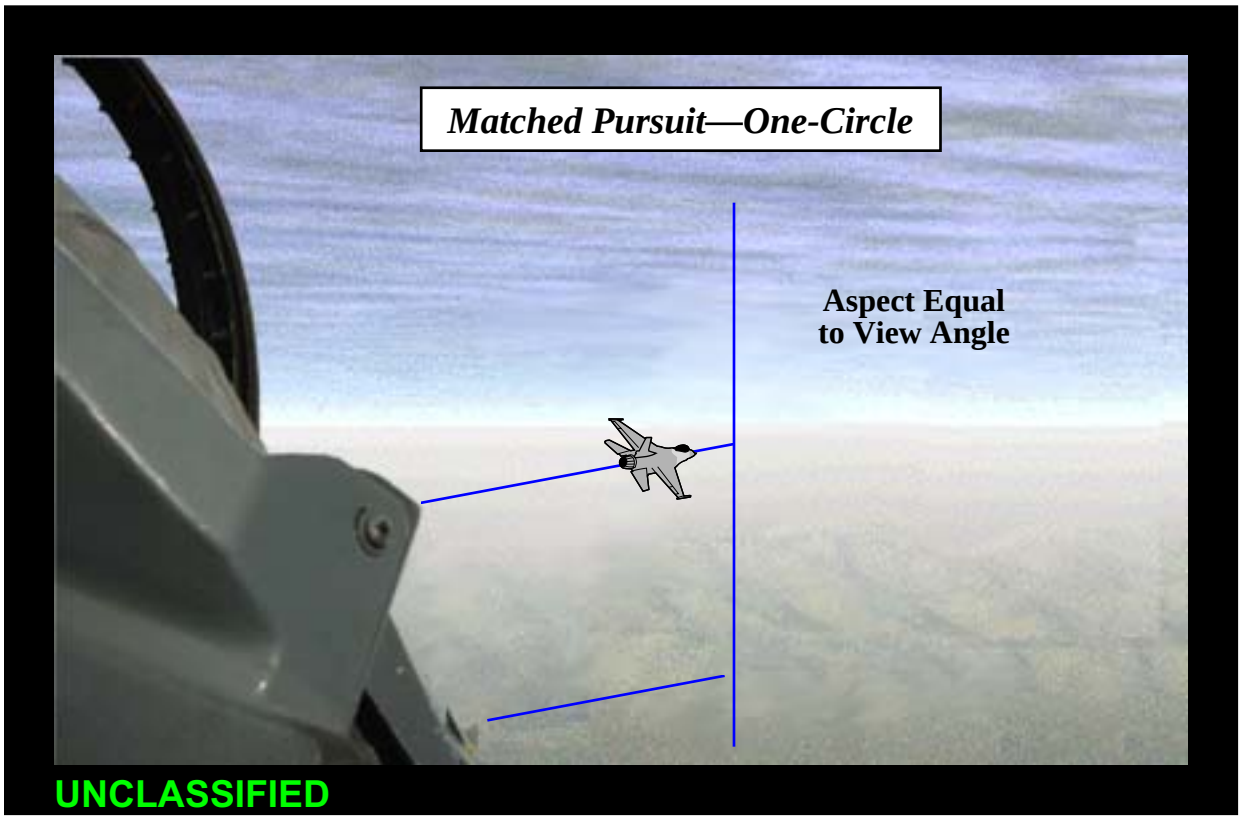
4.6.14 Turn Circle Shrink in a One-Circle Fight. Radius Effect During One-Circle Fight. In a one-circle fight the same thing happens, but the range between the aircraft after the 180 degrees is less. The spread between them is hundreds of feet versus thousands in a two-circle. Although the turn circles pull away from each other, the distance will soon close down due to the reduce G available to each aircraft. The turn radius will open up and the ability to get nose-on will diminish. (See **Figure 4.55**, Turn Circle Shrink in a One-Circle Fight.)

Figure 4.55 Turn-Circle Shrink in a One-Circle Fight.



4.6.15 Matched Pursuit: One-Circle. The first picture to measure status happens at the merge. Two fighters pass in completely neutral geometry. This means they are co altitude, have 180 degrees HCA and turn simultaneously toward the same cardinal direction while holding each other on the horizon with roll control. The next assessable picture occurs as the adversary crosses the fighter's 3/9 line across the circle. Again, on the horizon the adversary views you through his 3/9 line as you view his aircraft on your 3/9 line approximately one diameter away. The turn remains matched degree-for-degree and foot-for-foot—completely neutral in geometric terms. (See **Figure 4.56**, Matched Pursuit; One-Circle.) The key indicators of matching are the adversary is on the horizon, and both fighter and adversary view each other through equal AA as aspect climbs to 180 degrees. Each fighter turns 180 degrees to the next pass and because of energy bleed off and TC shrink (brought about by reduction in airspeed and hence turn radius), the fighters end up in the final position of equality— nose-to-nose on the horizon with 180-degree HCA. Neither fighter gains an angle or elevation advantage, and the second pass will occur neutral in relation to geometry and energy.

Figure 4.56 Matched Pursuit; One-Circle.



4.6.16 Two-Circle Matched Pursuit.

4.6.16.1 High-Aspect BFM Winning and Losing Cues. If two theoretically equal fighters merge with 180 degree HCA, and then match each other in both angles and altitudes they will continue to merge neutral. However, this is not a likely scenario due to differences in pilot skills, aircraft capabilities, and less-than-equal initial merge geometry/energy levels. Assume that your initial merge with an adversary is at 180 degree HCA with no lead turn by either of you. You visually identify the aircraft as a hostile and are in a two-circle fight. You execute a perfect two-circle game plan and after turning 90 degrees, you look across the circle and see the hostile aircraft level with you, but the hostile has turned more than 90 degrees. Are you winning or losing? Losing. You continue your turn (doing IRCM and expending OBCM if necessary) and decide that the only way the hostile could have done that was to have expended a lot of energy. So once inside minimum range for a missile attack you light the AB and continue with the two-circle plan. 180 degrees after the second merge you notice that the hostile is across the circle, is lower in altitude than you are, and has turned considerably less than you. Now who is winning? These are the types of cues you must recognize to determine if the fight is going as you planned or not. If not, change the plan.

4.6.16.2 The same basic concept applies to two-circle fights with the exception that one compares the aspect angle to the amount that the adversary is around the turn. A matched pursuit picture occurs when each fighter views the other through equal AA after 180

degrees of turn. The fighters will pass 180 degrees at the next merge. Neither fighter gains an angle or elevation advantage.

4.6.17 Winning the Turn Horizontally. Winning turns in the horizontal requires holding the adversary on the horizon with roll control and pulling aft hard enough to make the adversary appear to lose the rate or radius contest of the turn so you may convert it to a usable advantage at the next pass. To illustrate the winning picture, use three points in the turn: across the circle, just prior to the next pass and just after the pass.

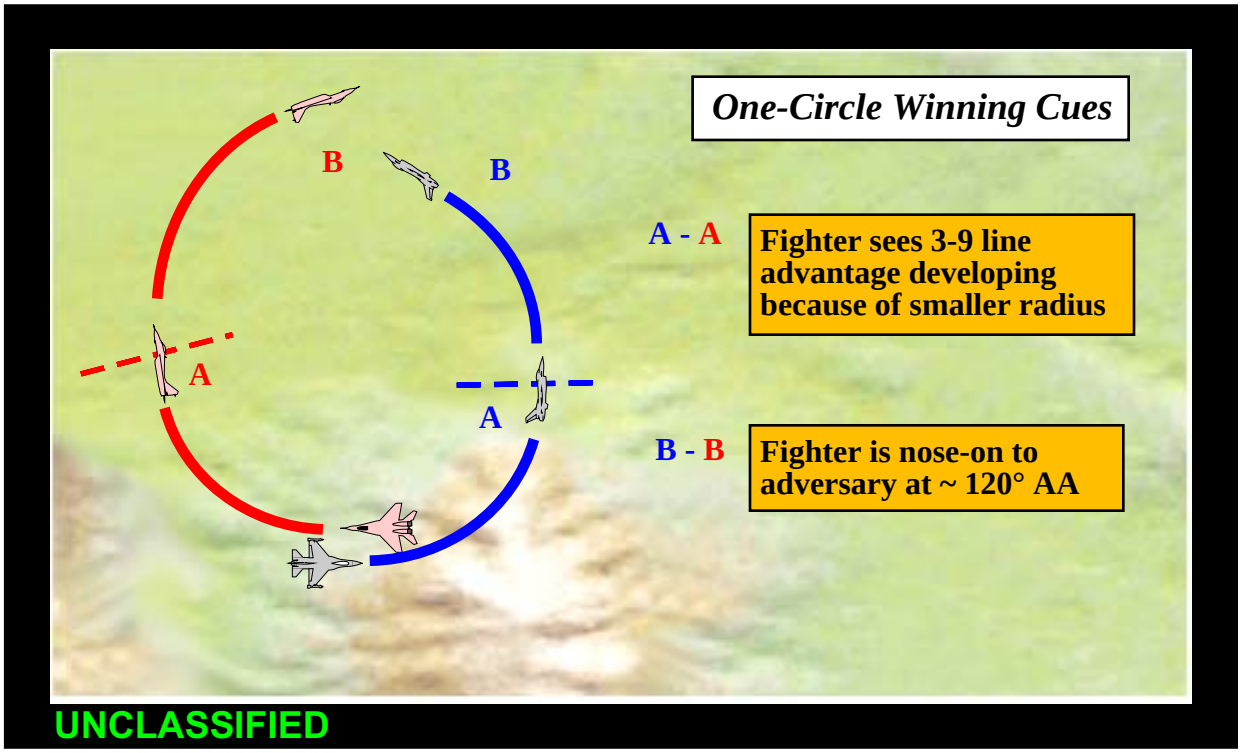
4.6.18 Winning the Turn Vertically.

4.6.18.1 Less capable adversaries can present what appears to be a neutral fight in angles and hide a lower capability for a short time. Eventually though, to keep the angles even, this adversary will have to pay back the Ps by descending. A power-limited adversary may try this for intimidation or to mask the airframe weakness. The key indicator here is that the adversary slowly begins to drop below the horizon as he over banks to get the nose down to use Ps. As the turn commences, the adversary flies below the fighter without attempting to bring the nose back up to zero out the angles at the pass. This vertical delta is an advantage you can use at the pass to enhance your position in angles (discussed later). Important keys to recognize in this situation are that the adversary eases off the horizon and does not attempt to point at the pass. ***CAUTION:*** If the adversary rapidly departs the horizon and points at you from below, you probably have a gameplan being used against you. If it is not countered early, you may give away significant advantage after the next pass, or even find yourself in a WEZ.

4.6.18.2 To get the best performance out of your jet, a nose-low pull produces the greatest rate with the lowest airspeed bleed. The sight picture for this nose-low pull is to keep the adversary within about a beer can or two of the horizon. The nose-low pull uses up some of the potential energy for the current performance. Choose the time at which you desire to spend this energy. Typical times that a fighter may want to spend this energy are to prevent losing cues, pulling to a WEZ, pulling to match a nose-low adversary or pulling to point first or intimidate. At these times, as you see the adversary LOS down on the horizon, orient Lv to freeze the vertical LOS as you pull to match, deny a WEZ etc.

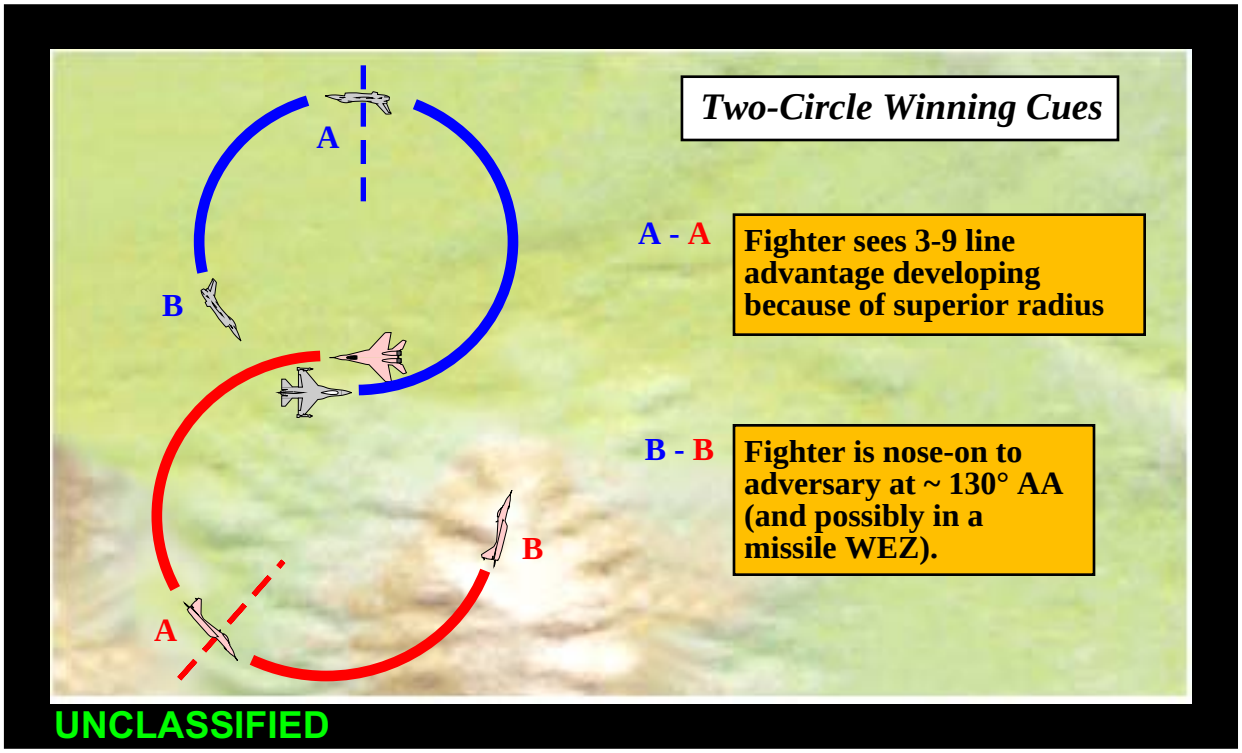
4.6.19 One-Circle: Winning Cues. In a one-circle contest, as shown in **Figure 4.57**, One Circle Winning Cues, the first indication that the adversary is losing the fight is determined after 90 degrees of turn. At this point, you will be looking out your 3/9 line and the adversary will be looking back, aft of his 3/9 line. As the adversary finally pulls you through his 3/9 line, you will notice LOS begin across the horizon in the direction of the adversary's nose. ***NOTE:*** This is not “canopy drift” but a drift along the horizon—all of the high-aspect pictures discuss drift on the horizon, not drift on the canopy. In each turn the adversary goes from 6 to 12 o'clock every time. Canopy movement is constantly dynamic and nearly irrelevant to assessing advantaged status. As the pass continues, notice the adversary LOS accelerates across the horizon as you point at the adversary's aircraft and close the range. This is the area to look at for exploiting an advantage.

Figure 4.57 One-Circle Winning Cues.



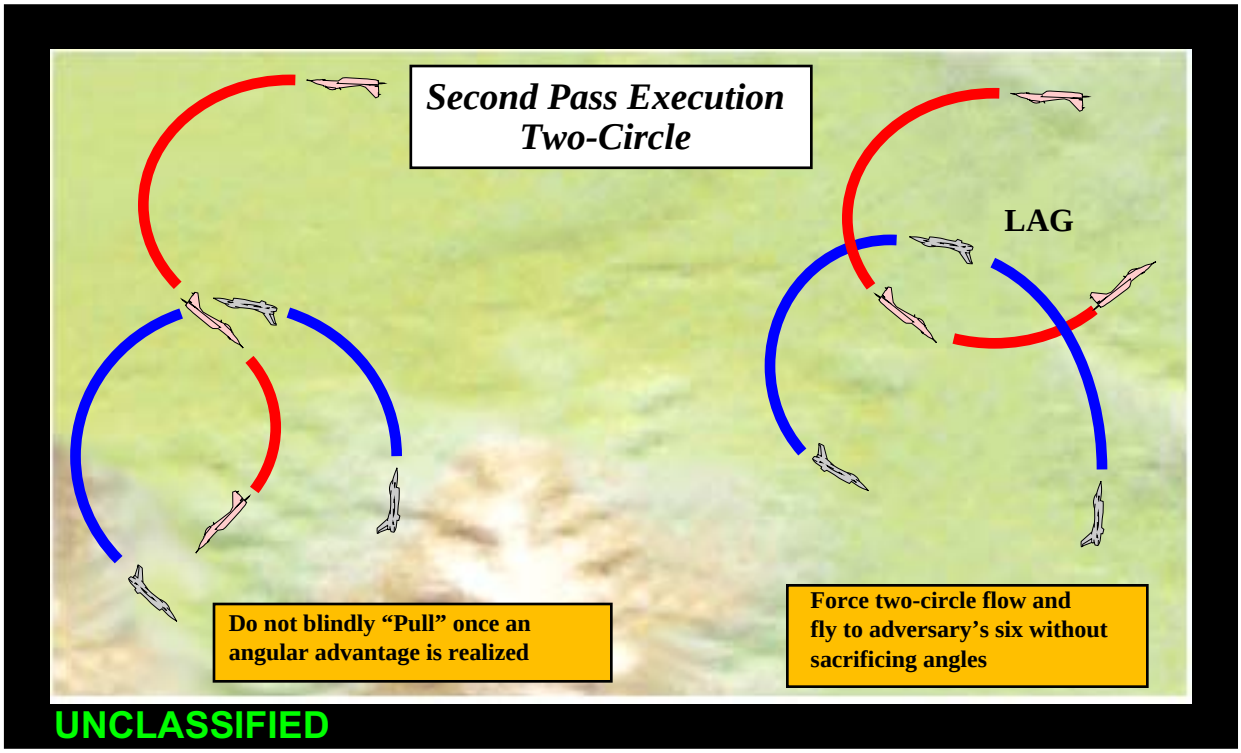
4.6.20 Two-Circle: Winning Cues. In a two-circle fight, as shown in **Figure 4.58**, Two-Circle Winning Cues, the losing adversary will begin to lag in turn rate as the turn continues. As you turn to put the adversary on your 3/9 line, notice the adversary is looking back along a line aft of its 3/9 line. The LOS is irrelevant at this point; you are going opposite directions. The key indicator of advantage is from angle only and is difficult to see. As the turn progresses, you will be able to point at the adversary before the adversary points at you, and LOS in the direction of the adversary's nose will appear. Again, this is the area where the advantage must be exploited, with a properly executed lead turn.

Figure 4.58 Two-Circle Winning cues.



4.6.21 Second-Pass Execution—Two-Circle. Winning the turn does not win the pass. The proper pursuit course must be set up prior to the second pass based on the angle advantage gained throughout the turn. If the turn is continued to the next pass, than you will meet relatively high aspect again and will fail to generate the necessary range for weapon employment and an offensive position. After the fighter gets through the first couple of merges and starts to see an advantage, he needs to accomplish several steps at each pass. First, he must recognize the advantage when a lead turn opportunity presents itself, fly his aircraft to the correct geometry, and finally start the turn to exploit the adversary's performance limit. Execution: As the fighter continues the turn and sees that he will point at the adversary first, decide whether to continue to pull, or ease off the turn and look for the lead turn cues discussed previously. If you can employ ordnance, then continuing to pull and shoot is an acceptable move. If range is in question for a shot, then lagging off for a lead turn will keep you driving the fight and eventually lead to an offensive transition. The process differs from one-circle to two-circle fights depending on energy and follow-on game plans. (See **Figure 4.59**, Second-Pass Execution—Two-Circle.)

Figure 4.59 Second-Pass Execution—Two-Circle.



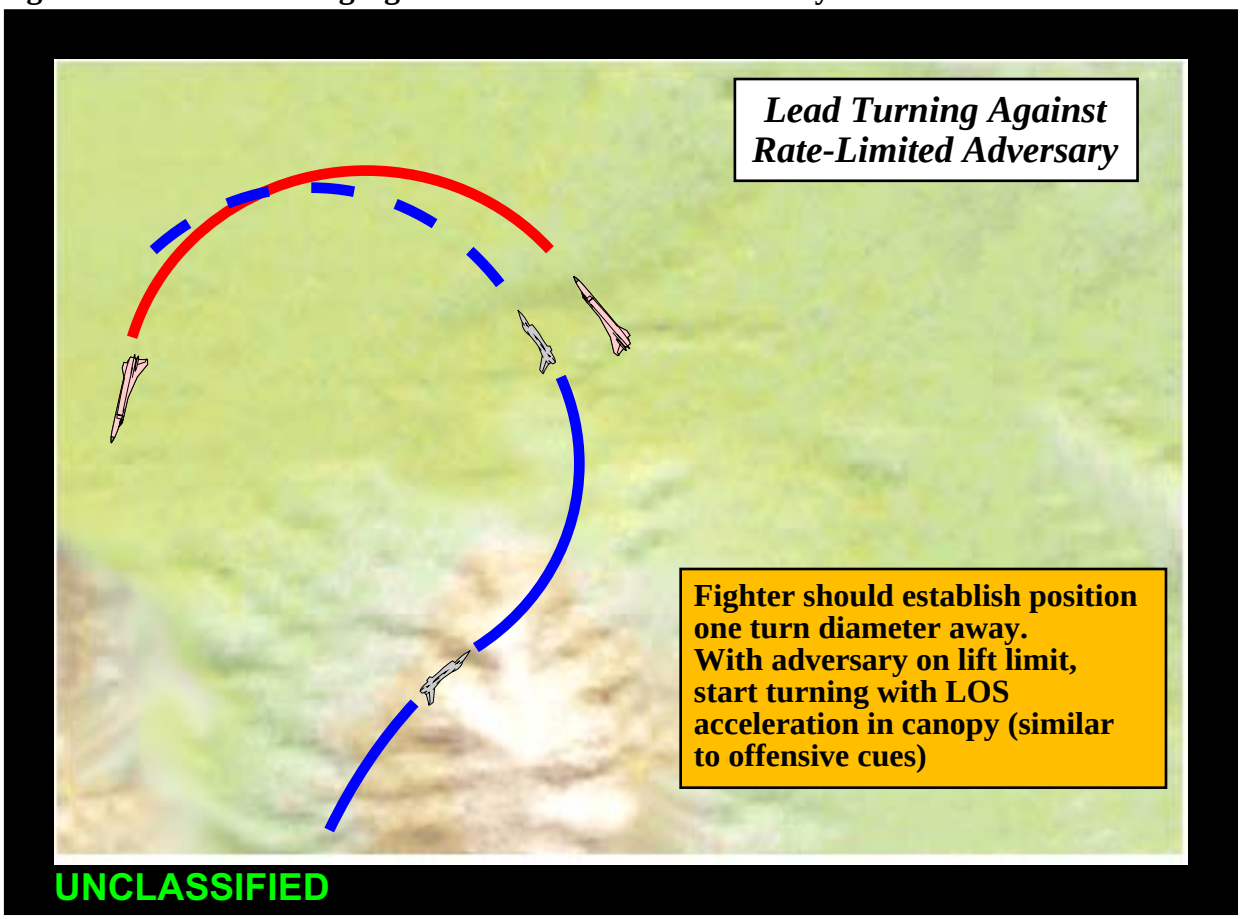
4.6.22 Lead Turning Against Rate-Limited Adversary.

4.6.22.1 If the adversary is rate limited, the fighter assesses winning cues after 180 degrees of turn as noted by the ability to point at the adversary before the adversary can point at him. Don't put the adversary in the HUD until you're ready to shoot. The fighter recognizes this advantage, but this is not the time to mechanically start lead turning. The geometry of the situation places the two-circle turn center apart from each other by roughly two radii. The fighter must align his turn circle center near the adversary's to establish a controlling position. Align your turn circle similar to an offensive BFM turn circle entry. Point to where the adversary was and begin your turn when you see LOS aft attempting to cross the adversary's six o'clock about 3,000 feet back. The adversary is, by definition, on a performance limit because he is losing the turn and cannot negate the fighter's plan (the adversary's turn circle radius is as small as it is going to get, and the fighter is entering it offset from the nose).

4.6.22.2 This adversary limitation allows the fighter to begin to align turn circles by easing off the turn premerge to hold the adversary about 1 o' clock position away. The fighter begins the lead turn when the adversary's LOS rate accelerates rapidly along the horizon, not later than 180 degrees HCA. The acceleration of LOS is the visual cue to start the lead turn. At this visual cue, roll and set your LV slightly below the adversary with a maximum pull to reduce HCA in order to pass approximately 3,000 feet aft (on turn radius away). Just like the offensive turn circle entry, the best turn will be accomplished from a point slightly higher than an adversary as you start the turn. However, tactically you may not want to merge look up vs. a HOBs adversary. If the fighter continues to align turn circles with mechanics described above, he will see aspect decrease after each merge. A common

error is for the fighter to continue a max performance turn to put the adversary in the HUD. If this occurs, the fighter pursues in an offset circle and repeatedly come nose-on to the adversary (medium to high aspect). The fighter can quickly lose control of the intended gameplan and lose shot envelopes as the adversary continues to turn. Simple turning will not generate controlled gun envelope even after 10 turns. You must align turn circles. (See **Figure 4.60**, Lead Turning Against a Rate-Limited Adversary.)

Figure 4.60 Lead Turning Against a Rate-Limited Adversary.

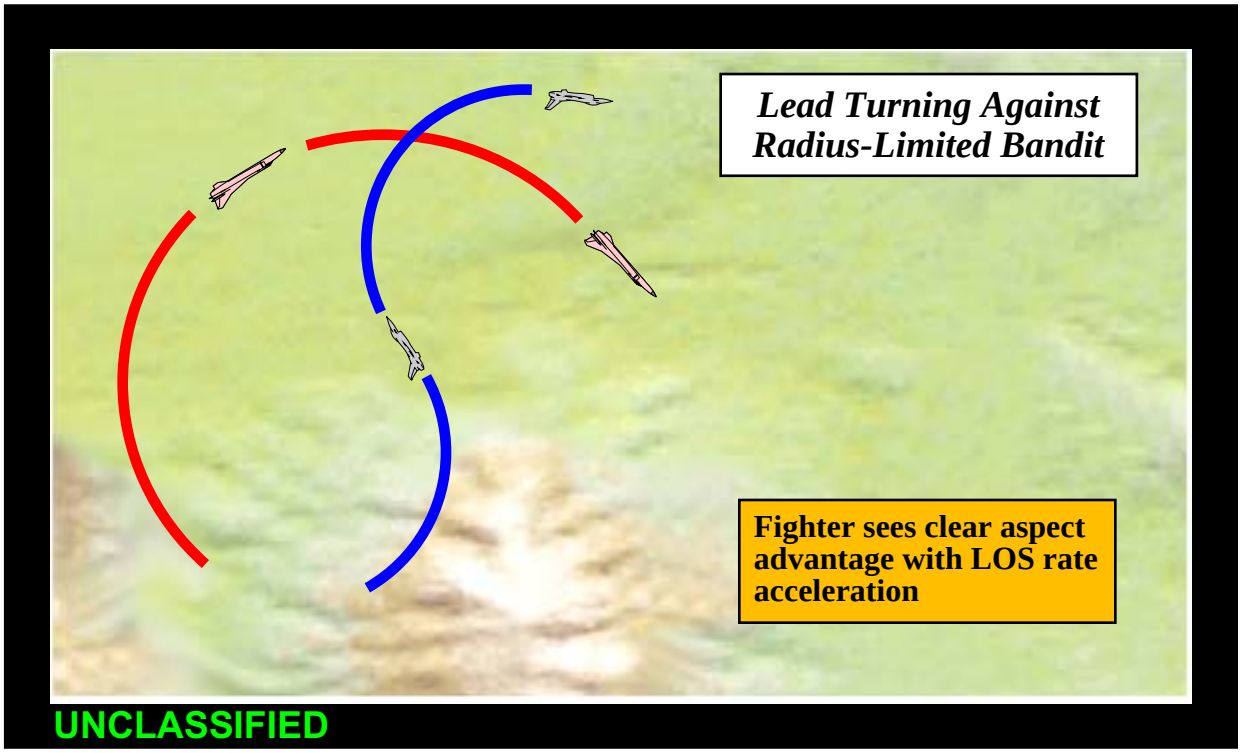


4.6.23 Lead Turning Against a Radius-Limited Adversary.

4.6.23.1 Lead turning in a one-circle fight uses the same visual cues; you will see an advantage. You will observe the adversary moving on the horizon and in the same direction his nose is pointing. (See **Figure 4.61**, Lead Turning Against a Radius Limited Adversary.)

NOTE: The adversary is scribing a larger radius, and you are inside the TC. To capitalize on the pass, you must reverse turn direction and execute the lead turn as the adversary's LOS rate accelerates on the horizon. This reversal of turn direction switches the fight from a one-circle fight to two-circle fight.

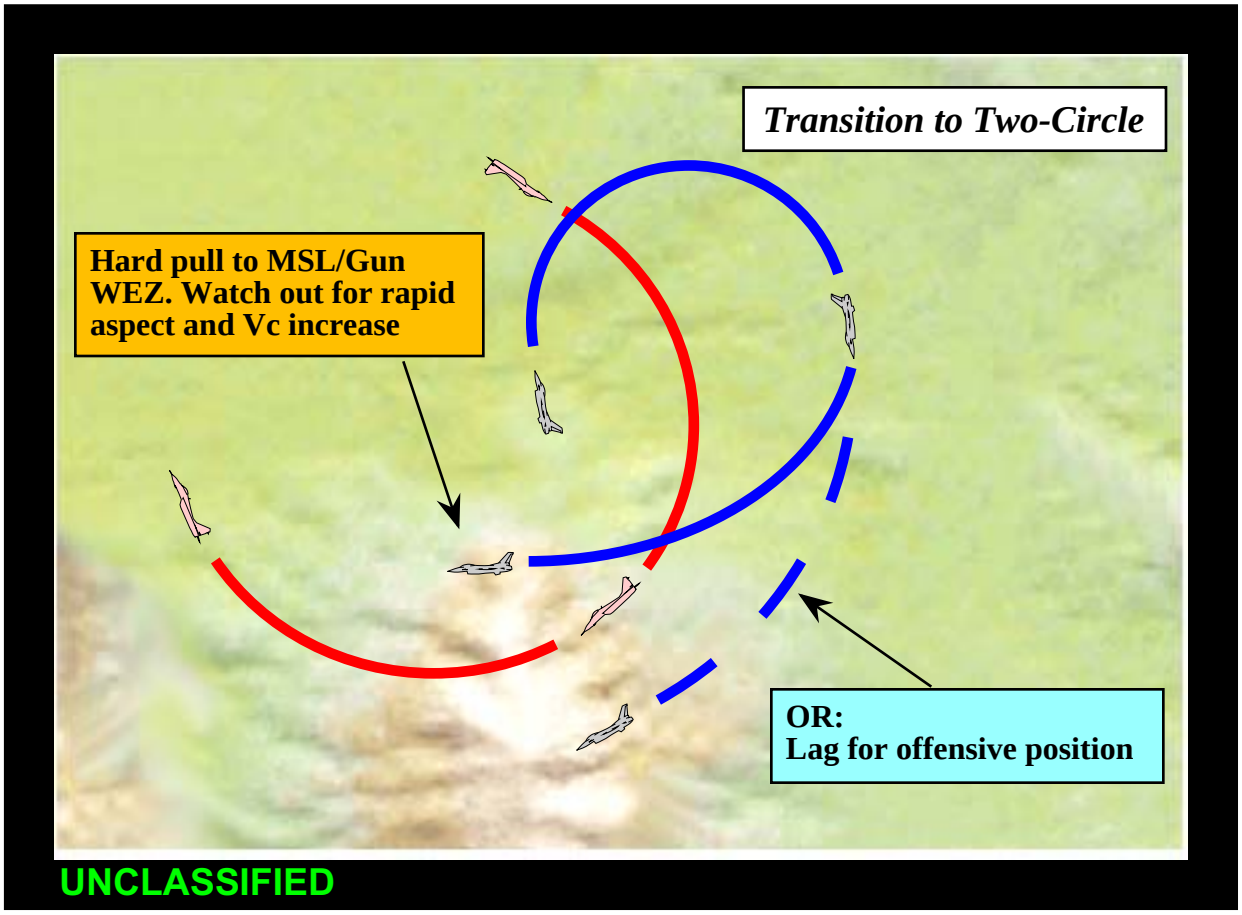
Figure 4.61 Lead Turning Against a Radius-Limited Adversary.



4.6.23.2 A Lead turn in a single-circle pass uses the same visual cues, where the fighter sees advantage. You will observe the adversary moving on the horizon and in the same direction his nose is pointing. This indicates the adversary is scribing a larger radius, and the fighter is inside the turn circle. To capitalize on the pass, the fighter must reverse turn direction and execute the lead turn as the adversary's LOS rate accelerates on the horizon. Reverse the turn and blend in the G as the adversary passes 1 o'clock position to the opposite side of the HUD. The amount of G in the turn may not be a limiter turn and will vary based on the range to the adversary. Pull hard enough to get HCA decreased yet not so many G so as to pass inside of one turn radius behind the adversary's 6 o'clock. Passing too close behind the adversary's 6 o'clock with high HCA may cause the adversary to reverse, thus, negating your advantage.

4.6.24 Postlead Turn Transition To Two-Circle Pursuit. In order to gain the initial advantage in the one-circle contest, you may deplete energy to a state lower than or equal to the adversary'. You reverse, the fight now changes character, and you see a winning cue in a two-circle fight. At this point, you need a positive rate Delta, instead of better radius, to win the two-circle pursuit. (See **Figure 4.62**, Postlead Turn Transition to Two-Circle Pursuit.)

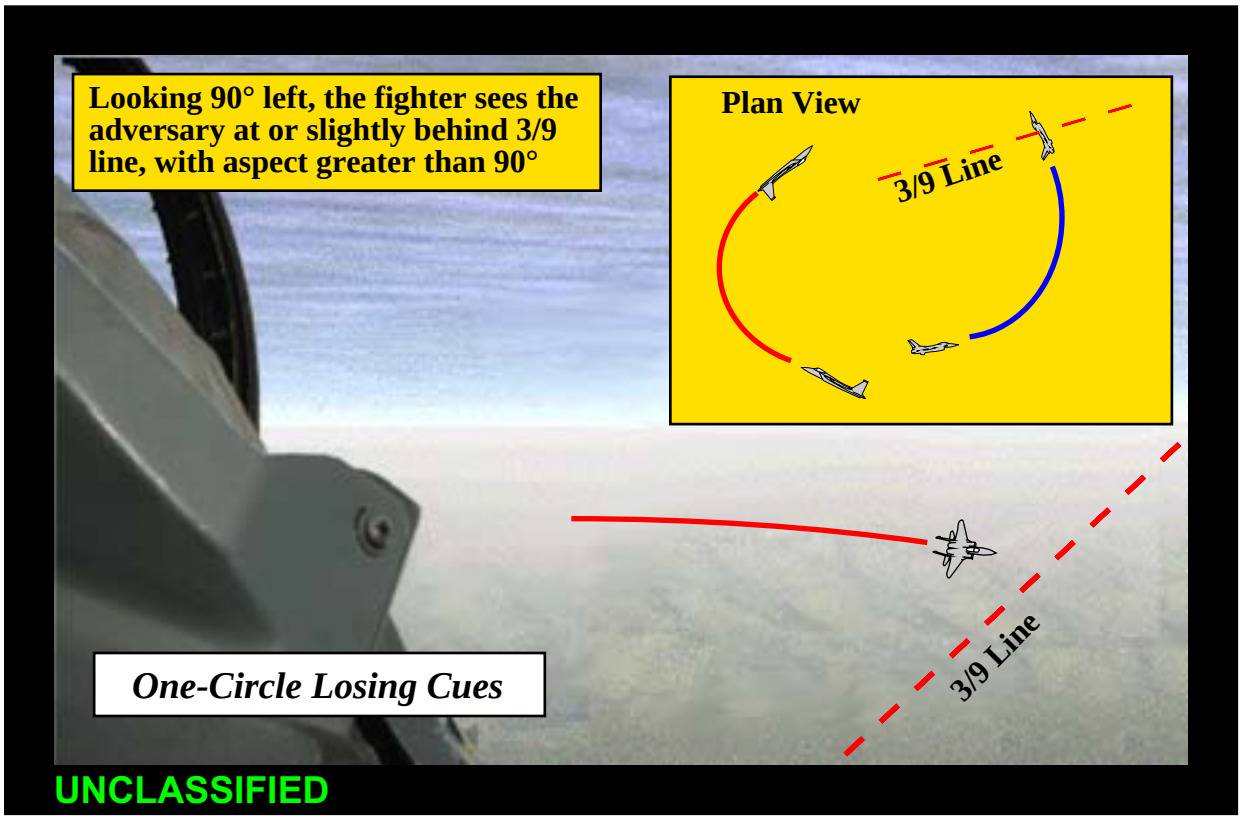
Figure 4.62 Postlead Turn Transition to Two-Circle Pursuit.



4.6.25 Losing Cues. Flying the best BFM platform made, you would think that you should rarely get a cockpit view of the losing clues in either a single-circle or two-circle flight. There are occasions (besides buffoonery by the stick actuator) where you may get into a losing picture at the pass or during the turn. It is important to recognize this quickly and prepare to change the fight at the next pass. The key indication of losing the turn and what to do about it at the next pass is the next point in our BFM discussion.

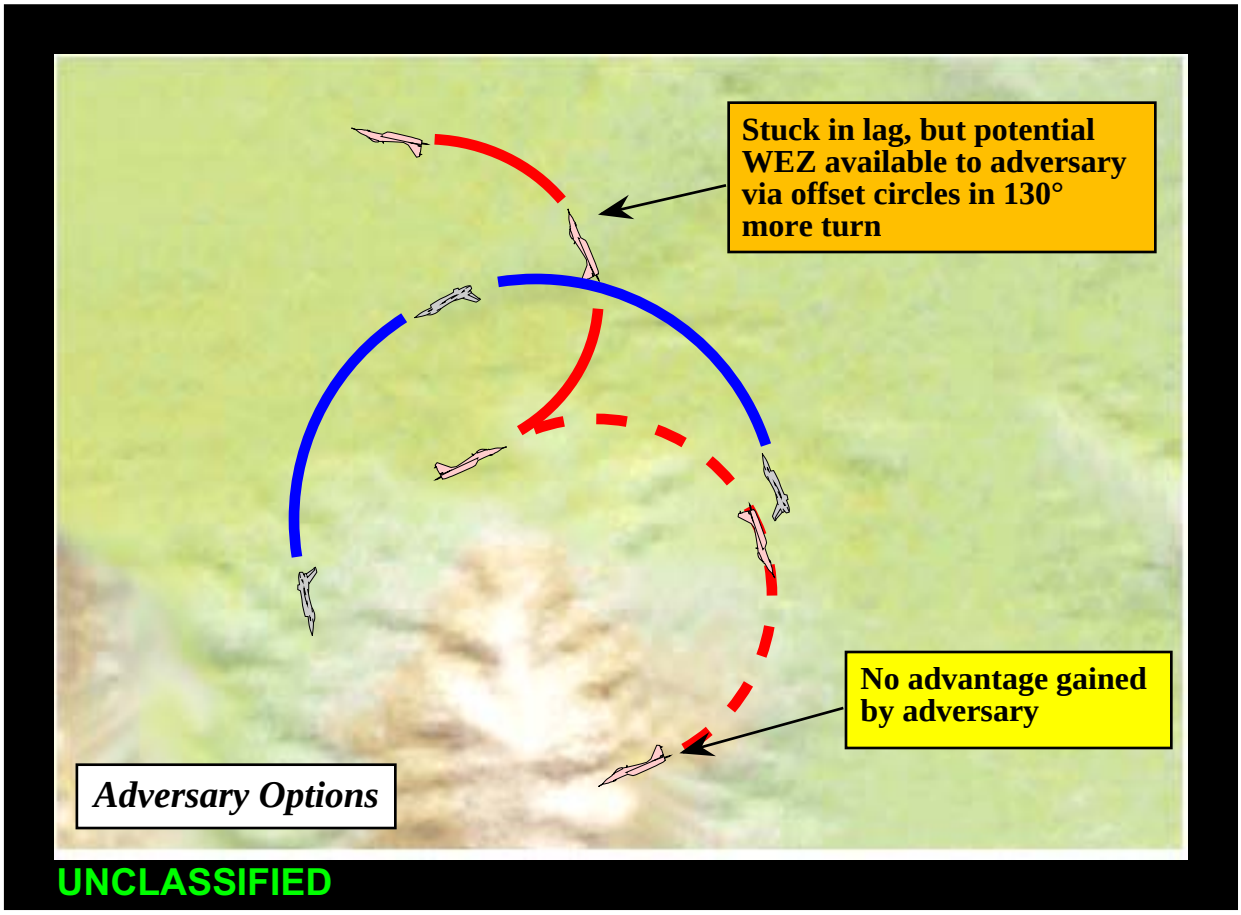
4.6.26 One-Circle Losing Cues. Arriving at the merge with too much energy and/or not reducing energy quickly enough usually causes a loss of the first turn of a one-circle fight. (See **Figure 4.63**, One-Circle Losing Cues.) Depending on the severity of the situation, i.e. approaching an adversary WEZ one solution is to reduce power and pull LV on while assessing the adversary's intentions. The loss of a one-circle contest will first be apparent at the 90-degree point: the adversary's nose now is inside your circle. You are viewing the adversary aft of your 3/9 line, as the adversary is looking at you forward of his 3/9 line. The best indicator of how much is lost is determined by the adversary's drift rate across the horizon (slowing) or how fast the adversary nose approaches. As the turn continues, the adversary's nose will come around to point at your aircraft before you can point back. At this point, let us revisit the physics that determine what is going on.

Figure 4.63 One-Circle Losing Cues.



4.6.27 Adversary Options. Lift limit and airspeed define the fighter and the adversary's TC. The adversary's lift limit is similar to yours (most fourth-generation types are). The adversary's smaller radius is due to slower airspeed. (See**Figure 4.64**, Adversary Options.) Rate will probably be in your favor at the pass, so transition to a two-circle fight. Do not continue to pull and arrive with 180-degree HCA. Stay slightly out front to influence the adversary to reverse the turn into two-circle pursuit. Your energy advantage will then be optimized for the fight type (two-circle). Easing out front will open you up to a fleeting gunshot and the possible permanent defender role, so minimize the amount while still "tempting" the adversary. Turn in the same direction as before the pass—it will be the adversary's choice to reverse or not. If the adversary goes the same direction as before the pass, any advantage gained will be lost. If the adversary reverses into your higher energy two-circle plan, the adversary will probably get stuck in lag. The bottom line: If you are losing the radius fight, switch to rate.

Figure 4.64 Adversary Options.

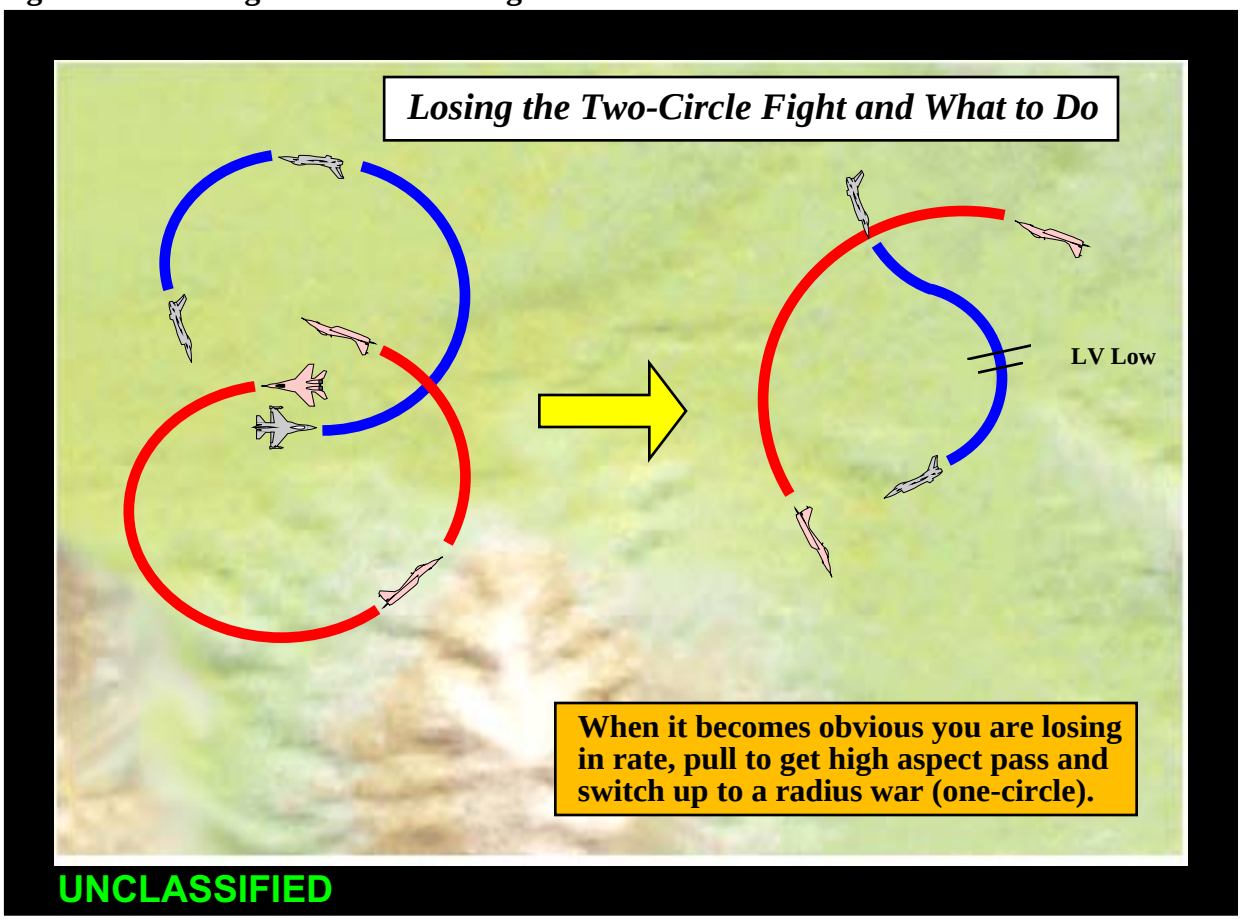


4.6.28 Two-Circle: Losing Cues. Losing a two-circle fight may be hard to see until approaching the pass. You can project the loss by looking at your airspeed indicator. If it shows you well down the lift limit line (below low corner [330 knots]), you will probably be at a disadvantage unless the adversary is also slow. Halfway through the turn, look across the circle and assess relative aspects. Across the circle, the adversary will be slightly advantaged in HCA, and as the turn progresses, the adversary's nose will point at you before you can point back. Horizon drift and canopy movement are both dynamic and of little assessment value prior to the pass.

4.6.29 Losing the Two-Circle Fight and What to Do. If the losing picture occurs, you may be losing the rate fight. The only other choice is a radius fight. The adversary may have used up all its energy on this turn. Pull hard enough to prevent the adversary from lead turning you (LV low will help). If at the second pass you are still losing, it is time to switch to the radius fight (one-circle). (See **Figure 4.65**, Losing the Two-Circle Fight and What to Do.) Approach this pass as close to the adversary as possible (within training rules). Any horizontal distance at the pass, as you reverse your turn direction away from the adversary is turning room for the adversary. Expend all required energy to minimize it. The initial turn after the pass is not up, as in a rolling reversal, but a LV-on turn in the same POM. In converting to one-circle, you force the adversary to slow down to stay aft of your 3/9 line and bring the energy level down to yours. Both you and the adversary are now “equal” and the win will go to the most efficient

airframe and engine combination (assuming no BFM mistakes). An out-of-plane switch to single-circle is another option we'll discuss in Using Vertical at the Pass section.

Figure 4.65 Losing the Two-Circle Fight and What to Do.



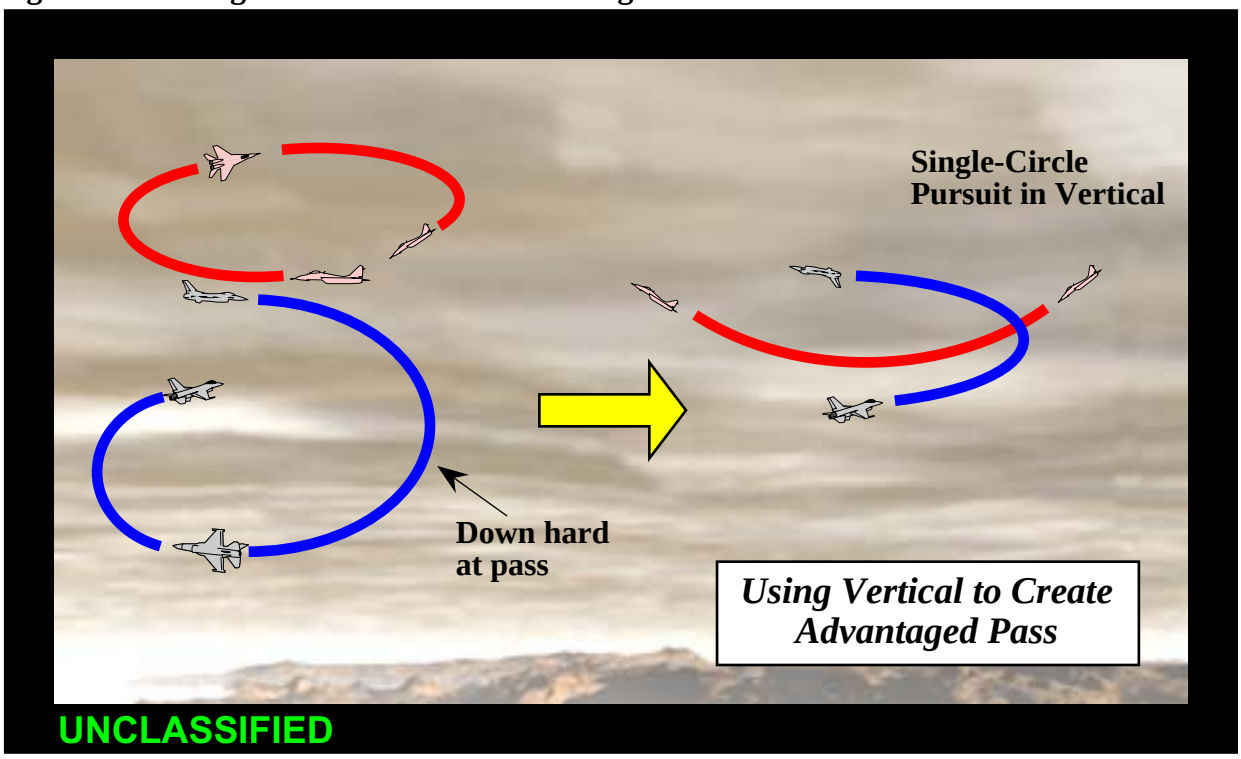
4.6.30 Losing the Fight in Altitude. If keeping up with the adversary's turn performance forces you to descend to pay off the Ps, you are losing the fight in altitude. Recognition—you are at maximum G to keep up with the angles, and the adversary is against a blue-sky background. Losing in a two-circle fight this way is the same as losing it horizontally. Continue to use altitude to gain parity at the pass and get close for the one-circle fight you want. The key to damage control is to switch to a radius fight. If you are losing horizontally, descend by lowering your Lv to match the adversary's angles while ensuring you will have the nose authority to point at the next pass.

4.6.31 Using Vertical to Create an Advantageous Pass.

4.6.31.1 As mentioned earlier, your goal is to drive the adversary down his lift limit line in the one-circle and two-circle fight; i.e., beating him down on energy to the point where we now can exploit our energy advantage. Another way to beat the adversary down on energy is to initiate an aggressive nose-low lift vector on to in lead maneuver. Un-countered, this maneuver can create up to 90 degrees of aspect advantage for the vertical fighter. The key to the aggressive out-of-plane maneuver is lift-vector placement. Generically, place the Lv on or into the lead of the adversary until approaching one turn radius away. Then, adjust lift

vector for the pursuit course and gameplan desired. For two-circle flow, you'll need to adjust Lv behind the adversary. For one-circle flow, keep Lv on to make the pass as close as possible. (See **Figure 4.66**, Using Vertical to Create Advantage Pass.)

Figure 4.66 Using Vertical to Create Advantage Pass.



4.6.31.2 Adversary is late to recognize and/or counter. As the diagram above shows, the adversary continues turning in the same plane. He is late to recognize the out-of-plane maneuver, and therefore, does not counter or counter's too late. The fighter places lift vector on the adversary as he goes aggressively nose-low. As the fighter comes back up to attack the adversary, the adversary is pulling down hill to point and Wez deny the fighter. The desired result is a low to high merge (greater than 60 degrees pitch), with the fighter now turning one-circle in the vertical to pressure the adversary as the adversary fights against gravity (God's G) to get his nose back up hill. For a pure vertical pass the fighter has the advantage going up hill because once he pull's over the top gravity helps your turn shrink your radius. Therefore, the distance you travel across the ground is less. The adversary, however, has to fight gravity and will have an increasing turn circle and ground speed which creates an advantage for the fighter.

4.6.31.3 If the nose position at the pass is less than 60 degrees, optimize the result; do not turn prior to the pass (unless it is to reduce spacing); because you seek one-circle pursuit. The adversary must select the turn direction for the nose-low recovery and commit first. You will not have energy to change directions once committed. A common error is to follow the normal lead turn LOS cue and turn two-circle. To fight this tendency, you should approach on the belly side of the adversary at the pass. This influences the adversary to turn down and accentuate the problem.

4.6.31.4 If the adversary never points down hill, the fighter will see significant offensive advantage cues at the next merge, and will be able to transition to two-circle offensive pursuit very quickly. If the adversary counters the vertical nose-low maneuver with an aggressive vertical nose-low move of his own, you will essentially be in a one-circle fight in the vertical POM. The same winning and losing cues previously discussed in one-circle fights apply. The move at the next pass is driven by altitude available above the floor. Use 4,000 feet above the floor as a ROT to execute a maximum G split-S; less than that requires a floor transition.

4.6.32 Floor Transitions. As the fight approaches the floor (less than 4,000 feet above), the aggressive vertical down maneuver is no longer an option. The positional relationship and airspeed drives the fight. Do you have nose advantage? If so, where are you on the lift-limit line? What is the adversary' energy state? If you are at or near low corner, a two-circle rate fight may be in order. If you are at a nose position disadvantage, you will have to transition to a one-circle radius fight unless you are way high on airspeed. In that case, you have a choice. Lastly, if neutral approaching the floor, your energy state relative to the adversary's will drive the type of fight. Low energy typically forces a one-circle fight, higher energy allows for two-circle rate fight.

4.6.33 Gameplans.

4.6.33.1 Four common scenarios found in high-aspect BFM are: vs. a power-limited adversary, a turn-limited adversary, starting with an energy-deficient, and lastly, an equal adversary. Fights are never truly neutral, and there will usually be some airframe weakness or pilot error to exploit. Remember that the best adversary's will predict your intentions and not let you get away with your desired plan, so have a backup. These discussions are maneuver oriented and allow for ordnance types common to the airframe. This is BFM, not "air combat tactics for all occasions." There is never adequate space to lawyer every possible combination. This section does not address the helmet-mounted sight adversary.

4.6.33.2 When developing your gameplan, consider the following: Type of jet you are up against (MiG 15 or MiG 29)? You won't know until VID at pass. Your ordnance capabilities vs. the adversary—can he shoot me across the circle? Limited IR? Helmet- mounted sight? Environment: one vs. one perch or multi-bogey environment with wingman in the vicinity? Consider the following matrix in your decision making process:

- (1) Assess merge geometry and adversary capabilities and limitations at the pass.
- (2) Initiate a maneuver: turn across tail; or turn one-circle in-plane; or aggressive out-of-plane.
- (3) Assess adversary reaction and win/neutral/lose cues.
- (4) Determine need for defensive reaction or offensive transition.
- (5) Assess again and set up adversary to continue with gameplan.
- (6) Adversary counters gameplan: switch to Plan B.
- (7) Initiate Plan B. Repeat.

4.6.34 Power-Limited Adversary. The power-limited adversary (e.g., a FISHBED) operates at a lower Ps for a given energy state than the F-16. The airframe may be able to generate an

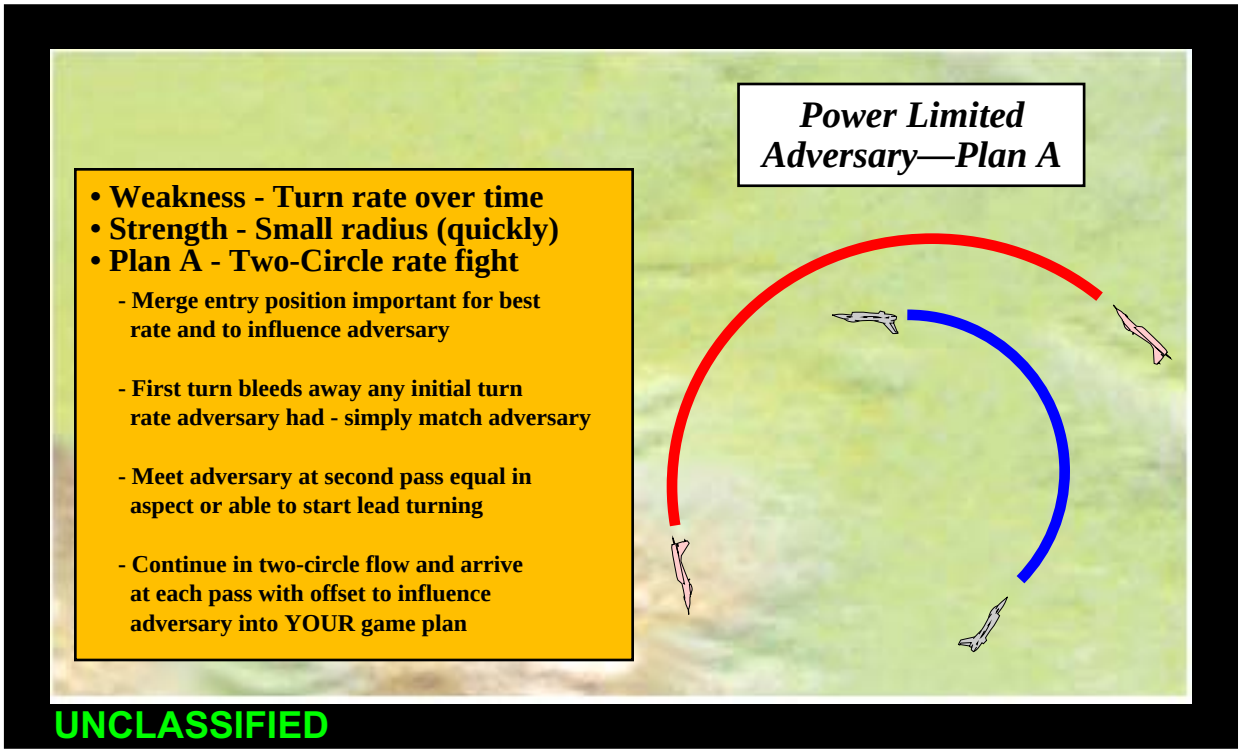
equal or higher turn rate for a short time at high airspeeds. However, adversary speed decay is faster and a turn rate deficit will result. The adversary's strength in the first few turns of the fight is a smaller turn radius due to the slower speed. The adversary may force you to deplete energy (by pointing at you) to continue to force the one circle fight. Try to influence a two-circle fight. Plan A starts slightly high with horizontal offset at the merge to allow a LV-down turn to establish the best rate. This first turn will be a status quo (just matching the adversary) turn to arrive at the next pass with the same entry picture as the first pass. Use roll to hold the adversary near the horizon. If the adversary uses vertical, stay equal by adjusting your LV with roll. Pull to maintain your best rate airspeed envelope assuming you have winning or neutral cues.

4.6.35 Power-Limited Adversary: Plan A. The adversary is turn rate deficient, and you want to keep going two-circle to preserve your rate advantage. At each subsequent pass, you will be able to point at the adversary first, but before getting nose on, stop the turn and hold the adversary about a clock position away from the nose until adversary's LOS rate accelerates across the horizon. This maneuver sets up the horizontal distance that forces the adversary to turn towards the fighter and keep the two-circle turn going. Look for a lead turn opportunity with the LV below the adversary. If the adversary tries to convert to one-circle at this point, the adversary will commit suicide by flying into your gun envelope. Each subsequent pass is the same; use the altitude to reduce the negative Ps pay out during the lead turn. (See **Figure 4.67**, Power Limited Adversary—Plan A.) The most common error during this engagement is to pull the adversary all the way to the nose/HUD resulting in a close pass. Doing so does not influence the adversary to continue the two-circle fight and allows the adversary the option of transitioning to a one-circle fight.

4.6.36 Power-Limited Adversary: Plan B.

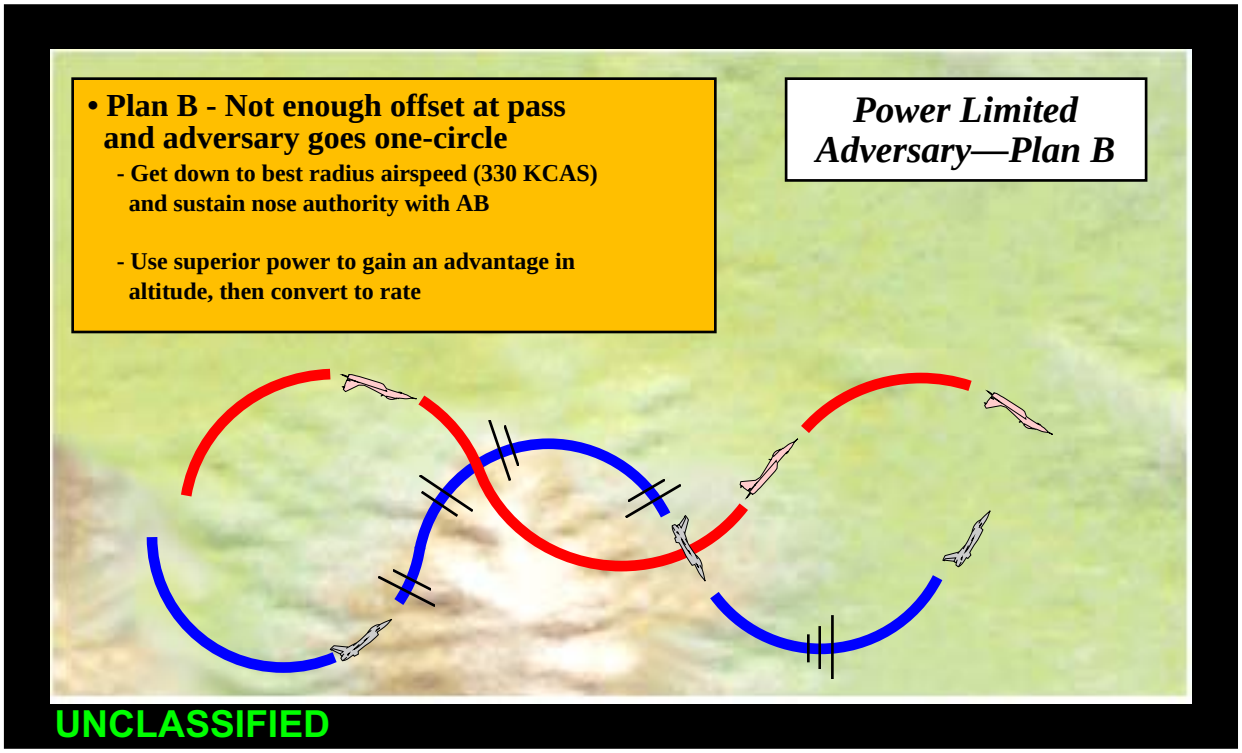
4.6.36.1 A single-circle fight is a radius war, but remember your advantage - energy over time. Here are two different techniques. The overall objective of the first gameplan is to point at the adversary, either for a WEZ or to force the adversary to pull power and honor the fighter’s nose. The power modulation technique for this gameplan is as follows: if you are 330 KCAS or below, your radius will be relatively unaffected in the next turn regardless of power—keep it in AB for best rate. If it is above that, you will want to reduce power to minimize the radius as quickly as possible. As soon as you approach 330 KCAS, reselect AB. Now fight your best one circle fight.

Figure 4.67 Power-Limited Adversary—Plan A.



4.6.36.2 The second technique allows the fighter to maintain the energy advantage to exploit the adversary deficiency (i.e. thrust). The pitfall of first power technique is an early power reduction jeopardizes the fighter's energy advantage vs. the thrust limited adversary. The second technique is to keep your power up anytime less than 400 KCAS and pull hard enough to WEZ deny while forcing the adversary to point. The higher energy fighter will see a classic single circle losing cue. However, the fighter should continue the turn in the same direction and force the adversary to reverse. Assuming the adversary reverses turn direction, the fight is now back to two-circle, remember Plan A. If the adversary doesn't reverse the fighter gains the turning room back, with an energy advantage and neutral cue after the next pass. (See **paragraph 4.6.27**, Adversary Options) The adversary's has turned 360 degrees in a thrust deficient aircraft. At the third merge the fighter has beat the adversary down on energy and will own exclusive use of the vertical. Take advantage of this exclusive use of the vertical by performing a lead turn with a pull straight up at the third merge. This allows the fighter to stay aft of the adversary's 3/9 (deny any look up shots), stop your ground track and build turning room in the vertical. (i.e. the adversary cannot deny the use of the vertical). Once the adversary chooses a turn direction, adjust your Lv to lag until greater than one turn radius away. One turn radius is the minimum amount of turning room required to point. Once greater than one turn radius away, readjust your Lv towards the adversary to kill or transition to offense. (See **Figure 4.68**, Power Limited Adversary— Plan B.)

Figure 4.68 Power-Limited Adversary—Plan B.

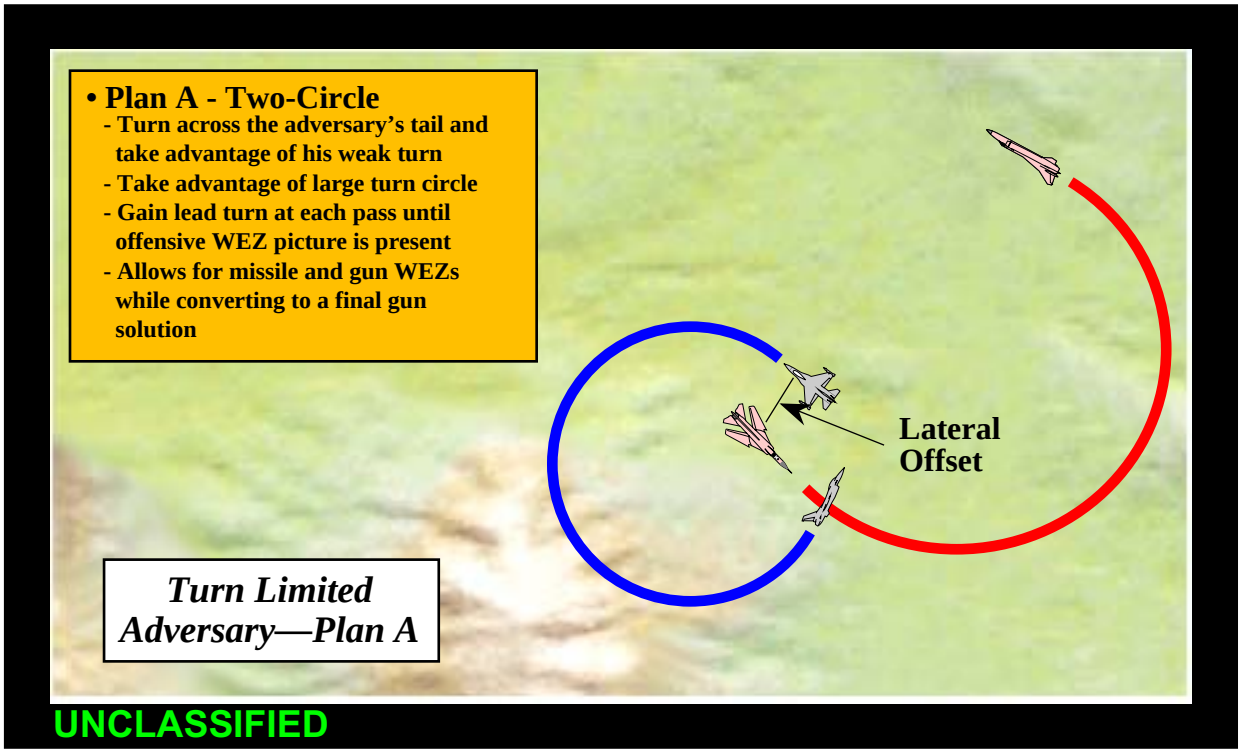


4.6.37 Turn-Limited Adversary: Plan A.

4.6.37.1 Turn-limited adversaries (e.g., a FLOGGER) are usually easy to deal with since they are both radius and rate limited. A turn-limited adversary also has some Ps problems that reduce the rate even farther as the turn progresses. Turn limitations are generally a result of carrying external stores or a poor airframe capability in G or lift. Either a one- or two-circle fight will work well against this adversary.

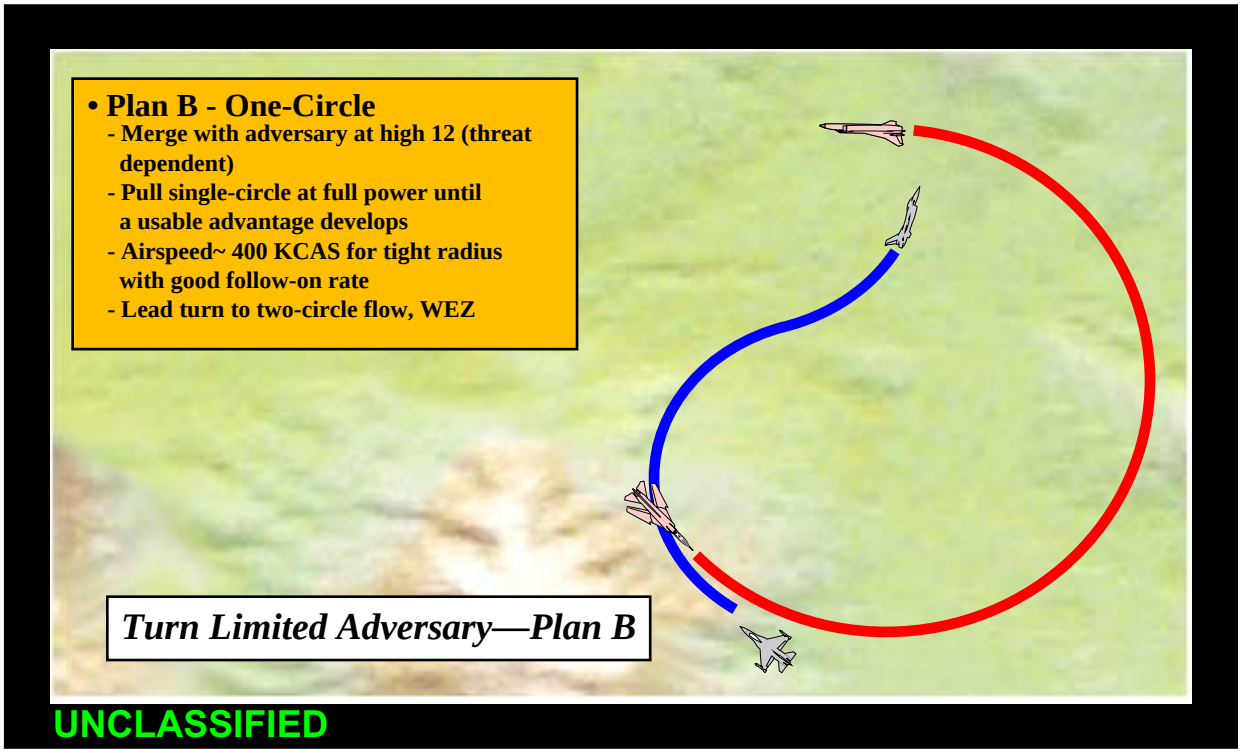
4.6.37.2 If any lead turn is available premerge, a two-circle fight will usually provide the quickest kill if you have all-aspect missiles available. A full limiter nose-low pull will provide about a 1.5 to 2.0 NM look-up beam shot, and the opportunity to end the fight immediately with an AIM-120 or AIM-9M shot across the circle. If all-aspect missiles are unavailable, or other circumstances dictate establishing a controlling position over achieving an immediate WEZ, complete the turn with an optimum pull, preserving airspeed to close the circles up and collapse the turn centers. This is done in full AB, nose low with only enough G to ensure an angular advantage at the next pass. A common error is to pull at the aft limit to generate a big advantage picture and then have no energy or ordnance left to pursue it. At the pass, you must keep pulling only to gain advantage—not at the aft limit. This preserves turn rate for the next pass, which will be a well-advantaged, two-circle lead turn, and heading for the control position. (See **Figure 4.69**, Turn Limited Adversary—Plan A.)

Figure 4.69 Turn-Limited Adversary—Plan A.



4.6.38 Turn-Limited Adversary: Plan B. Assuming no turning room is available, and therefore there is no lead turn opportunity, the fighter would like to merge with the adversary dead center at high 12 o'clock at the pass. This cuts out all horizontal handicaps and provides the best visibility through the merge. Establish one-circle pursuit with full AB after the adversary starts turning. The one-circle advantaged cues develop quickly while holding the adversary just above the horizon. Your pull should ensure a usable advantage at the second pass and not bleed Ps at the maximum rate. This will set up a lead turn from inside the adversary's turn circle and result in a transition to a two-circle fight. The pursuit will require airspeed for best rate to establish and maintain control. You can generally use AB throughout to preserve follow-on energy since the turn-limited adversary cannot compete in the radius war. (See **Figure 4.70**, Turn Limited Adversary—Plan B.)

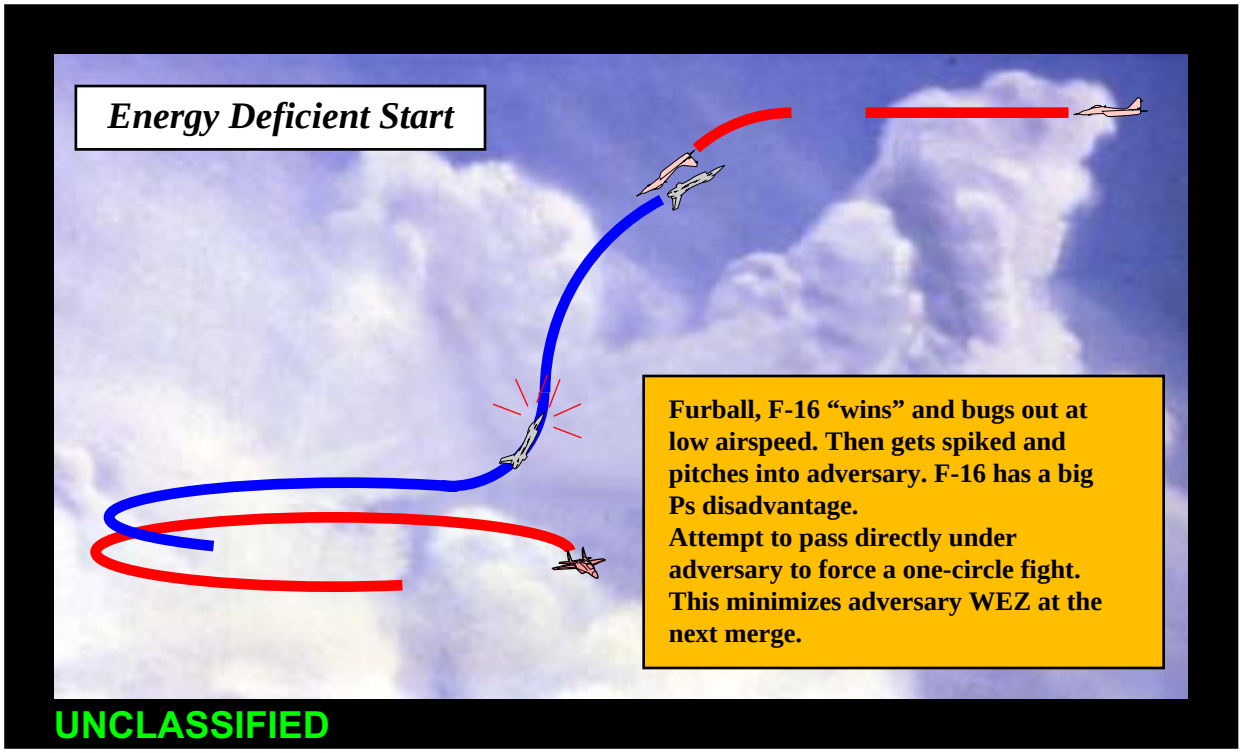
Figure 4.70 Turn-Limited Adversary—Plan B.



4.6.39 Energy-Deficient Start.

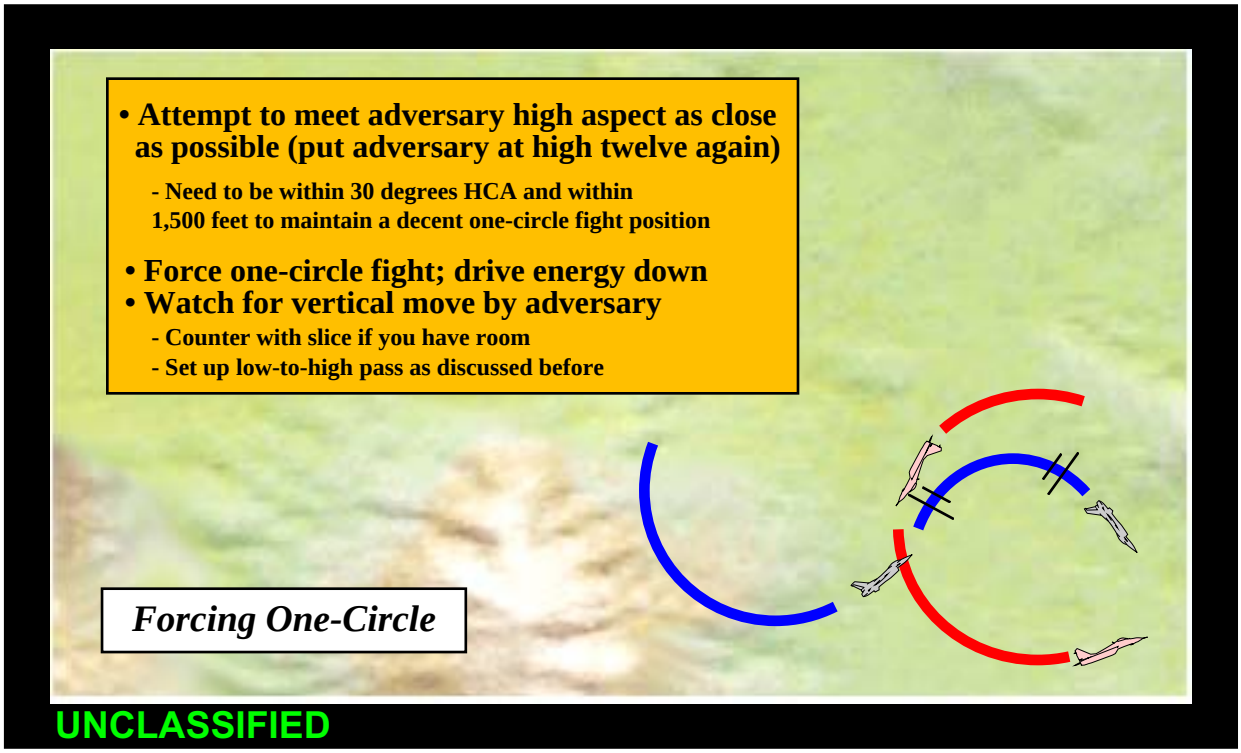
4.6.39.1 Some fights start with less than optimum energy. Some situations that could cause this problem are late jettison decisions, intercept errors, egressing one fight straight into another, entering the merge from a defensive notch, or climbing to the merge in idle (IRCM). The energy problem is temporary if you execute a game plan that brings the adversary down to an equal energy state. The adversary's advantage is then gone, and the fight is on more equal terms. (See **Figure 4.71**, Energy-Deficient Start) A quick recap of energy principles is in order. Low energy means low-turn rate. It also means a small turn radius. If the adversary has to deal with a small radius in the first turn, he will have to reduce his energy level to avoid being spit out front. This is the foundation of Plan A.

Figure 4.71 Energy-Deficient Start.



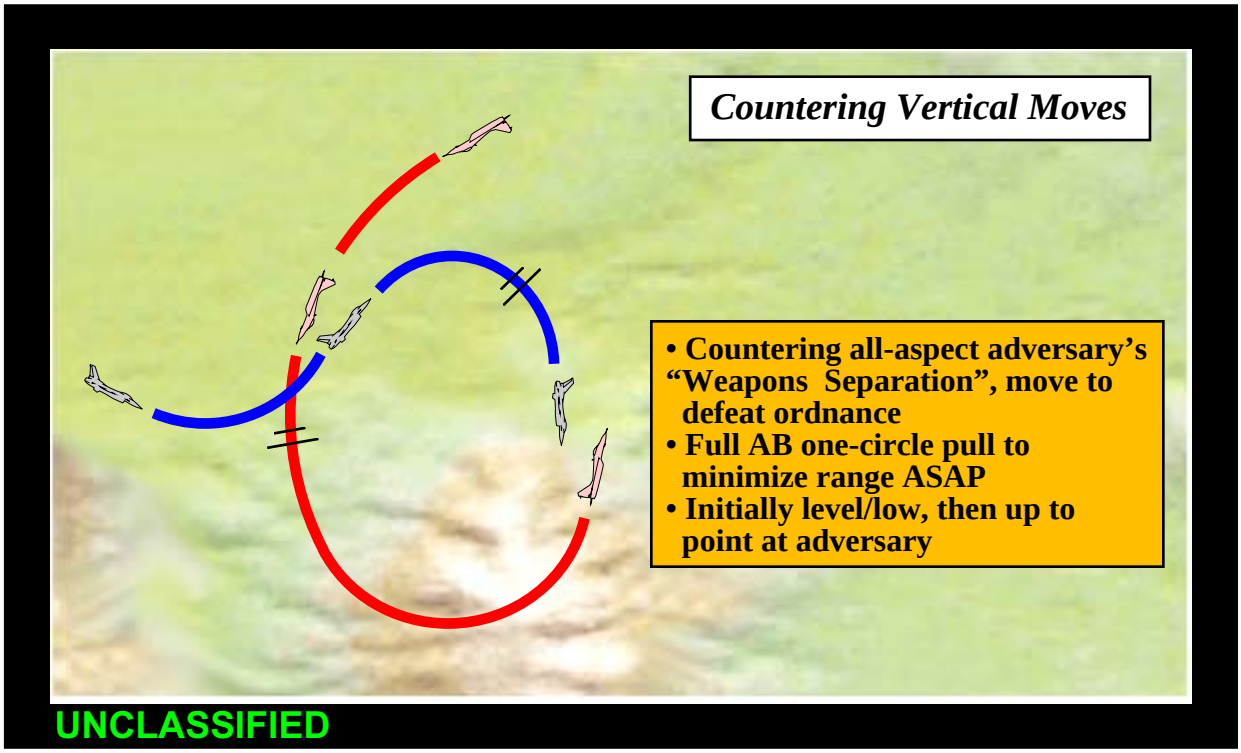
4.6.39.2 Plan A starts with a pass directly under the adversary to afford the best opportunity to get the one-circle fight started. (See **Figure 4.72**, Forcing One-Circle.) This decision minimizes the adversary's WEZ at the next merge. Your small radius forces the adversary to reduce power (or go up) to cope with the next pass. If the adversary elects to stay with you in the horizontal, his energy state will drop and the fight will equalize (which is better). If the adversary chooses to convert the excess kinetic energy into potential by going up, you must recognize the opportunity to convert this to a low-to-high turn at the next pass as shown in **Figure 4.62**, Postlead Turn Transition To Two-Circle Pursuit. The key execution point is to ease off the turn enough to be able to point at the adversary at the pass and force his nose down to exploit the one-circle turn. The vertical merge angle will be the deciding factor of how much you can get after the pass. If you have the luxury, go deep and pull up steep. Make the pass as close to vertical as you can to gain the maximum advantage. In a one-circle entry to this pass, the amount of vertical you can generate will be small, but the key to the pass is angle, not distance. The adversary has objectives also and will probably see the energy situation from the vantage point of the best game plan too. If the pass occurs with greater than 1,500 feet offset or more than 30 degrees AA, the one-circle plan may not be available—you may have to fight the two-circle fight—Plan B.

Figure 4.72 Forcing One Circle.



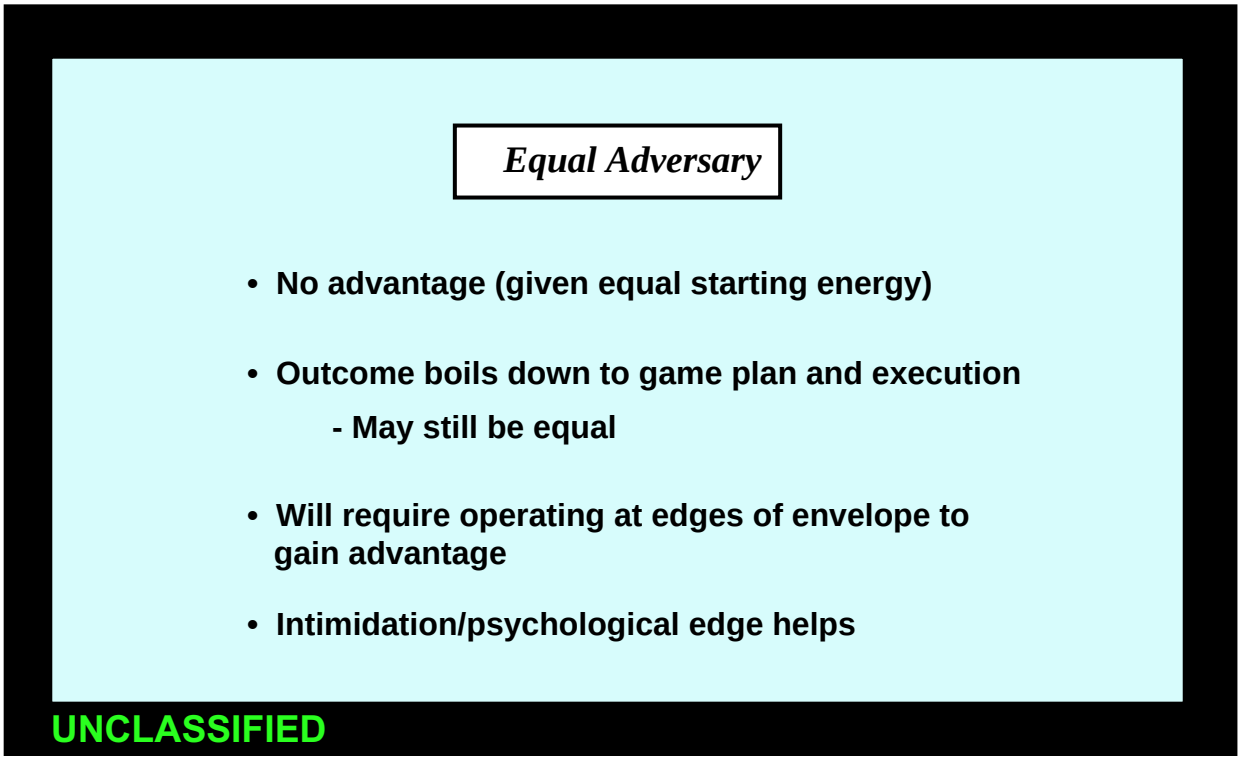
4.6.39.3 The key energy concept here is the realization that you cannot win this fight and only Plan A will save you. Remember, that the adversary is likely carrying all-aspect ordnance (both radar and heat). The adversary may go up at the pass to seek turning room and the best turn radius to get the nose back on you for weapon employment. If low energy were not the issue here, the best move would be to go up with the adversary. The problem is that the adversary's vertical capability can create enough range to gain a WEZ if you do not maneuver to keep the range tight. In most cases, the adversary will have to come around the corner nearly all the way before a shot opportunity exists. You can deny a shot generally with a tight, near-the-limit turn and efficient vertical use to force the adversary back in to the execution at the pass. In two-circle fights, the range between the fighter and adversary is greater than the one-circle case. This makes the set up of the low-to-high scenario easier, but it also opens up the WEZ for high-aspect ordnance. Do not get greedy with the vertical down move. Get around as quick as you can while preserving your over the top airspeed requirement. Opening up the turn at the bottom will definitely create ordnance possibilities for the adversary. Once advantage is established, the adversary will be equal energy-wise, and the fight will be in your favor. (See **Figure 4.73**, Countering Vertical Moves.)

Figure 4.73 Countering Vertical Moves.



4.6.40 The Equal Adversary. Fighting an adversary equal in capability has a predictable result when both of you approach with equal knowledge—a low speed, close range stalemate at the floor. The problem here is that one can counter the move of the other. These fights are the primary reason that there needs to be a "designated training aid" and "fighter" in all high-aspect BFM training. The problem is there are an ever-growing number of airframes that approach maneuvering parity with the F-16. Now, the spread between capabilities is narrower and must be addressed. The problems you face at the merge with an equal adversary are frustrating. The turn rate and radius are the same. (See **Figure 4.74**, The Equal Adversary.) When the adversary approaches a performance limit, you do too (assuming equal energy levels). There is no clear advantage available through the throttle or stick. The fight outcome will depend on the two variables left—the game plan and the pilot flying it. These fights typically rely on the extreme edges of the flight envelope and the exploitation of the gravity vector in the vertical. Adversary mistakes are generally the deciding factor. Psychology and intimidation are important tools in this fight. The best method to win is to master all the fundamentals of this section to exploit the full envelope of the aircraft both legally and knowledgeably. It is a highly variable exercise of your understanding of high-aspect BFM because of the spectrum of adversary knowledge you may face. Careful attention to WEZ is critical for survival. Some of the basic fighter maneuvers discussed in the high aspect and defensive sections are not always applicable with a known HOB adversary.

Figure 4.74 The Equal Adversary.



4.6.41 Basic Fighter Maneuver Proficiency Exercises. The exercises described in the following paragraphs are intended to teach you how to determine ranges visually; to recognize LOS pictures; to learn the weapons symbology; to recognize weapons opportunities; to practice switchology; and to learn to employ weapons. These exercises will also introduce maneuvering in respect to another aircraft. While accomplishing these exercises, do not fail to continually cross-check range and overtake. Do not get padlocked on the green stuff and forget what is happening spatially around you. Know your airspeed, altitude, and fuel.

4.6.41.1 Ranging Exercise. This exercise is useful for both offenders and defenders. If used as an offensive exercise, the offender learns the visual picture associated with important ranges such as missile minimum employment ranges, gun WEZ and the bubble. When used as a defensive exercise the defender learns to estimate ranges while looking behind the aircraft.

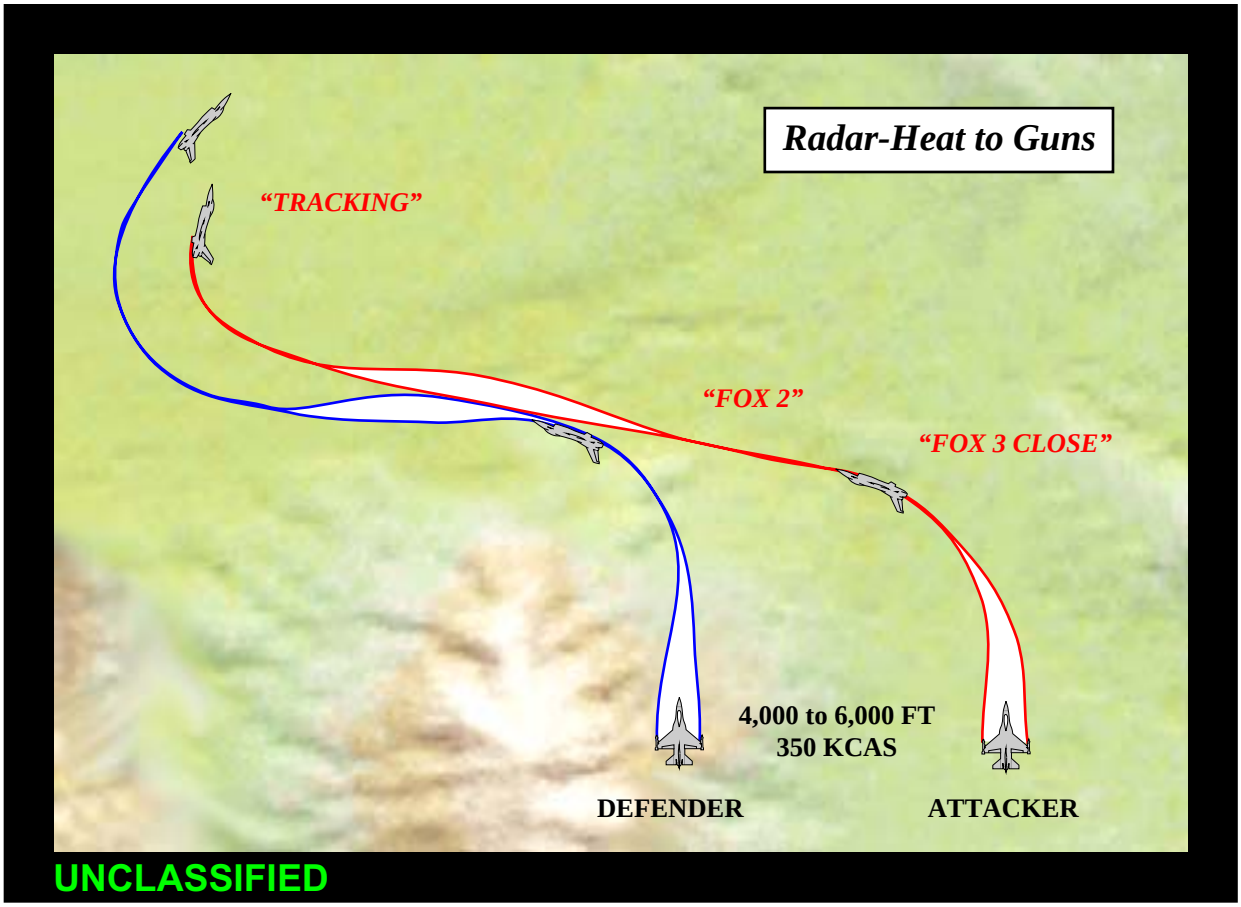
4.6.41.1.1 Offensive. Start with the offender 1.0 to 1.5 NM in trail with an airspeed advantage and the defender holding 300 to 350 knots. The offender then closes to minimum range (bubble) with either aircraft calling range in 1,000- to 500-foot increments. Note size and detail comparisons at key ranges such as minimum missile employment (Beam, aft quarter and tail) and gun WEZ ranges.

4.6.41.1.2 Defensive. Start as in above but with emphasis on the defender pilot calling the ranges in the briefed range increment (1,000 to 500 foot). As the offender reaches maximum gun WEZ (with M56 selected) change sides. This forces the defender to turn in the seat to maintain/ regain tally. Additionally, performing this exercise with the defender turning allows the offender to present various angle-off pictures (lead, pure,

and lag) that will be seen during BFM and medium- to high-angle gunshots.

4.6.41.2 Offensive Radar-Heat-to-Guns Exercise. Begin the exercise by flying 4,000 to 6,000 feet line abreast and 350 KCAS. (See **Figure 4.75**, Radar-Heat to Guns.) Each aircraft will call "C/S READY" and the flight lead will initiate the exercise. The defender will then make a 3- to 4-G level turn away from the offender. The offender will obtain a radar lock using an ACM mode take an AIM-120 shot (C/S Fox III), continue to turn and place the defender in the HUD for a valid AIM-9 shot (C/S Fox II). The defender will reverse the turn following the offender's "FOX II" call or as required. The offender will then close for a CINE-Tracking gun shot (one that is stabilized with maximum amount of valid gun video), or a snapshot/separation, as briefed. The offender will call tracking on each gun attempt. The defender may change plane slightly after the first tracking call. The exercise will terminate with two to three valid gun tracks or after achieving pre-briefed objectives. You can vary this exercise by doing it without a radar lock to practice no-lock missile and gun employment. Another option is to employ the AIM-120 in addition to, or instead of, the AIM-9.

Figure 4.75 Radar-Heat to Guns.



NOTE: This exercise will allow the offender to practice short-range missile employment on a non-maneuvering target and continuous gun employment under varying flight conditions (level,

climbing, descending, accelerating, decelerating, and rolling). The defender must maintain a tallyho and remain predictable through the exercise.

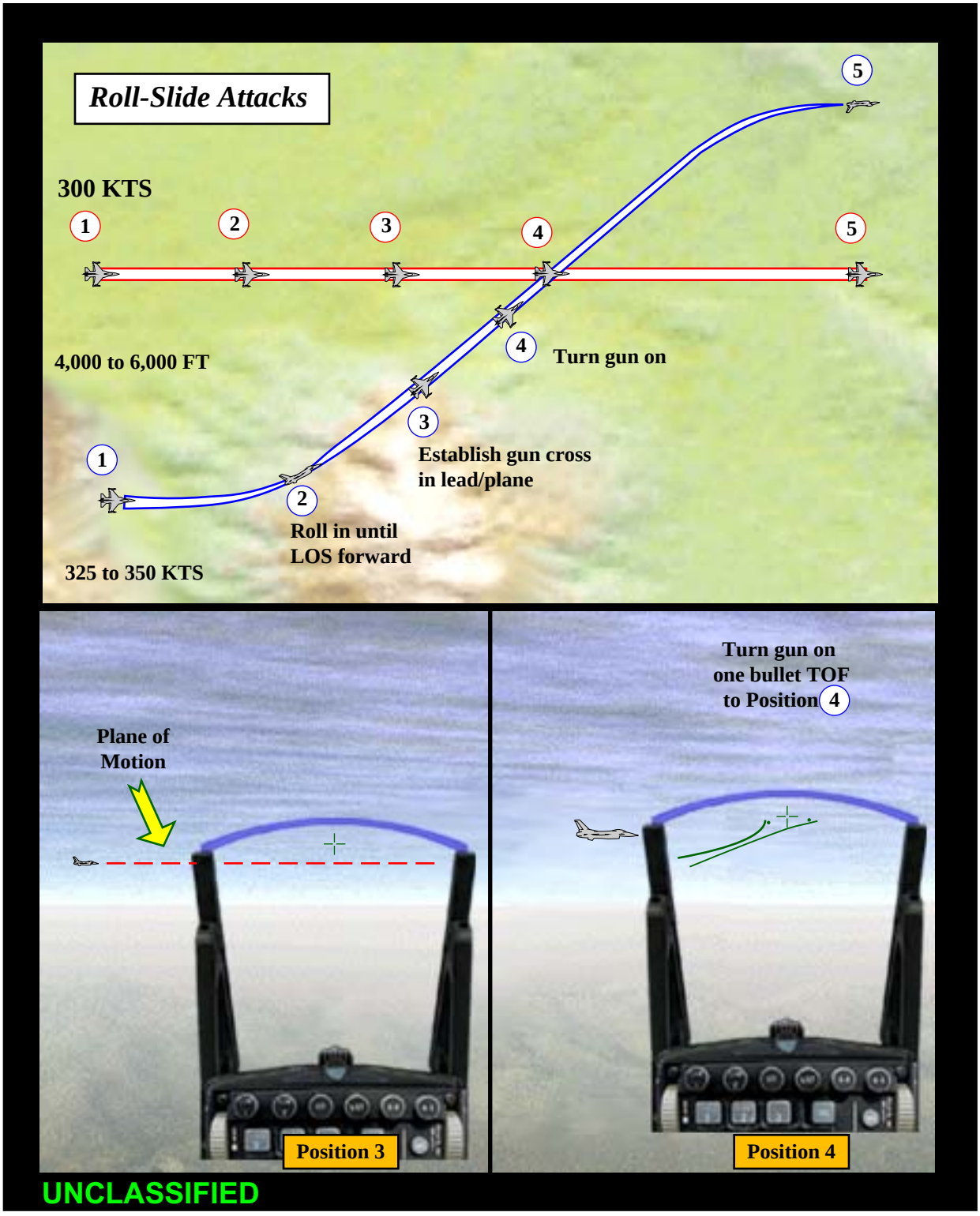
4.6.41.3 Defensive Heat-to-Guns (w/Jink) Exercise. The same starting parameters are used as in **Figure 4.75**, Radar-Heat to Guns. After the "Fox II" or turn reversal, the offender can fly any combination of the following: lag pursuit (gun cross in lag), pure pursuit (gun cross on), lead low (inside gun WEZ with a low POM established), lead high (inside gun WEZ with a slightly high POM established, and lead on (when in POM and gun parameters). Two leafs of the exercise may be accomplished by having both aircraft roll out, the offender extending for range and airspeed, and then a "reverse turn" call to set the starting parameters again. On the second leaf, the defender calls the ranges and the pursuit curves (lag, pure, lead low, lead high, and lead on). A jink maneuver may also be added when the defender observes "In-Range, In-Lead."

NOTE: This exercise builds defensive sight pictures to recognize when in gun envelopes to help in jink timing. The defender should note various ranges and the amount of lead required by the offender to be in a gun WEZ.

4.6.41.4 Roll-Slide Attack Exercise. The defender sets speed at 300 to 350 KCAS with the offender 4,000 to 6,000 feet and slightly forward of line abreast (5 to 10 degrees). (See **Figure 4.76**, Roll-Slide Attacks.) The offender maintains an airspeed advantage. At the "BEGIN MANEUVER" call, the defender flies a non-maneuvering flight path. The offender performs roll-slide gun attacks by initially pulling in plane toward the defender until forward LOS is seen and attempts a radar lock (slewable ACM). The offender then rolls out and places the gun cross in the defender's POM. The offender should now concentrate on taking a valid high LOS rate gunshot. This is not a saddled up gunshot. Pull the trigger early enough (based on LOS rate) to put bullets on the defender and then reposition by rolling out, going high if required to avoid the bubble and extending out to line abreast on the opposite side. Repeat the maneuver until the flight lead/IP terminates the exercise. On each subsequent pass, the offender should climb and descend slightly to set up varying pictures from a high or low position off the defender.

NOTE: This exercise teaches the offender to predict and establish the required lead and correct plane to achieve gun parameters on a non-maneuvering target from a beam or front hemisphere start. One of the primary skills emphasized is effective employment of the gun without violating training rules and minimum range. The offender should concentrate on using the gun cross to set weapons parameters and letting avionics and radar locks help to assess gunshots. The radar may or may not lock the defender and even if it does get a lock, it will not likely happen soon enough to be of any value other than for shot assessment, so the offender should be in a no-lock mindset from the beginning.

Figure 4.76 Roll-Slide Attacks.

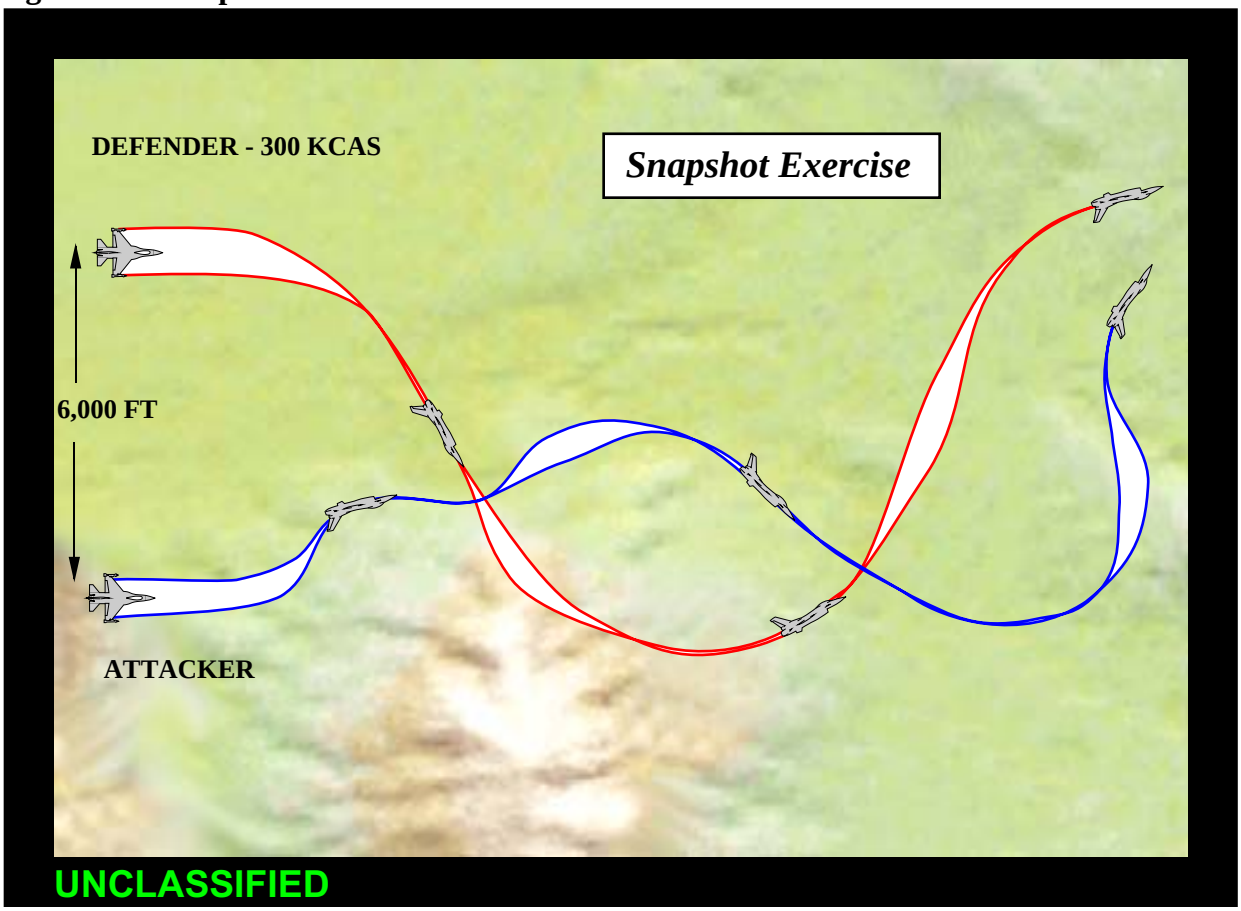


4.6.41.5 Snapshot Exercise. The offender starts at 6,000 feet line abreast with the defender and airspeed approximately 400 KCAS. (See **Figure 4.77**, Snapshot Exercise.) At the "BEGIN MANEUVER" call, the defender starts a level turn into the offender using G as necessary to create moderate (90 to 110 degrees) angle-off. The offender establishes lead and maneuvers for a quick gunshot and then repositions for another attack. Excessive G by the defender may result in heading crossing angle (HCA) greater than 135 degrees in which case the exercise will be terminated.

NOTE: This exercise forces the offender to assess aspect angle, angle-off, and LOS rate to predict target motion and a gun solution. It allows practice of the switchology required for quick gun attempts in a controlled environment.

CAUTION: You must maintain minimum-range bubble integrity. If LOS stops, you are on a collision course and should immediately correct and/or terminate/KIO the exercise. You must maintain the tallyho at all times during the exercise.

Figure 4.77 Snapshot Exercise.



4.6.41.6 Cross Turn Exercise. The exercise starts with a line-abreast formation with the wingman 5,000 to 7,000 feet out. (See **Figure 4.78**, Cross Turn Exercise.) The flight lead initiates the exercise by calling "CROSS TURN" at which time a Mil power, 3.0 to 3.5 G cross turn is performed. At approximately 120 degrees of turn lead calls "CLEARED TO MANEUVER," at which time the offender attempts an entry to Fox II or guns parameters

while the defender continues a 3-G turn. The offender attempts to get the shot prior to the defender completing 360 degrees of turn. Terminate at the shot call. The offender basically has three avenues to arrive in weapons parameters:

- An immediate pitch to point and drive inside the defender's predictable turn circle, followed by a slice into weapons parameters (high-to-low entry).
- An immediate slice to point and drive inside the defender's turn circle, pitching up into weapons parameters (low-to-high entry).
- An unloaded extension for lateral turning room (approximately 3 seconds) followed by a pull-to-point at the defender in weapons parameters (belly entry).

NOTE: This exercise teaches you to predict the bandit's turn circle, POM, and recognition of sufficient turning room/lead required.

4.6.41.7 High-Aspect Gun Exercise. Start at 15,000 to 20,000 feet MSL, 400+ KCAS. (See **Figure 4.79**, High-Aspect Gun Exercise.) The offender should be 9,000 feet behind the defender, offset far enough to the side so the defender can maintain sight throughout the exercise. The defender initiates a 6-G, level, Mil power turn into the attacker. The defender pulls as required to place the offender forward of 90 degrees of aspect. (The lift vector is 90 degrees of aspect. Placing the offender in the HUD equates to 180 degrees of aspect.) The defender places the offender between the lift vector and halfway to the HUD, resulting in 90 to 135 degrees of aspect. (Remember, that 90 degrees of aspect is the most difficult shot, as it requires the greatest amount of lead angle, and has the highest LOS rate.) The offender remains in plane with the defender, and closes for a high-aspect shot. The defender plays the G as required to maintain 90 to 135 degrees of aspect. The attacker should be able to take the shot by 3,000 to 5,000 feet of range. Once the shot is taken, the offender rolls wings-level and passes behind the defender. Both aircraft unload and extend away from each other. As both aircraft approach 9,000 feet of separation, they initiate a turn toward each other. The defender again pulls enough Gs to place the attacker at 90 to 135 degrees of aspect. The offender again closes for a high-aspect shot. (The above sequence can normally be repeated three to four times before getting low on airspeed and altitude.)

NOTE: This exercise offers the opportunity to practice using many of the enhanced envelope gunsight (EEGS) features to accomplish a high-aspect gunshot. It also teaches recognition of higher aspect gun opportunities before transition into lower aspect gunshots.

Figure 4.78 Cross Turn Exercise.

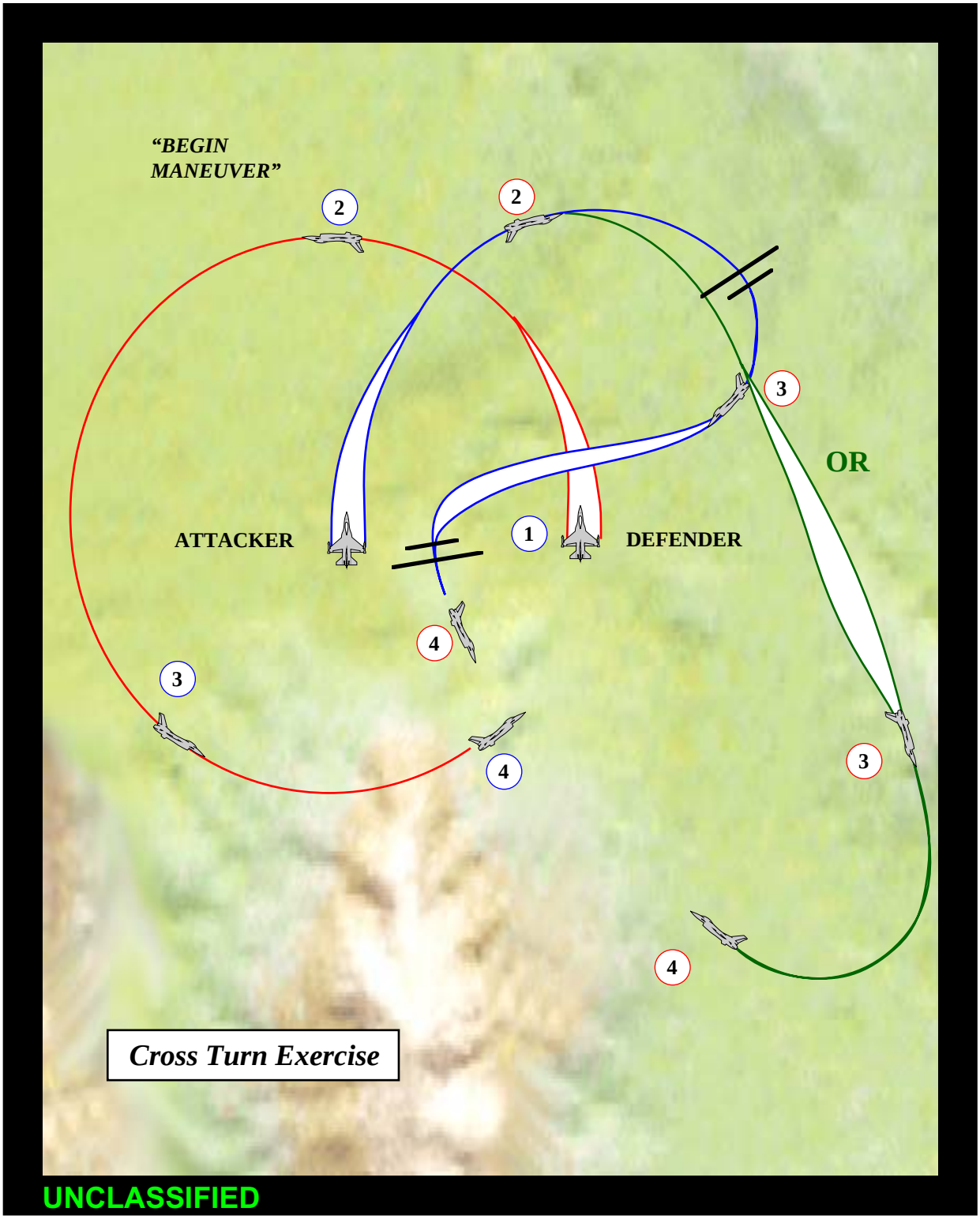
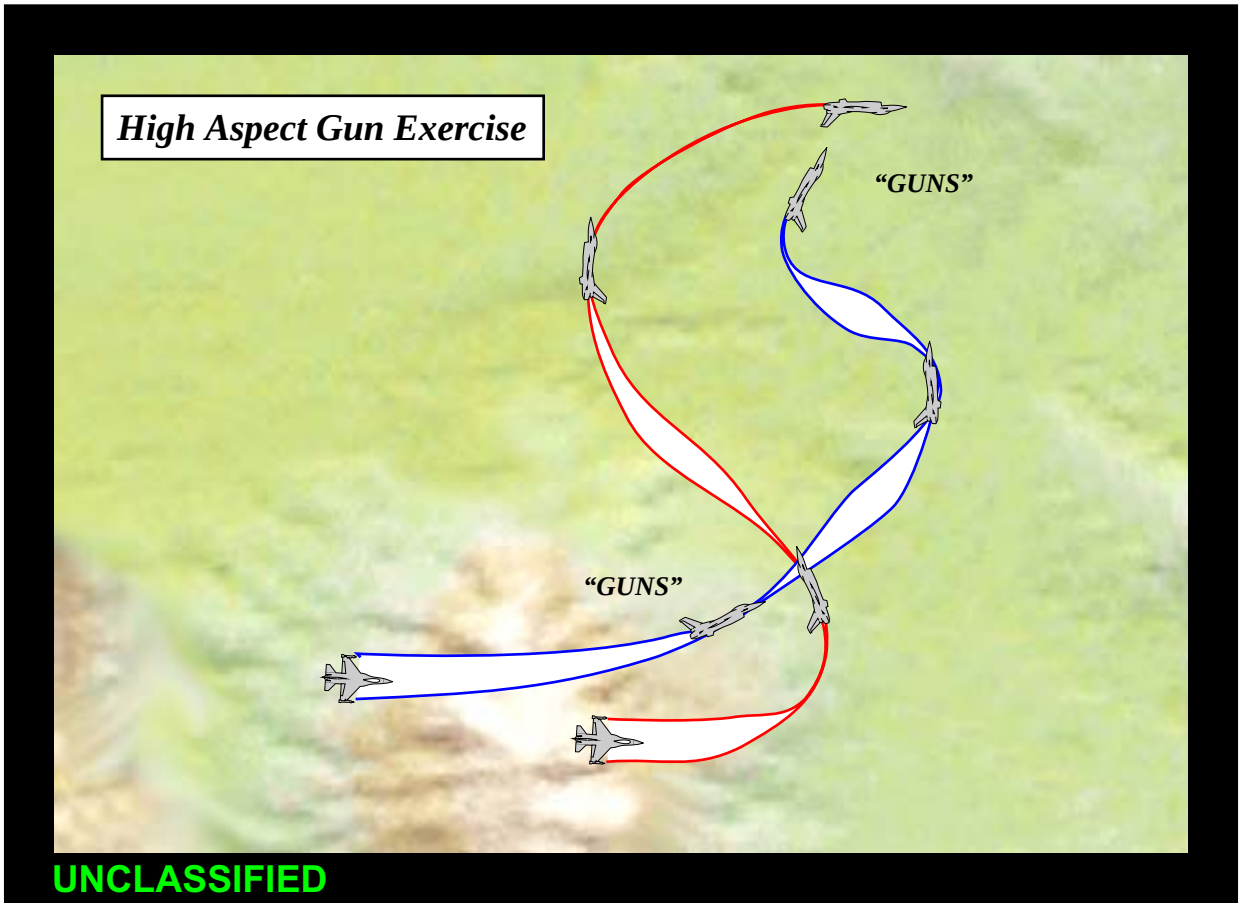


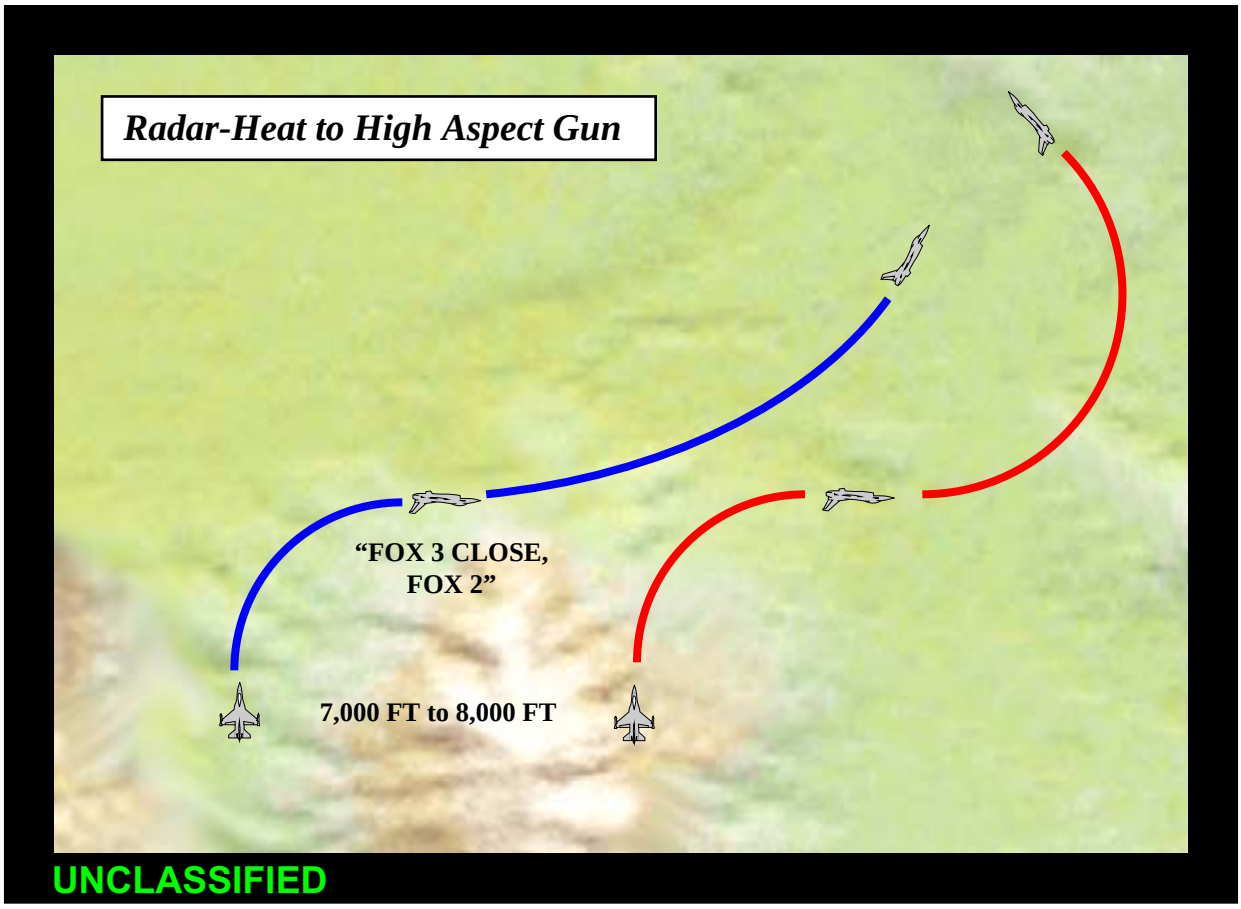
Figure 4.79 High-Aspect Gun Exercise.



4.6.41.8 Radar-Heat to High-Aspect Gun Exercise. This is basically the same exercise as in **paragraph 4.6.41.2**, Offensive Radar-Heat-to-Guns Exercise, except it is initiated from slightly increased lateral distance of 6,000 to 8,000 feet. (See **Figure 4.80**, Radar-Heat to High Aspect Gun.) After the Fox 3/2 call, the defender initiates a hard turn (5 to 6 Gs) to place the offender at approximately 90 degrees of aspect. The defender adjusts G and power to maintain aspect and hold approximately 250 knots while the offender attempts a high-angle gunshot. After the Fox 3/2 call, the offender will maneuver for a high-angle gunshot by establishing lead with the gun cross and in the defender's plane-of-motion (POM). The defender should be in the bottom two-thirds of the HUD. As the offender places the defender in the proper HUD location, the offender cross-checks the EEGS 1-G cross and places the 1-G cross in the proper POM with proper lead. Proper lead is established when the Level V pipper is slightly behind or on the defender. The offender should be able to begin firing between 3,000 to 5,000 feet. A lethal burst is required (1 to 2 seconds) due to the fleeting nature of this shot. The offender should continue firing down to minimum range while making adjustments for lead and POM, then reposition high. As the offender repositions, the defender rolls wings-level and extends in Mil power to open the range. The offender extends until approximately 4,000 to 5,000 feet range then starts a hard-G turn back into the defender. The defender, at the offender's turn, also starts a hard turn into the offender again placing the offender at 90-degrees aspect and slowing to around 200 to 250 knots. ***NOTE:*** This exercise allows for a controlled high-aspect gun

attack, teaching lead and POM requirements to foster the learning of the sight picture used later in dynamic BFM.

Figure 4.80 Radar-Heat to High Aspect Gun.

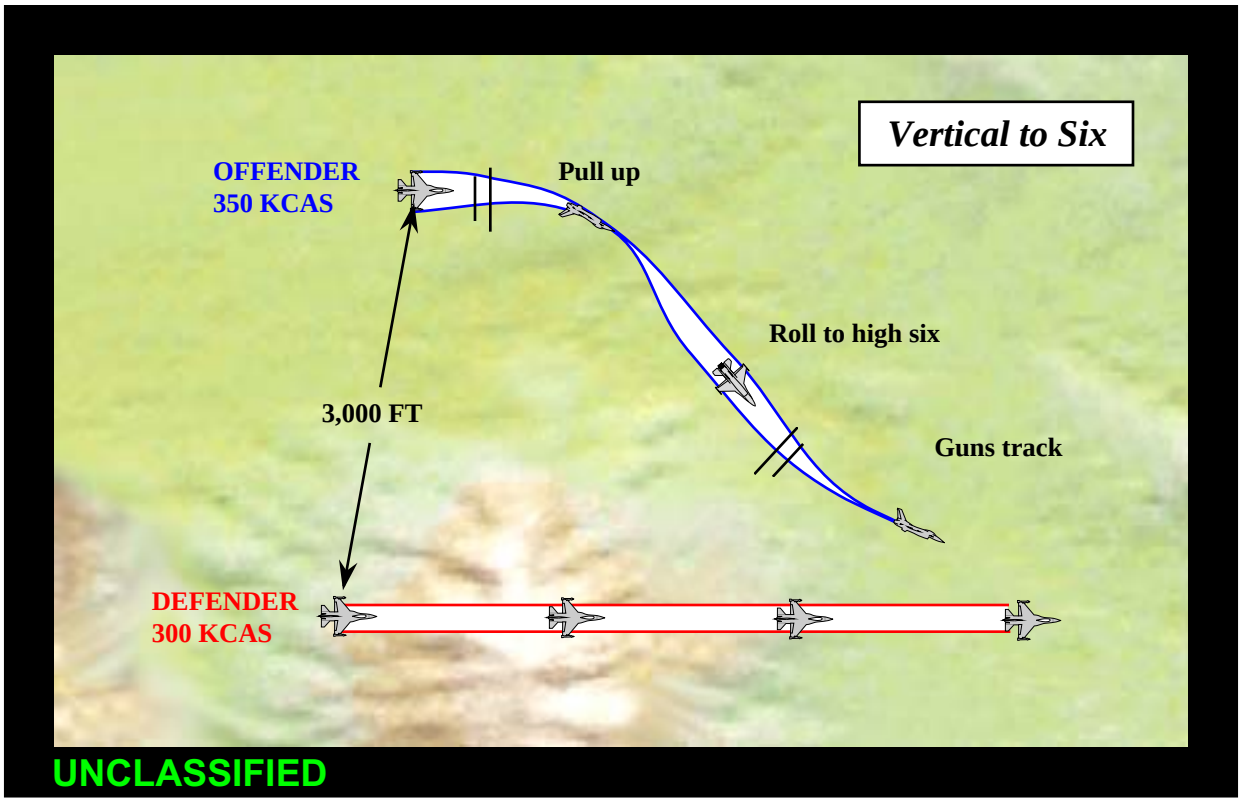


4.6.41.9 Vertical-to-Six Exercise. (See **Figure 4.81**, Vertical to Six.) With the defender flying straight and level, the offender obtains lateral spacing of 3,000 to 4,000 feet, with 50 to 75 knots of overtake, and 30 to 45 degrees in front of the defender's 3/9 line. Once in this position the offender starts a vertical pull to stop offender's forward motion and start a LOS motion by the defender forward on the canopy. Once the defender is moving forward on the canopy and is approaching LAB with the offender, the offender starts an unloaded roll to place lift vector in lead with the defender's motion. From this vertical position above the defender, the offender aligns fuselages, adjusts power to control closure, and controls lead and POM to attempt a high-aspect gunshot, ideally 1,500 to 2,000 feet above and slightly in front of 90 degrees aspect provided there is adequate distance. If distance is not available, the offender should place the lift vector above and pull to a barrel roll type ending. The offender should be no further aft than 2,000 to 2,500 feet with a no-lock IR missile employment opportunity.

NOTE: This exercise practices taking you from a defensive/neutral position to an offensive position by using a rolling and pulling maneuver. Use this exercise for later defensive BFM

missions when practicing overshoot maneuvering. Definitely use the exercise for the high-aspect BFM phase.

Figure 4.81 Vertical to Six.

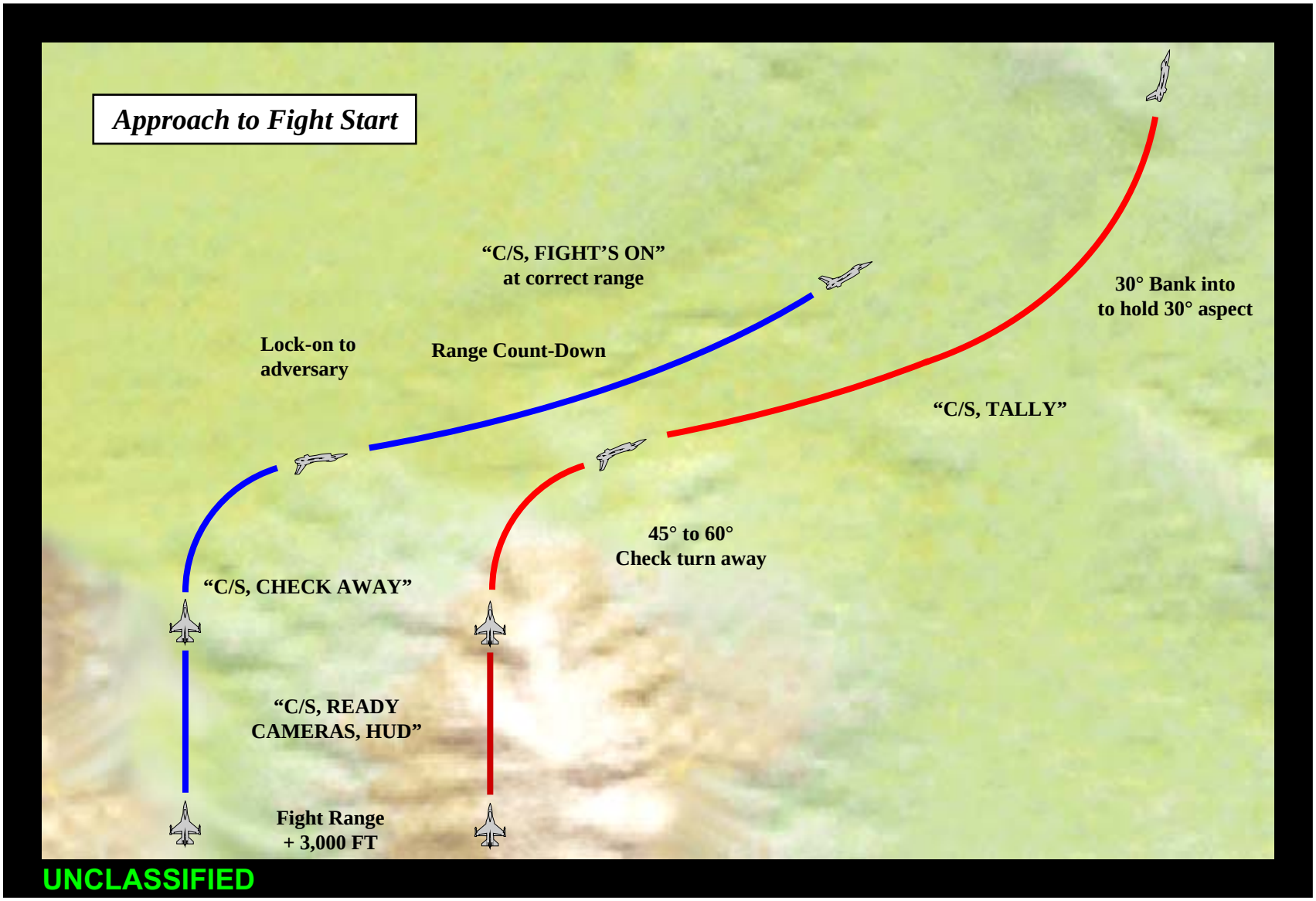


4.6.42 Setup Parameters for Basic Fighter Maneuver. Prescribed training setups facilitate a building block approach to teach these necessary skills. These training setups are designed to present a solvable problem and the ability to describe and teach the appropriate cues necessary to develop the mental picture and "stick and rudder" coordination required in BFM.

NOTE: The procedures described in **paragraph 4.8.3.1** through **paragraph 4.8.3.5** are just one way to start these BFM sets. Your unit may prefer a different method or use different airspeeds and altitudes. For all setups a radar lock is presumed; use A/A TACAN as a backup.

4.6.42.1 Approach to Fight Start From Line Abreast. (See **Figure 4.82**, Approach to Fight Start.) After both pilots obtain starting parameters and call "READY," the IP/flight lead will check the flight away from the offender. The offender obtains a radar lock and places the defender in the center of the HUD for 9,000-foot setups and under the bore cross for 3,000/4,000-foot setups. At the check turn, the defender checks 45 to 60 degrees away from the offender and holds the heading until spiked. The defender then reverses to about 30 degrees of bank, obtains the tally, and holds the offender at 30-degree aspect. The offender counts down ranges until reaching fights-on range at which point the offender calls "FOX 3/2 FIGHT'S ON" and BFM will begin.

Figure 4.82 Approach to Fight Start.



4.6.42.2 BFM Parameters at the “Fight's On.”

4.6.42.2.1 The 3,000-Foot Setups. The fighter starts closure from approximately 6,000 feet back and calls closing range in 500 feet increments (i.e., “4,500 FEET, 4,000 FEET, 3,500 FEET, FOX 2 FIGHT'S ON!”). (See **Figure 4.83**, 3,000-Foot Setups.)

4.6.42.2.2 The 4,000-Foot Setups. The fighter starts closure from approximately 6,000 feet back and calls closing range in 500 feet increments (i.e., “5,500 FEET, 5,000 FEET, 4,500 FEET, FOX 2 FIGHT'S ON”). (See **Figure 4.84**, 4,000-Foot Setups.)

4.6.42.2.3 The 9,000-Foot Setups. The offender starts closure from approximately 12,000 feet back and calls closing range in tenths of miles (i.e., “1.8, 1.7, 1.6, FOX 3/2 FIGHT'S ON”). (See **Figure 4.85**, 9,000-Foot Setups.)

4.6.42.2.4 High-Aspect Setups. (See **Figure 4.86**, Visual Butterfly Setup.)

4.7 Air Combat Maneuvers. ACM involves coordinated maneuvering between two or more fighters employing basic fighter maneuver (BFM) to kill, defend, or separate from bandits. The priorities for an element as they enter a merge should be (1) Survival, (2) Lethality, and (3) Mutual Support. At its most basic level, the element, as a fighting team, begins with a foundational relationship between flight lead and wingman. The lead of the element is responsible for the overall conduct of the team. The wingman supports lead's objectives and fulfills a supporting role by default.

4.7.1 Flight Path Deconfliction. Deconfliction contracts must be established between the fighters. These deconfliction contracts are defined by the defensive fighter (DF), engaged fighter (EF), and supporting fighter (SF) roles. Deconfliction contracts are typically established via communications. Brevity is paramount, and should be delivered with directive comm preceding descriptive comm. Communications within the ACM environment should use a “challenge and response” format whenever possible to avoid conflicts and ensure comprehension. The key to the success of ACM is the establishment and adherence to ACM responsibilities. Disciplined execution of these responsibilities is critical for survivability and lethality. A DF must fly the best BFM possible and cannot be expected to maintain visual and deconflict. An EF is responsible for flight path deconfliction from any DF. SFs must deconflict from any DF or EF. If there is more than one fighter actively defending, initially the fighter in trail should deconflict within the element until conditions or comm changes the current status (e.g., break turn called for the element, or both fighters notch together). (See **Table 4.11**, Deconfliction.)

Figure 4.83 3,000-Foot Setups.

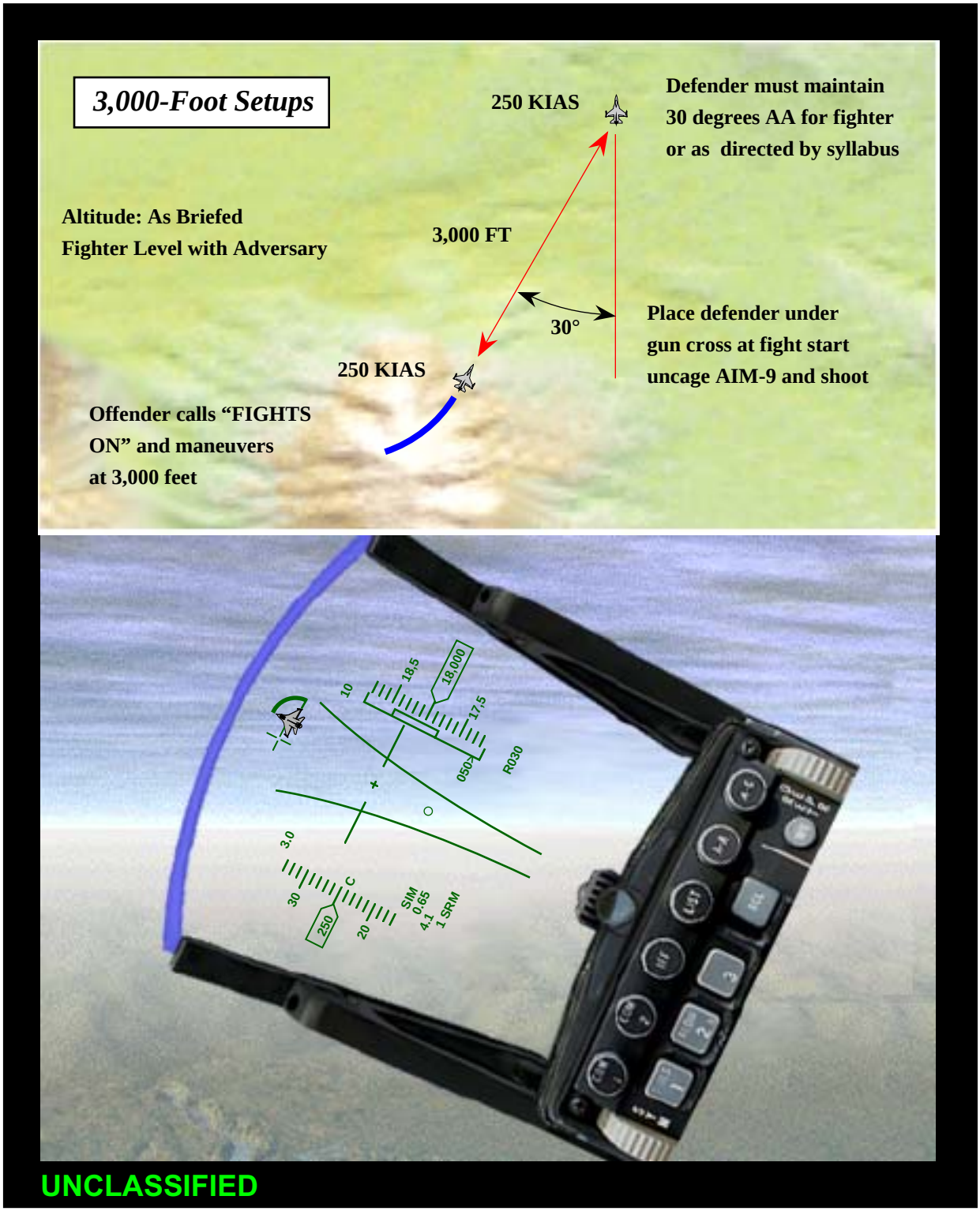


Figure 4.84 4,000-Foot Setups.

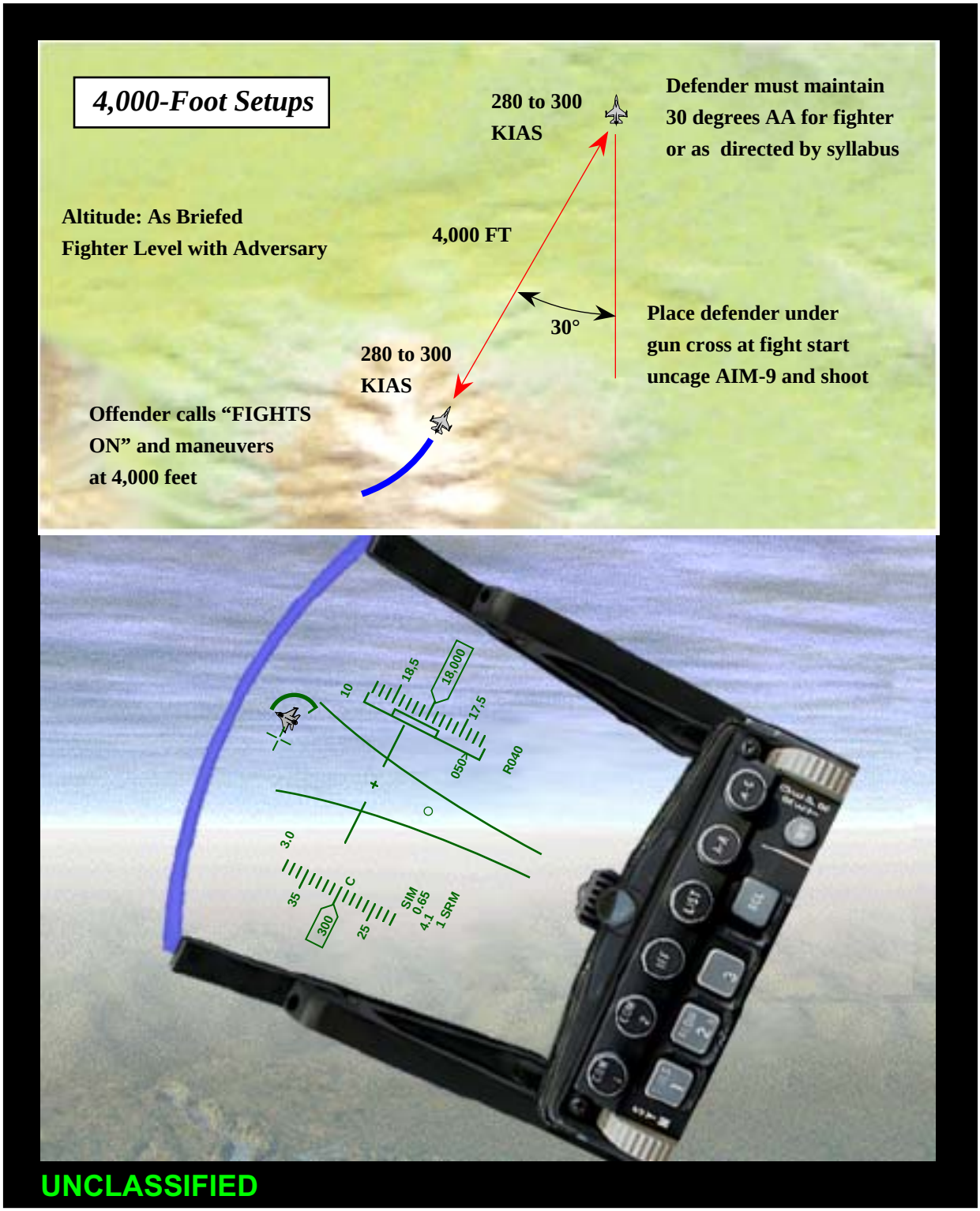


Figure 4.85 9,000-Foot Setups.

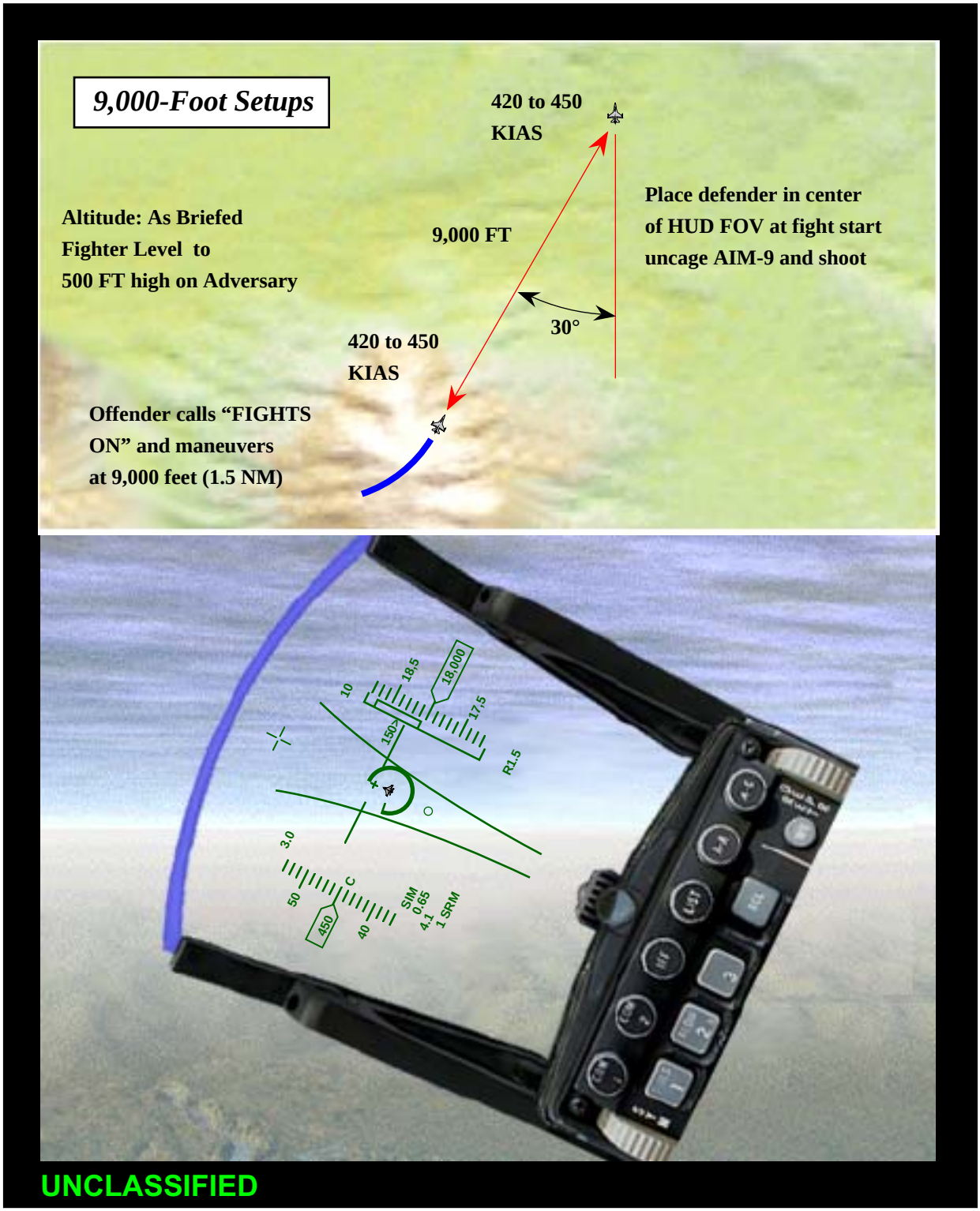


Figure 4.86 Visual Butterfly Setups.

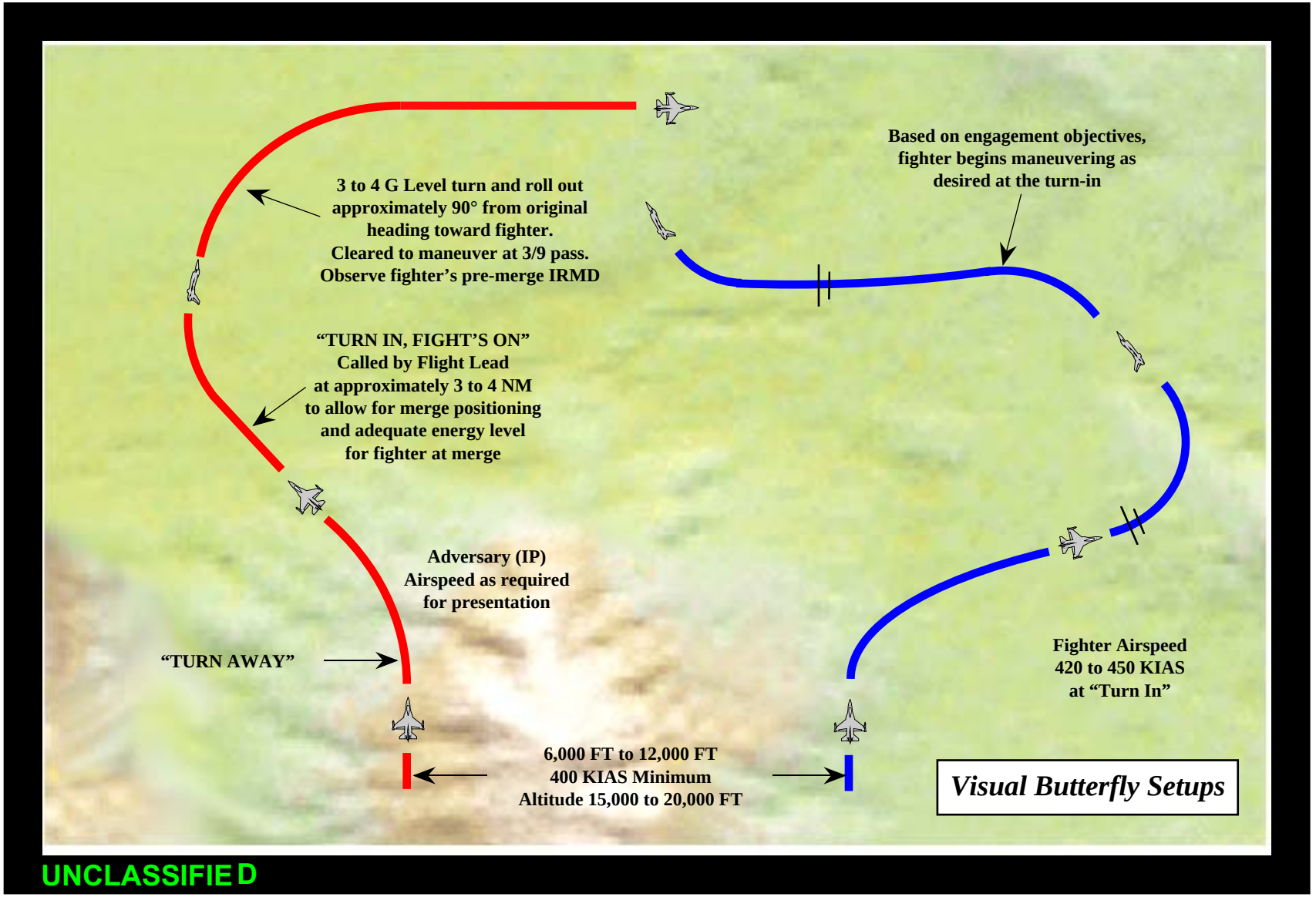


Table 4.11 Deconfliction.

Role	Deconflicts from
Defensive Fighter	—
Engaged Fighter	Defensive fighter
Supporting Fighter	Engaged and/or Defensive fighter
UNCLASSIFIED	

4.7.2 ACM Communication. Clear, concise, and correct communications are vital for effective element employment. Each pilot must firmly understand MPM, Attachment 1, “Operational Brevity Words, Definitions and Counterair Communications Standards,” and correctly use them at the proper moment in a fight. Only daily practice and constant critique will allow you to gain and maintain proficiency in communication. The time to start improving your communication is not after the first “BREAK RIGHT” call. Use full call signs when beginning radio transmissions to gain the attention of other flight members and allowing uninvolved flights to “tune out” your transmission. All missions (not just A/A) should focus on communications discipline. Brevity is paramount, and transmissions should be delivered with directive comm preceding descriptive comm. Communications within the ACM environment should use a “challenge and response” format whenever possible to avoid conflicts and ensure comprehension. The terms listed below are from MPM and AEM.

- “DEFENSIVE”—Speaker is under attack, is maneuvering defensively, and is unable to ensure deconfliction or mutual support.
- “ENGAGED”—Informative call used to establish engaged and support roles in the visual arena. [3-1.5-specific] prior to the initial engaged and supporting roles being established, the “ENGAGED” call may be used by the wingman as a request only. “OFFENSIVE” or “NEUTRAL” may be added, time permitting, to enhance SA.
- “SUPPORTING” [3-1.5-specific]—Supporting fighter is assumed to be visual and NO JOY and is executing supporting fighter's responsibilities.
- “PRESS”—Directive call to continue the attack; MS will be maintained. Supportive role will be assumed by the speaker.
- “CLEARED”—Flight lead response. Requested action is authorized. Mutual support may be detached to fulfill briefed contracts (e.g., split criteria, shot doctrine). Wingmen will ensure deconfliction from flight lead.
- “NEGATIVE” [3-1.5-specific]—Requested action is denied. Maintain previous role.
- “SWITCHED”—Indicates an attacker is changing from one aircraft to another.
- “ENTRY” [3-1.5-specific]—(Used with sub-cardinal and altitude description, high/low.) A request to swap roles from the supporting fighter.
- “STATUS”—Request for an individual's tactical situation. (Group name) Request for a full positional update in digital bullseye format on the specified group.
- “ANCHORED (w/location)” - Informative call to indicate a turning engagement at the specified location.

- "BUGOUT (w/direction)" - Separation from that particular engagement/attack/ operation; no intent to reengage/return.

4.7.2.1 Radio Choice. ACM communications are mostly interflight in nature and should be made on the interflight radio frequency (usually VHF). Exceptions to this are those situations where some portions of the comm such as "ANCHORED" calls may convey important information to other package members or C^2 assets, and warrant transmission on package-common frequency. Only do so if comm density and priorities allow.

4.7.2.2 Radio Transmission Techniques.

4.7.2.2.1 Directive Transmissions. A directive call is required when a threat warrants an immediate reaction for survival. Directive radio transmissions must be prefaced by the call sign of the aircraft or flight being addressed (e.g., "VIPER 1, BREAK RIGHT"). Most directive transmission also require a descriptive component. After making the directive transmission, "VIPER 1, BREAK RIGHT" pause briefly, then add the applicable descriptive (e.g. "BOGEY, RIGHT 5, 2 MILES"). Re-transmit the directive call if the directed fighter is not complying. The priorities need to be placed on the execution of the directed action. Other mission tasks are secondary until the threat has been negated or defeated. A series of purely directive calls may be required due to limited time (e.g., "VIPER 1, BREAK RIGHT," "VIPER 1, JINK NOW," "VIPER 1 EXTEND") if there is no time to include the descriptive without jeopardizing the safety of Viper 1.

4.7.2.2.2 Descriptive Transmission. Descriptive transmissions that are components of directive transmissions are formatted as shown above. Otherwise, descriptive calls are normally prefaced by the call sign of the aircraft doing the talking (e.g., "VIPER 1, TALLY TWO, LEFT 10, 5 MILES, 20 HIGH"). Visual point-out calls are standardized into the format shown in **Table 4.12**, Visual Point-Out Transmission Format.

4.7.2.3 Controlling Agency Point-Out Considerations.

4.7.2.3.1 Communications. "Threat/Untargeted/Pop-up/Leaker/Faded" calls can be excellent sources of information. This SA can be used to focus flight sensors.

4.7.3 Air Combat Maneuvering Responsibilities. In addition to the responsibilities listed below, any fighter in the engagement should call the adversary ID as soon as it can be determined.

4.7.3.1 Defensive Fighter (DF). During defensive maneuvering, devote maximum attention to defeating any weapons in flight, denying an adversary WEZ, upgrading defensive situation to neutral or offensive geometry, or separating if possible. DFs have one overriding priority—survive. Fly best defensive BFM and do not hit the ground.

4.7.3.2 Engaged Fighter (EF). The EF responsibilities are as follows:

- Ensure flight path deconfliction with the DF, if one exists.
- Maneuver to ID and kill the adversary in minimum time. If unable, make the adversary predictable.
- Keep the SF informed of status and intentions.

- Allow the SF to engage if in a better position to quickly kill or control the adversary.

Table 4.12 Visual Point-Out Transmission Format.

Clock Position Format (Range less than 5 NM, fighters on the same heading, or visual) • Call Sign • Tally • Number and type aircraft, or threat (Bogey/Hostile) • Left or Right (side of aircraft) • Clock position (don't say "o'clock", just the "number", i.e. "Right 3") • Range (Use whole numbers of miles. "1 MILE", "2 MILEs", etc. Avoid "1.5 MILES, "9 THOUSAND FEET", etc.) • Elevation in increments of 10 degrees high or low (level is assumed otherwise) •
Example: "VIPER 2, BOGEY, RIGHT 2, 4 MILES, 20 HIGH" **BRAA Position Format** • Call Sign • Type aircraft, or threat (Bogey/Hostile) • Bearing • Range (Use whole numbers of miles. "1 MILE", "2 MILEs", etc. Avoid "1.5 MILES, "9 THOUSAND FEET", etc.) • Altitude ("X THOUSAND FEET" if known otherwise degrees High or low) • Amplifying remarks **Example:** "VIPER 2, BOGEY, BRAA, 360, 8, 15 THOUSAND"
UNCLASSIFIED

4.7.3.3 Supporting Fighter (SF). The SF may have to perform several tasks at once while surviving the threat and must clearly understand the responsibilities and priorities. The SF's priorities will change depending on the EF or DF's status. The SF's responsibilities are as follows:

- Maintain visual and ensure flight path deconfliction with the engaged or defensive fighter.
- Maintain tally and do not become defensive.
- Maneuver for a shot of opportunity.
- Sanitize the area about the flight.
- Engage other factor threats.
- Maintain overall SA to include additional threats, fuel and weapons state, and separation opportunities.

- Direct the bugout.

4.7.4 Shots of Opportunity (SOO). The goal of the element is to achieve the quickest kill. A SOO is defined as an available shot taken by any fighter currently fulfilling deconfliction responsibilities. Fighters employing SOO must be able to maintain deconfliction responsibilities while shooting. SOO are expected to meet all Clear Avenue of Fire (CAF) requirements unless a defensive situation exists. In most cases, SOO should be possible without a role change IAW the following criteria:

- Flight path deconfliction duties are fulfilled.
- CAF is met (unless defensive).
- Advisory "FOX 2/3" call made.

If conditions meet SOO criteria, no verbal clearance to fire is required. If there is any doubt whether the shot will jeopardize the safety of any friendly fighters, do not shoot (e.g., engaged fighter in a gun WEZ). Assess the tactical situation and determine whether it is more important to maneuver for a SOO or sanitize for additional threats. For example, if an EF is clearly offensive and in a position to employ ordnance, and the adversary appears unaware of the SF, the SF may assess the priority to sanitize versus maneuver to take a SOO. If a fighter goes defensive, the SF or EF must maneuver immediately to kill the adversary. In a defensive situation, survival outweighs CAF requirements. In many situations, CAF may be borderline, and slight maneuvers by the EF may allow a CAF-compliant shot by the SF, quickly ending the fight. Flight lead SFs always retain the authority to direct wingman EFs to maneuver as required to provide CAF for SOOs. Wingman SFs should not hesitate to make directive calls to flight lead EFs to enhance CAF compliance. However, IAW MPM, such calls by the wingman are requests only, and the flight lead may or may not comply. Solid BFM principles should not be sacrificed for SOO.

4.7.5 Air Combat Maneuvering Role Establishment.

4.7.5.1 Deconfliction Role Establishment—General. The hierarchy to determine which fighter should be relieved of deconfliction responsibilities is as follows, in descending order of priority:

- The fighter against whom the adversary appears to be maneuvering.
- The fighter in the best position to establish a offensive position on the adversary.
- The fighter with the highest SA.
- The flight lead (default state until altered).

Subsequent sections fully describe specific communications to establish or alter deconfliction roles. In the interest of communications brevity, avoid making unneeded deconfliction communication when an adequate deconfliction contract is already established. For example, if the flight lead is in the EF role in an unobserved conversion on a bogey group, no "ENGAGED" call is required. The wingman is already deconflicting from the flight lead and has done so throughout the intercept. There is no need for additional communications. Similarly, if a DF forces a bandit overshoot and reverses, there is no requirement to "upgrade" the DF's status to EF, and "downgrade" the EF status to SF.

The EF is still deconflicting from the DF, and this supports the gameplan, even though the "DF" is now in a guns WEZ on the bandit.

4.7.5.2 EF Role Establishment, BVR-to-WVR Transition. Engaged and supporting roles are usually finalized during the terminal phase of an intercept. Generally, the group owner should plan to be the EF IAW the "highest SA" note in **paragraph 4.7.5.1**, Deconfliction Role Establishment—General. Sometimes deconfliction roles need to be established or altered well prior to the merge (e.g., split or notch/attack situations). If Viper 2 calls "VIPER 2, SPLIT WEST GROUP, BRA 320, 9, 25 THOUSAND" and Viper 1 responds with "VIPER 2, PRESS," the roles are established upon Viper 2's acknowledgement. Wingmen may acknowledge the flight lead's "PRESS" call with either their callsign, "VIPER 2", or "VIPER 2 ENGAGED". Range to the threat and SA-level as to adversary intent are the main considerations in choosing the acknowledgement. Range should be less than 5 nm and reasonable SA as to adversary intent should exist prior to calling "ENGAGED". In the "SPLIT" example, above, the correct response by Viper 2 would be callsign. In high aspect merges, delay the role assignment until adversary intent can be accurately determined. If Viper 1 owns the group, Viper flight is visually bracketing, and it becomes obvious that the adversaries are leaning on Viper 2, relieve Viper 2 of deconfliction duties to allow optimum postmerge BFM, while Viper 1 deconflicts and kills the adversarie(s) with unobserved shots. The correct call from Viper 1 is "Viper 2, PRESS." Viper 2 responds with "VIPER 2 ENGAGED" (due to close range and clear adversary intent). If Viper 2 cannot fulfill the duties of the EF (insufficient ownship SA), the response to lead's press call would be, "Viper 2 UNABLE." In the bracket situation above, if the bogeys lean towards Viper 1, Viper 1 does not need to make an "ENGAGED" call (existing flight lead/wingman deconfliction contract is adequate) but should make tally point out calls to the wingman. Some situations may allow the wingman to make an "ENGAGED" call as a request to the flightlead to take the EF role prior to any engaged or supporting roles being established. For example, Viper 2 visually picks up a threat at left 10, 10 high that did not previously meet split criteria and Viper 1 is unaware. The correct call from VIper 2 is "VIPER 2 ENGAGED, LEFT 10, 3 MILES, 10 HIGH. Viper 1's available responses are "PRESS", "NEGATIVE", or "CLEARED" IAW **paragraph 4.7.6.3**, Role Change Communications. Until Viper 1, calls "PRESS", Viper 2 must still maintain the deconfliction responsibilities.

4.7.5.3 Supporting Fighter Role Establishment. The wingman is assumed to have the SF role unless some other role has been previously established. The flight lead assumes the SF role by directing the wingman to "PRESS." The role change is complete when the wingman acknowledges with callsign or an engaged call (as appropriate based on range and anticipated maneuver). When resuming the SF role from a previously engaged or defensive role, the wingman calls, "VIPER 2, SUPPORTING." If the flight lead was previously deconflicting from the wingman and then gives the wingman a visual point-out during the bugout phase, the wingman's call of "VIPER 2 VISUAL" resets the element roles back to the default with the wingman deconflicting from the flight lead.

4.7.5.4 Defensive Fighter Role Establishment—Mature Engagement. In an engagement where EF and SF roles are already established, make a "SWITCHED" call if the adversary switches from one fighter to another. A "SWITCHED" call in no way communicates a

handoff of responsibilities unless “DEFENSIVE” is included. The term “SWITCHED” merely conveys the adversary's current pursuit course. If the SF must drop deconfliction responsibility in order to survive, the SF calls “HOSTILE SWITCHED, (C/S) DEFENSIVE.” The EF acknowledges with call sign and any amplifying data. DF status is given to the former SF when the EF acknowledges the “DEFENSIVE” call. The EF will ensure deconfliction from the DF while maneuvering to kill the bandit. [In training, if an element mate in close proximity does not respond to an initial “DEFENSIVE” call, cannot deconflict, or is not visual with the DF, a terminate/knock-it-off may be required for safety]. As soon as the situation changes and the DF is no longer threatened, the DF calls either “PRESS” (from flight leads) or “SUPPORTING” (from wingman). Either of these calls relieves the EF of deconfliction duties and transfers them back to the SF (formerly DF).

4.7.5.5 Defensive Fighter Role Establishment—Surprise Attack. In a situation where the F-16s detect an attack from the aft quadrant requiring a defensive break turn, DF status will initially go to any F-16 receiving a directive break call. For example, if Viper 2 detects a bogey attacking Viper 1 and calls “VIPER 1, BREAK LEFT, BOGEY LEFT 7, 2 MILES, 20 HIGH”, Viper 1 is the DF. If bogey intent is unknown, or the directive break call is not directed to a specific flight member, the fighter in trail is responsible for deconfliction. If a different contract is required, it must be included with the initial call. For instance, if in the above situation, Viper 2 perceives the bogey to be attacking Viper 2, the call would be “VIPER 1, BREAK LEFT, VIPER 2 ***DEFENSIVE***, BOGEY LEFT 7, 2 MILES, 20 HIGH.” Viper 1s acknowledgement of this call allows Viper 2 to have DF status.

4.7.6 Role Changes. Prolonged turning fights are not wise considering the capabilities of modern adversary aircraft. Quick kills with SOO are the preferred method to achieving success in the visual arena. Role changes should therefore be the exception, rather than the rule. Adherence to the following contracts is critical. No role change is complete until acknowledged by both fighters.

4.7.6.1 Role Change Considerations. Given the SOO options provided by modern missiles, it is an unusual circumstance when the EF and SF roles need to be exchanged once they are established. Situations requiring a role exchange could include ordnance limitations, adversary switches or offensive BFM errors by the current EF (stuck in lag, etc.). If possible, the SF should strive for a CAF-compliant SOO without requesting a role change. The SF should only request a role change if (1) it is necessary to drop deconfliction duties in order to kill the bandit and (2) doing so will result in a quicker kill than if the EF continued the current attack. “Neutrally” engaged fighters either across the circle, in a stack, or in a scissors will rarely be able to alter their maneuvering without risking becoming defensive before the bandit is killed. Thus, neutrally engaged fighters should only approve a role change request if they can fulfill SF deconfliction duties without degrading their maneuvering relative to the adversary. “Offensive” EFs who subsequently call “NEUTRAL” have conveyed the course of the engagement, increasing the reliance on the supporting fighter to employ SOO.

4.7.6.2 Role Change Contract. No role change is complete until acknowledged. Flight leads currently in the SF role, and desiring EF status, do not require clearance from EF wingmen. They can simply declare themselves to be the EF with “VIPER 1 ENGAGED” and direct the wingman to come off in a direction to provide adequate deconfliction until

the wingman gets visual and calls “SUPPORTING”. A wingman who cannot relinquish the engaged role without becoming defensive may respond with “VIPER 2 UNABLE.” Flight leads may also direct SF wingman to assume the EF role at any time, by simply saying “VIPER 2 PRESS”. This is an excellent technique with which to respond to a SF wingman’s “HOSTILE SWITCHED” call. Unlike flight leads, a wingmen should not declare themselves as the EF while a flight lead is currently the EF. SF wingman desiring to assume the EF role request permission with an “ENTRY” call which is subject to flight lead approval (see below). If a wingman in the DF role has maneuvered to neutral or offensive geometry, there is no specific requirement to alter the wingman’s status to EF. Wingmen continue to fight their best BFM under the existing DF/EF deconfliction contract. If the wingman is no longer threatened and wishes to resume deconfliction, the wingman merely calls “SUPPORTING”.

4.7.6.3 Role Change Communications. The term used by a wingman SF to request a role change to EF is “ENTRY.” “VIPER 2 ENTRY, (sub-cardinal direction, elevation)” is used when the wingman SF can kill or control the bandit but must drop deconfliction duties in order to do so. The responses available to the (flight lead) EF are “PRESS,” “NEGATIVE,” or “CLEARED.”

- “PRESS”—The wingman is the new EF, the flight lead is the SF and will adhere to all SF responsibilities. The role change is complete, upon the wingman’s acknowledgement, “VIPER 2 ENGAGED”.
- “NEGATIVE”—the role change is denied. The wingman must maintain the supporting role.
- “CLEARED”—The role change is not complete. The flight lead wants to give a “PRESS” but lacks adequate positional awareness on the wingman to ensure deconfliction. The wingman may continue to maneuver versus the adversary, but must maintain deconfliction from lead while providing additional positional information. As soon as the flight lead has enough information (or the visual) to ensure deconfliction, the flight lead should say “PRESS”. The wingman’s acknowledgement completes the role change. A correctly formatted “ENTRY” call enhances the current IF’s ability to obtain the visual.

4.7.6.4 Role Change Examples. See **Table 4.13**, ACM Comm Examples, for various role change situations and the applicable communications flows.

Table 4.13 ACM Comm Examples.

Normal EF to SF Role Change	EF to SF Role Change, EF Blind
Viper 1: “VIPER 1, ENGAGED NEUTRAL”	Viper 1: “VIPER 1, ENGAGED NEUTRAL”
Viper 2: “VIPER 2, ENTRY, SOUTHWEST, LOW”	Viper 2: “VIPER 2, ENTRY, SOUTHWEST, LOW”
Viper 1: “VIPER 2, PRESS”	Viper 1: “VIPER 2, CLEARED, VIPER 1 BLIND”
Viper 2: “VIPER 2, ENGAGED”	Viper 2: “VIPER 2’s, SOUTH LOW, 1 MILE”
Role change complete	Viper 1: “VIPER 2, PRESS”
	Viper 2: “VIPER 2, ENGAGED”
Hostile Switch from EF to SF Forces SF Defensive	**Hostile Switch to SF (SF not Defensive)**
Viper 2: “VIPER 2, DEFENSIVE”	Viper 2: “VIPER 2, HOSTILE SWITCHED”
Viper 1: “VIPER 1”	*Viper 1 chooses to exchange roles*
Hostile comes off Viper 2 and reacts to Viper 1	Viper 1: “VIPER 2, PRESS”
Viper 2: “VIPER 2, SUPPORTING”	Viper 2: “VIPER 2 ENGAGED”
UNCLASSIFIED	

4.7.7 Air Combat Maneuver Execution. The goal of ACM is to kill as many hostiles as possible in the quickest possible time while safely maneuvering as a coordinated team. The previous sections outlined the deconfliction, role establishment, and role change contracts required to safely maneuver. The following sections focus on tactics and maneuver to kill.

4.7.7.1 Merge Options. In offensive or high-aspect ACM situations, the merge is anticipated, and it is possible for the flight to position for a fairly optimal attack. The two primary options are “FAN” or “BRACKET” merge entries. The Fan attack option is primarily used against apparently unaware adversaries. The Bracket attack is used against high aspect (aware) adversaries when there is no requirement for radar missile defense. [If radar missile defense is required, two other options exist, Notch/Attack and Abort/Attack, which will be addressed in subsequent sections]. In surprise defensive ACM situations, the fighters must react from their present position, and little or no time is available for altering formation before defending. Flight leads should use any available time to turn to face the perceived threat axis or separate.

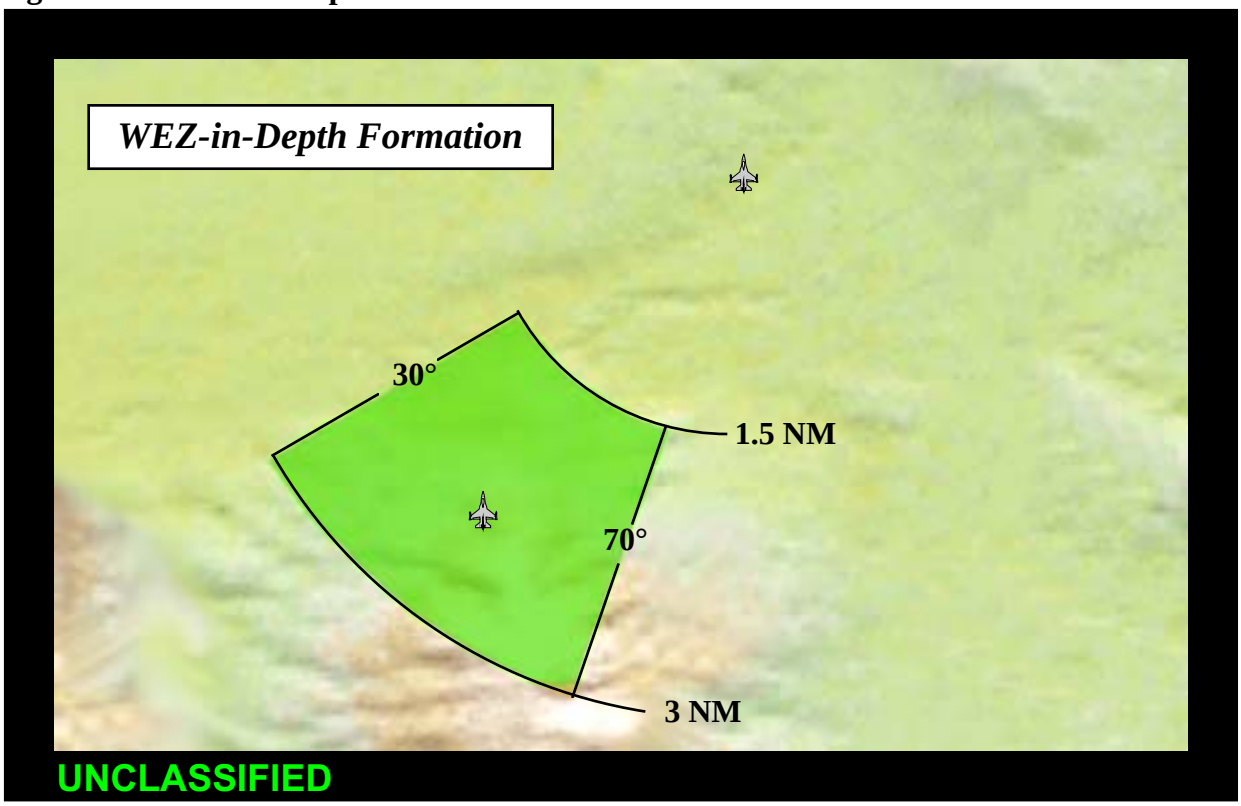
4.7.7.2 Premerge Positioning, Fan or Bracket. The SF's premerge positioning is critical entering the visual arena. Approaching the merge, the SF's priorities are, in order of priority, (1) staying visual, (2) setting the appropriate attack formation, and (3) achieving a sort/tally. With a properly flown Fan or Bracket merge by the EF, a visual SF in correct formation but with no premerge tally or sort can be highly lethal and survivable. Both the Fan and Bracket attacks present an adversary with “lethal choice”, meaning that the adversary cannot attack either fighter without being forced defensive by the other fighter.

4.7.7.3 Offensive ACM From a Fan Attack. In an offensive situation, typically the group owner is the EF. This is normally the flight lead unless the element targets multiple groups simultaneously, then drops the lead’s group and flows together to the wingman's group.

Situations requiring offensive ACM are generally the result of a single side offset (SSO) to fan conversion against an initially unaware bogey group. Then the bogey(s) becomes aware and reacts with the fighters aft of the bogey's 3/9 line, but prior to VID range (or the bogey defeats the EF's initial shots).

4.7.7.3.1 Offensive Tactics. The EF (usually the group owner) directs the SF to maneuver to WEZ-in-depth (WID) formation with "(C/S) DEPLOY", ideally 10-15 nm from the merge. The premerge objective of the SF should be to ensure a good 1.5-to-3 NM WID formation, which will allow a CAF-compliant shot under almost any circumstances. See **Figure 4.87**, WEZ-in-Depth Formation. As long as visual allows, the outer limits of WID offer more weapons separation and flexibility. The EF must ID the bogey ASAP and fly the best BFM to kill and remain offensive. The EF should also inform the SF of changes in status (i.e., becomes neutral). If the VID occurs too close for a WEZ to be available to the EF, a SOO by the SF is the quickest available kill. The keys to success for the SF are correct premerge WID. With a good WID formation, from the time the bogey breaks, the SF can maintain fairly pure pursuit for at least 180 degrees of bogey turn without having a flightpath conflict with the EF. This minimizes the chance of being detected by the adversary and provides an immediate WEZ when the EF calls the ID. As the SF waits for the ID and SOO, the SF must evaluate CAF carefully. If good premerge WID is not achieved, aggressive split-plane maneuvering may be required to prevent bandit tallyho and position for a SOO.

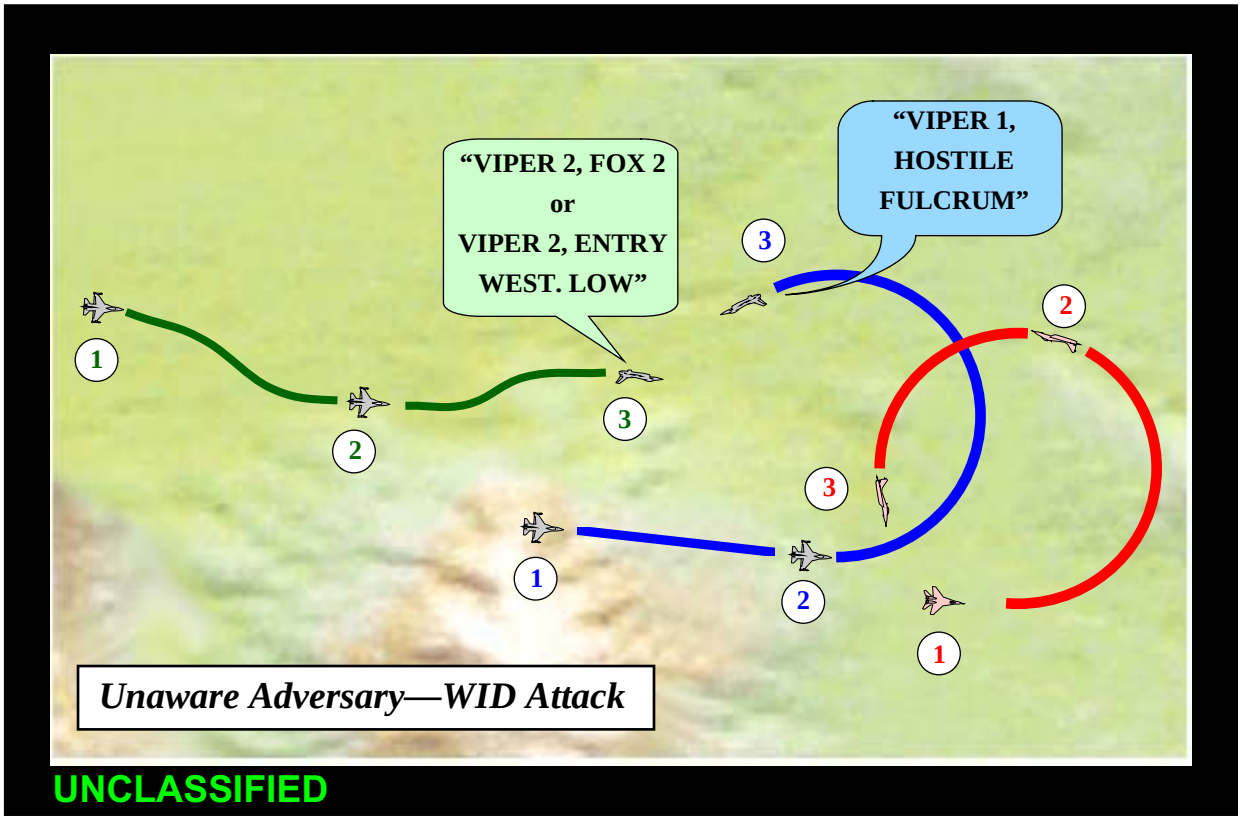
Figure 4.87 WEZ In-Depth Formation.



4.7.7.3.2 Adversary Options in Offensive ACM. Only three basic options exist for an adversary detecting the EF in the adversary's rear quadrant. (1) the adversary is unaware of the SF, and turns away from the SF, (2) the adversary is unaware of the SF and turns into the SF, (3) or the adversary is aware of both the EF and the SF and attempts to attack or switch to the SF. As previously stated, proper WID allows a CAF-compliant kill in any of these situations, and only the last one requires any significant ACM comm. In the two unaware scenarios, the SF should maneuver to keep the adversary unaware (pure pursuit will work fine from 2 to 3 NM WID), and consider a non-radar-locked AIM-9 as the primary weapon for the SOO See **Figure 4.88**, Unaware Adversary—WID Attack. In the third scenario, the SF should transmit a "SWITCHED" call while attempting a CAF-compliant AIM-120 (if available). IAW the "deconfliction relief hierarchy" the current EF should give EF status to the SF with a "PRESS" call (i.e., we relieve "the fighter against whom the adversary appears to be maneuvering" of deconfliction responsibilities). If a shot is unavailable to the new EF, the new EF flies best BFM to anchor the bandit. The long straight path required for the bandit to attack and merge with the new EF should provide ample room for the new SF to achieve a quick SOO and end the fight ("lethal choice" for the adversary).

4.7.7.4 High-Aspect ACM. An optimum entry against a high-aspect threat is one that allows the element to identify the threat and bring ordnance to bear quickly. The primary attack option versus high aspect bogeys is a Bracket, though WID can also be used effectively.

Figure 4.88 Unaware Adversary—WID Attack.



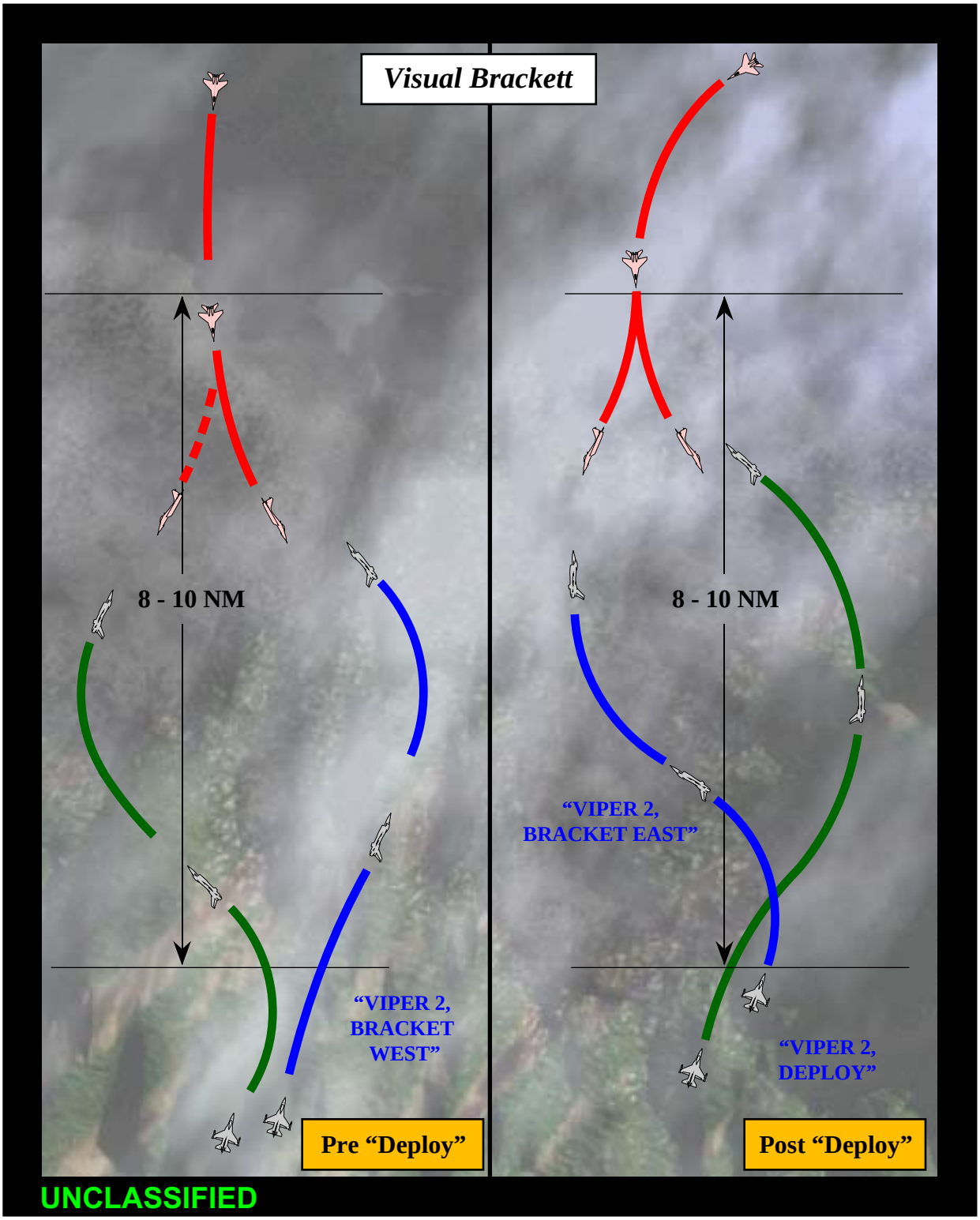
4.7.7.4.1 High Aspect ACM from Visual Bracket. The directive call is "(C/S), BRACKET (direction)." The desired formation is approximately 3 NM line abreast (or visual limits), and allows the flight to maintain visual mutual support and determine bogey intentions. (See **Figure 4.89**, Visual Bracket.) The objective is to "sandwich" the adversary between the two fighters and ideally to force the adversary to turn belly-up to whichever fighter (if any) the adversary is unaware of. Communications are critical to determine which fighter the bogey is attempting to engage. A combination of RWR, radar, and visual awareness is critical. As the group owner analyzes aspect and continues to offset to the merge, the other fighter maneuvers away from the flight in the stated direction to obtain turning room and a vertical separation. At 5 NM the owner should go pure pursuit. If the bogey(s) leans on one fighter, the other fighter should have an easy SOO at the merge. It is best to delay establishing ACM roles (EF/SF) until bogey intent becomes clear, then assign EF status to the fighter the adversary is attacking, and SF status to the other fighter. To be effective, the SF needs to anticipate the SOO, and start a hard turn to pure pursuit, timed so that the adversary and EF merge just as the adversary reaches the SF's HUD FOV. This allows the SF to shoot as soon as the adversary. After the EF passes the identification, the SF should have a quick SOO with no CAF issues at all.

4.7.7.4.1.1 Adversary Options, Post-Bracket. Similar to the offensive ACM situation, there are only three major options available to the adversary: (1) the adversary is unaware of the SF and turn away from the SF, going two-circle with the EF. (2) The adversary is unaware of the SF, but turns into the SF, going single-circle with the EF. (3) The adversary is aware of both fighters, and attempts to fight them both by flanking outside the EF and then switching to the SF.

4.7.7.4.1.1.1 Adversary unaware, turn away. The only challenge to the SF in this case is that an AIM-9 taken as soon as the EF and adversary pass may be kinematically defeated by the adversary's turn away, particularly if the SF bracketed to greater than 3 to 4 NM pre-merge. Consider an AIM-120, or wait until the adversary passes about 120 degrees of turn and closure is beginning to increase again if AIM-120 is unavailable. If the SF was "too close" pre merge, the adversary's turn away solves all the problems and allows a quick kill with either missile.

4.7.7.4.1.1.2 Adversary unaware, turns into SF. With proper pre-merge bracket position, and turn-in timing, there are about 5 to 10 seconds available after the VID for the SF to get off a missile shot. If no shots are available due to countermeasures, or insufficient pre-merge separation, the SF's best bet is an immediate vertical entry (low-to-high preferred) into the adversary's control zone. This is not a particularly challenging maneuver, but must be requested and approved via the previously described "ENTRY" contract. See **paragraph 4.7.6.3**, Role Change Communications.

Figure 4.89 Visual Bracket.



4.7.7.4.1.1.3 Adversary aware, switches to SF. With proper pre-merge position and turn-in timing, the SF should be able to kill the adversary before the switch is even apparent. However, if countermeasures or improper position prevent a

front quarter shot by the SF, and the switch becomes apparent, the SF calls "(C/S), HOSTILE SWITCHED". An EF (who is a flight lead) should immediately respond with ("C/S", PRESS). The new SF should deconflict while turning to immediately shoot the adversary with a SOO while the new EF flies best BFM to negate the adversary's attack and seize the offensive.

4.7.7.4.2 High Aspect ACM from WEZ In-Depth. WID also allows for a quick kill versus a high-aspect adversary. The most common situation for a high aspect engagement from WID is when a previously unaware adversary turns hot pre-merge, after the SF has already deployed to WID, and the EF elects not to attempt a Bracket due to insufficient range. The SF's most challenging job will be to maintain visual while maintaining the proper formation. The adversary retains the same three options as in the previous discussion and the SF responses are essentially the same.

4.7.7.5 Defensive ACM. Surviving a Defensive ACM situation requires (1) detecting and identifying the threat, (2) defeating the initial attack and denying subsequent attacks (3) killing the hostile with the earliest available shot. Flight integrity, mutual support, and disciplined application of contracts are the keys to achieving these objectives.

4.7.7.5.1 Adversary Detection and ID. Use all available sources to detect the adversary: Radar, RWR, calls from C^2 assets and, of course, good visual lookout IAW chapter 3 of this document. Proper tactical formation enhances visual lookout. If aft of the wingline in LAB you might do a good job looking behind lead, but lead will not be able to check your 6 o'clock very well. Just because you see an aircraft apparently pointing at your formation, that aircraft is not a "BANDIT" until visually identified. This has been a historical problem in ACM comm and must be avoided. Call the adversary a "BOGEY" until you can visually identify by type, or witness a hostile act (e.g. a missile launch).

4.7.7.5.2 Negating the Threat. If the adversary is detected in the element's aft quadrant and outside a WEZ, keep the element laterally and/or vertically spread and increase airspeed while formulating a gameplan (bugout, delouse, hard turn to attack, etc.) If the adversary is detected in a WEZ and intent is unclear, all fighters should assume they are under attack and execute appropriate maneuvers and countermeasures. The first priority is to get the flight moving in the correct direction with the appropriate directive call IAW **paragraph 4.7.2.2**, Radio Transmission Techniques. Establish deconfliction roles as soon as the adversary intent/SA level is apparent. See **paragraph 4.7.5.5**, Defensive Fighter Role Establishment. Until a DF is established, apply the basic contract of wingmen deconflict from leads (if turning towards each other), and trailing fighter deconflicting from the front fighter (if turning the same direction).

4.7.7.5.2.1 Hard Turn. A "HARD" call is a directive to initiate a high G, energy sustaining 180-degree turn (or as directed) in the indicated direction. It is used when the adversary is not yet in range to employ IR missiles. This turn is a stores-retaining, AB turn. Employing chaff is a good idea, but you should not use flares because they may highlight your position (the adversary may see your element mate, but not you). If turning to attack an adversary outside a WEZ, the

"HARD (left/right)" turn directive could also include "DEPLOY" or "BRACKET".

4.7.7.5.2.2 Break Turn. A "BREAK" call is a directive to initiate an immediate maximum performance 180-degree turn (or as directed) in the indicated direction. It assumes a defensive situation requiring infrared missile defense (IRMD). When executing a break turn or jink, maneuver the aircraft and use OBCM (i.e., chaff and flares). Consider stores jettison in actual combat and ensure the CAT I/III switch is in CAT I. If unsure if you should call for a hard turn or a break turn, call for a "BREAK" turn. IAW **paragraph 4.7.5.5**, Defensive Fighter Role Establishment, a fighter receiving a directive "BREAK" turn has DF status unless additional comm is included.

4.7.7.5.2.3 Jink. A "JINK" call is a directive call to perform an unpredictable maneuver to negate a gun tracking solution—you detected an adversary in a gun WEZ.

4.7.7.5.3 Principles for Success. All fighters break with maximum turn rate until the adversary shows awareness. If altitude allows, keep lift vector below the adversary until satisfied that there are no additional undetected adversaries, then orient lift vector as required. Maneuver split-plane when possible. The main principles to follow in accomplishing initial moves when the adversary is detected in the aft quadrant (WEZ available) are:

4.7.7.5.3.1 The pilot with the tally should:

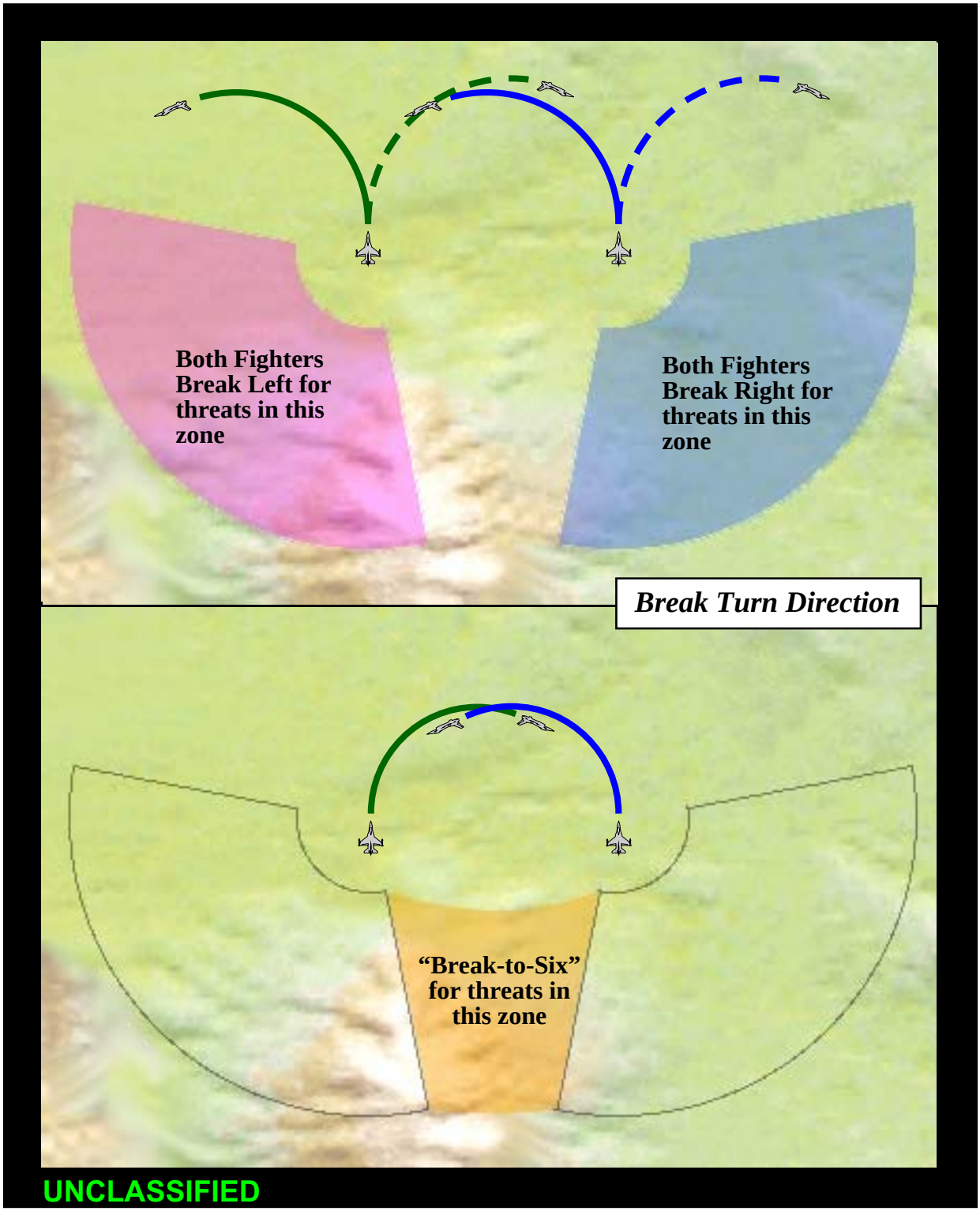
- Fly sound BFM by starting a hard/break/jink (as required) into the adversary with OBCM.
- Direct the flight as required.
- Attempt to ID the adversary ASAP.
- Talk element mate's eyes onto the adversary (descriptive comm), while deconflicting flight paths as required.

4.7.7.5.3.2 The pilot without the tally should:

- Perform the turn directed in the direction called.
- Dispense OBCM if required.
- Attempt to acquire the tally.
- Deconflict flight paths if the fighter with tally is the DF.

4.7.7.5.4 Choosing Break Turn Direction: Reference **Figure 4.90**, Break Turn Direction. If the adversary is "outside" the fighter formation, break the flight into the threat. If the adversary is at dead 6:00 to one of the fighters, break away from the unsweetened fighter. If the adversary is between the fighters, BFM principles generally require the fighters to break into one another. The directive call for this option is "(C/S), BREAK-to-SIX", (the defensive equivalent of "HARD-to-SIX"). DF role establishment in the break-to-six is identical to all other break turn situations.

Figure 4.90 Break Turn Direction.



4.7.7.5.5 Post-Break Adversary Options. If a defensive element survives the adversary's initial attack, the adversary only has two basic follow-on options: (1) The adversary is only aware of one fighter, and continues to fly offensive BFM versus this DF

unaware of the other fighter. (2) The adversary is aware of both fighters and tries to fight them both as effectively as possible. The adversary will reveal awareness level within a few seconds of the initial break turn. Training scenarios which drive a "switch and stick" adversary gameplan are unrealistic, and can reward unsound ACM.

4.7.7.5.5.1 Adversary aware of one fighter only. An adversary who enters the DFs turn circle and turns away from and belly-up to the SF can be reasonably assumed to be unaware of the SF. The SF now has the option to maneuver offensively as required to achieve a high PK SOO as soon as possible, and/or enter the adversary's control zone (CZ) as the EF. If the fighters were 2 NM or more LAB at the break turn, the SF should be able to select AB and continue the initial high-g turn after the hostile turns belly-up, and enter the CZ while taking a SOO. If the initial LAB was less than 9,000 feet, the SF may need to ease off the turn when the hostile goes belly-up and allow range to increase slightly before turning to point. This avoids forcing a minimum range missile shot (or having no WEZ). (See **Figure 4.91**, SF Options vs. Unaware Hostile.) If the fighters are in a break-to-six, and the hostile proves unaware of the SF, the SF will need a slightly longer extension to achieve turning room for a SOO. (See **Figure 4.92** Break-to-Six versus Unaware Hostile.)

4.7.7.5.5.2 Adversary Aware of Both Fighters. If the adversary is aware of both fighters, multiple "switches" are probable as the adversary attempts remain offensive. The initial switch may occur either early (the adversary switches to the SF as soon as the DF is forced into the break turn) or late (the adversary continues the attack on the DF, attempting follow-on missile shots, up until the adversary must switch to the SF to avoid losing offensive). (See **Figure 4.93**, Early/Late Switches.) Typically, the switch maneuver allows the DF to VID the hostile, as the hostile presents planform at about one mile while turning to point at the SF. Initial LAB spacing greater than 2 NM may allow the SF to get a valid missile shot on the switching hostile if the DF can communicate the ID in time. Thus, once the fighters are TALLY, ID (if not previously established) should be the priority comm in the initial moves of the switch. The DF should then immediately assume deconfliction with a "PRESS" or "SUPPORTING" call, allowing the other fighter to maneuver optimally against the hostile.

Figure 4.91 SF Options versus Unaware Hostile.

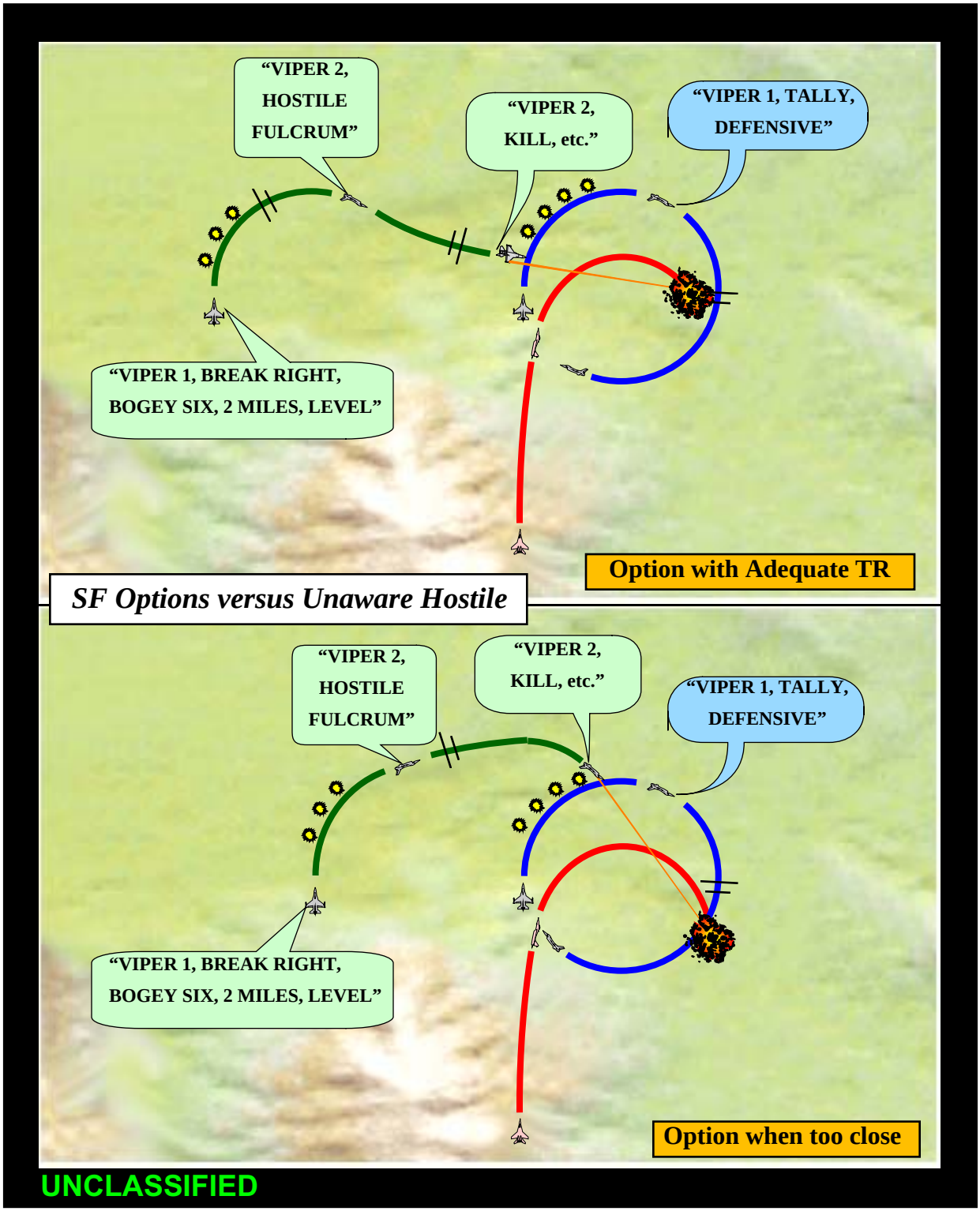


Figure 4.92 Break-to-Six versus Unaware Hostile.

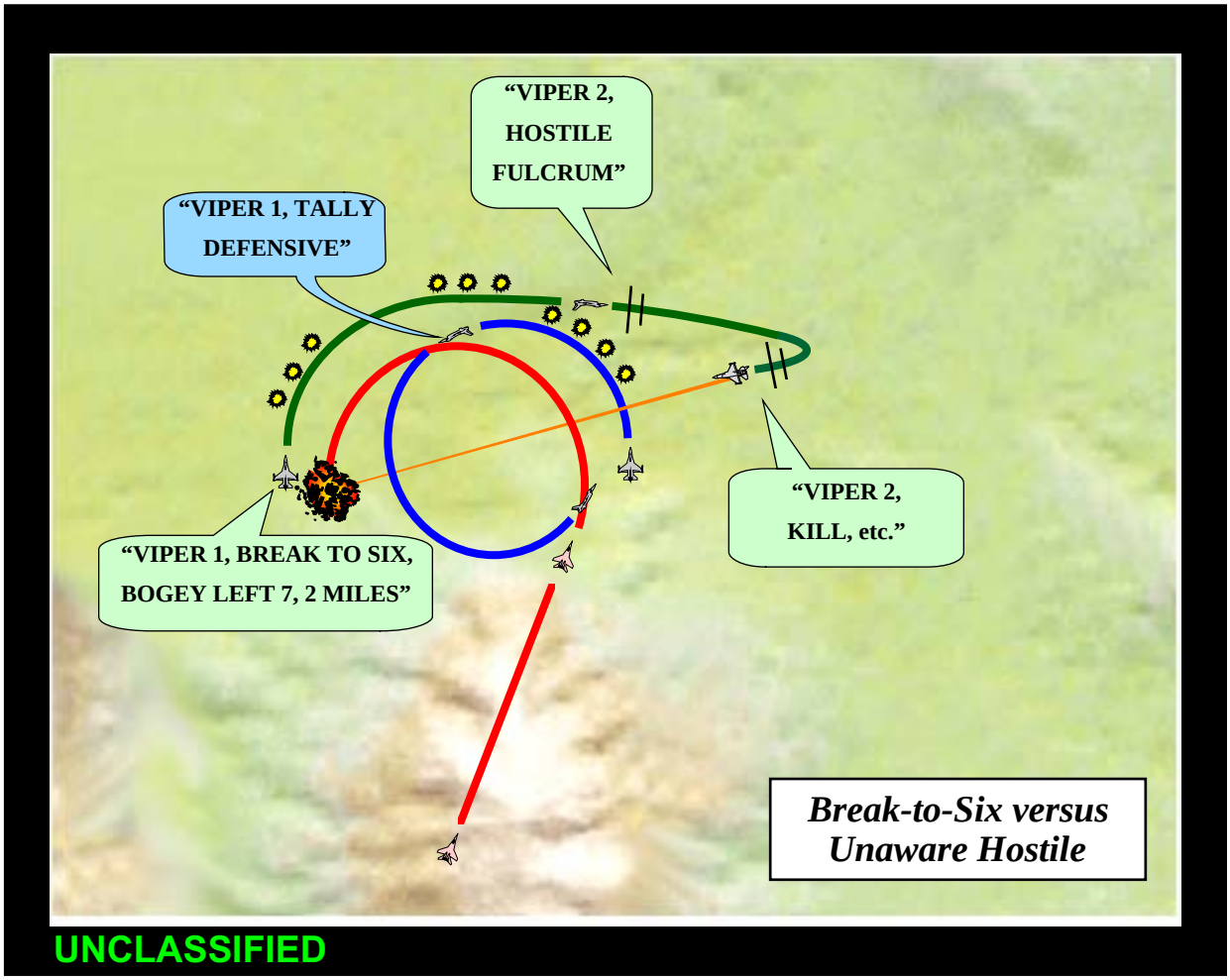
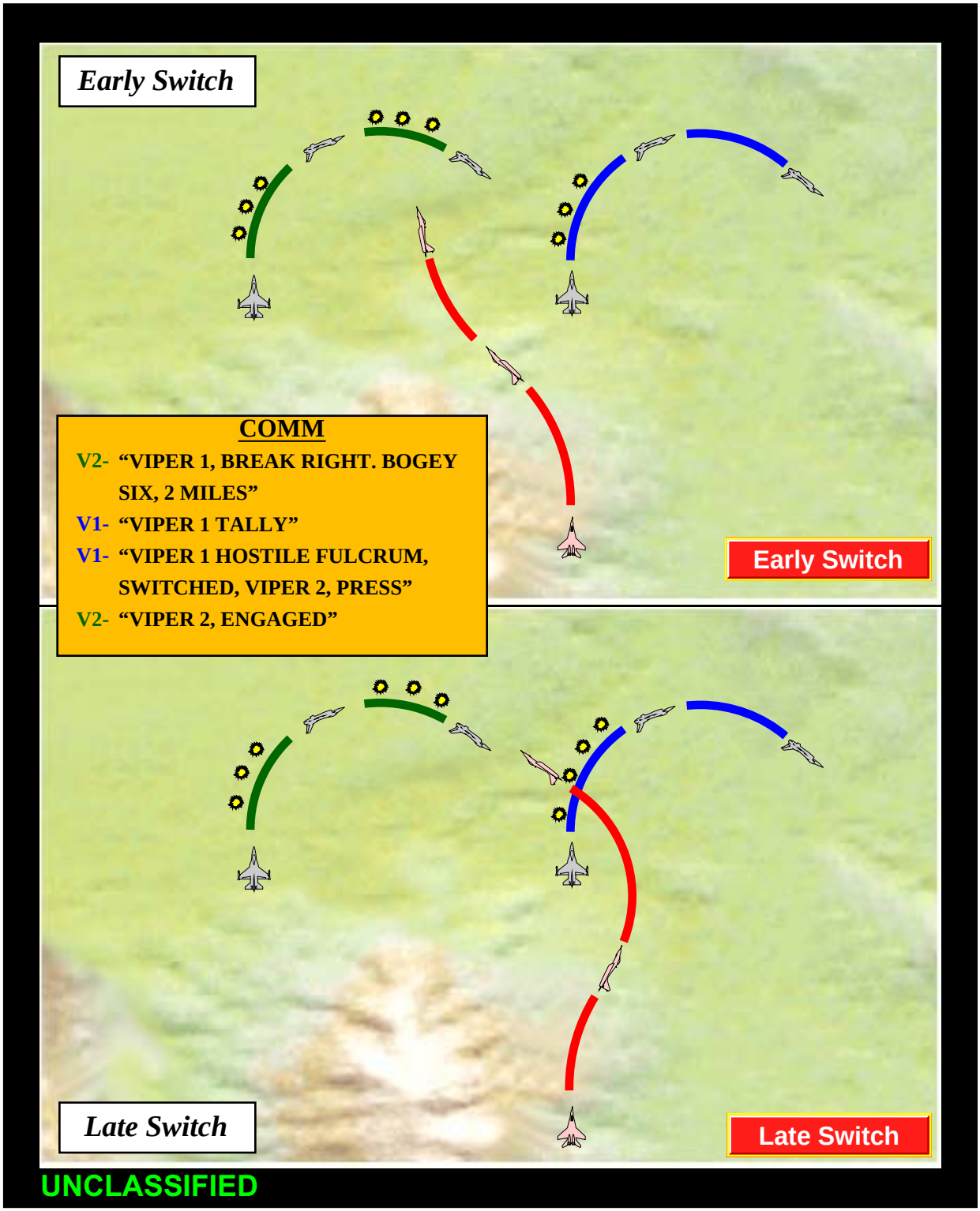


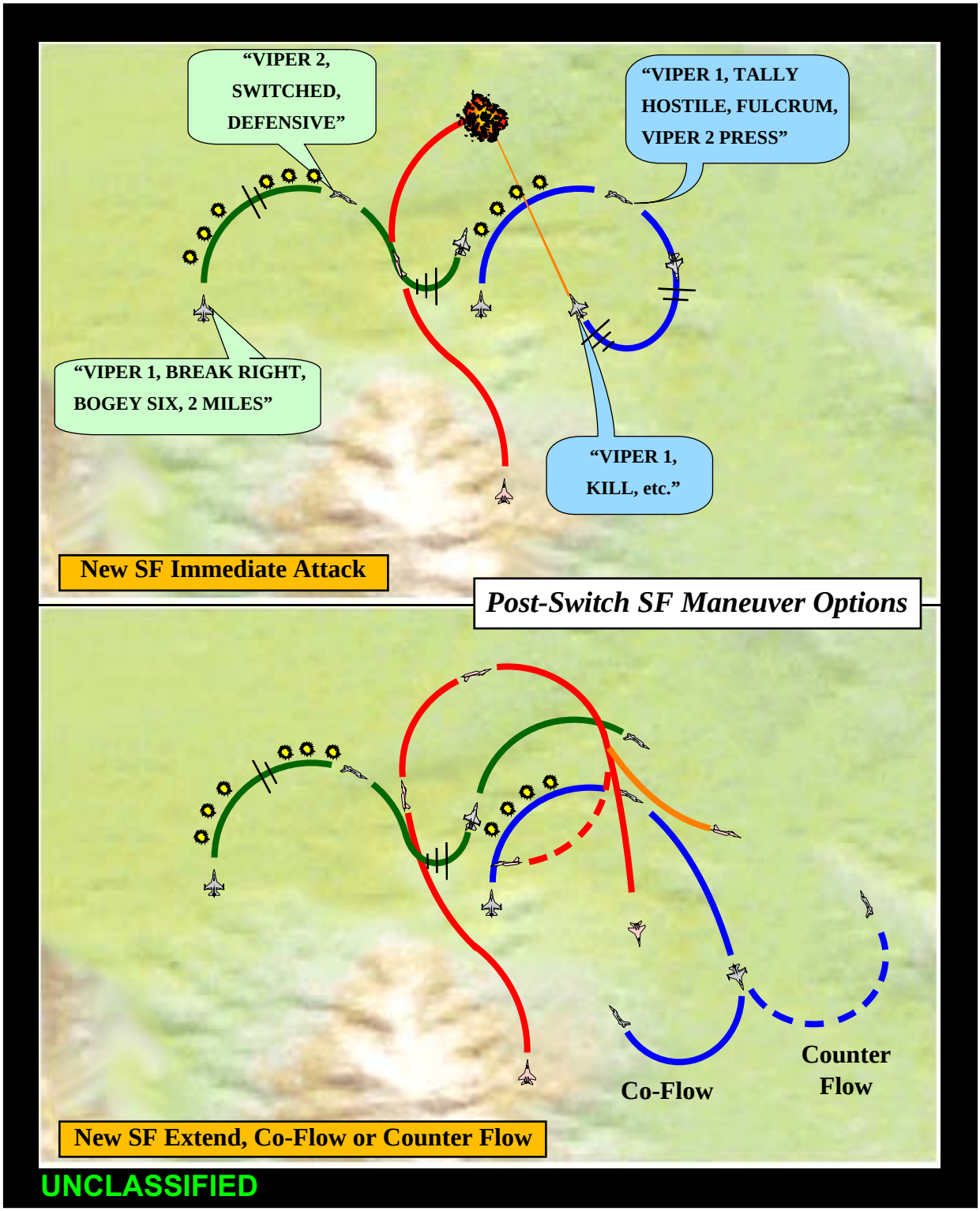
Figure 4.93 Early/Late Switches.



4.7.7.5.5.2.1 Post Switch Actions, New SF. The new SF (the fighter from whom the hostile just switched) has the option to extend or loosen the turn after the hostile switches. However, against an aware hostile, this is not an optimal plan. From an initial LAB formation, there is no way for the new SF to make any significant extension or reduction of turn rate without giving the hostile the ability to achieve a WEZ on the SF before the SF can have a WEZ on the hostile. A far better option is for the SF to maneuver exactly as if in a 1v1 defensive BFM situation against a hostile that flies well out the backside of the turn circle, since this is in fact exactly what the hostile has done (see **Figure 4.13**, Turn Circle Entry Timing). This maneuver involves an significant overbank (enhancing split-plane), full AB and limiter turn to keep the LV oriented on the hostile. It is very easy for the SF to maneuver in this manner while maintaining positive deconfliction from the new EF/DF. Initial LAB spacing of 2 NM allows the SF to easily get a SOO on the hostile soon after the hostile merges with the new EF/DF. Initial spacing of 1.5 NM allows an SOO if the SF flies aggressively and skillfully. Initial LAB spacing inside 1.5 NM will probably not allow a SOO, but will allow the SF to have an angular advantage on the hostile which can be exploited as the maneuvering matures. The SF must maintain deconfliction throughout these maneuvers, or the fighters must exchange roles again IAW **paragraph 4.7.6.2**, Role Change Contract. Note that the new SF's weapons separation for a SOO is not only a function of the element's initial LAB spacing, but also a function of how hard the original SF turned in the initial break. The tighter turn circle the original SF generates, the further away from the original DF (read: weapons separation) the hostile must fly after switching to merge with the original SF. This is one more reason both fighters must fly their best initial defensive break turns when maneuvering begins. See **Figure 4.94**, Post Switch SF maneuver options.

4.7.7.6 Follow-on ACM. Modern threat missiles reduce our ability to achieve weapons separation post-merge. Weapons separation is best built premerge. The Bracket and Fan options provide premerge weapons separation for the SF and allow assessment of the adversary's postmerge maneuvers, which is a good indication of the adversary's awareness. Bracket and Fan options also force "lethal choice" on post-merge adversary maneuvers. In defensive situations, initial LAB spacing of greater than 1.5 NM allows early weapons employment following a switch. In all the above ACM situations, the fight should be over quickly regardless of adversary awareness. However, the combination of an aware adversary using effective countermeasures, degraded weapons load on the F-16s, additional adversaries in the group, or F-16 maneuver errors can lead to a situation where the ACM fight degrades into extended post-merge unvarying. Two basic options exist in this situation: (1) transitioning to a survival-oriented plan until the hostile is controlled, then extending or (2) an early SF extension for ENTRY or SOO.

Figure 4.94 Post Switch SF Maneuver Options.



4.7.7.6.1 Transitioning to a Survival-Oriented Plan. Once a flight anchors with a fourth-generation threat, there is little opportunity for an extension without becoming vulnerable to attack. The hostile may need very little turn to threaten the SF, thus lim-

iting the time available to extend away from the merge. When anchored with an aware fourth-generation threat, the best option is for both fighters to initially concentrate on staying in tight with the hostile and avoiding any threat WEZ, while maximizing their split-plane maneuvering and trying to keep the hostile between them as much as possible (be the bread!). The fighters must rigorously adhere to their deconfliction contract, realizing that the situation is very fluid and they can swap roles quickly based on whomever the hostile is currently maneuvering against. It is impossible for an adversary to spend very much time in a situation like this without one of the fighters achieving an offensive position, and killing with a short-range missile or the gun. As soon as the hostile is threatened at this level, even if the hostile employs excellent defensive BFM, the opportunity now exists for the SF to extend towards the hostile's 6:00 (to insure survivability while the hostile jinks/defends) and then turn/pirouette for a CAF-compliant SOO if the EF has not yet achieved a kill.

4.7.7.6.2 Early Extensions for SF ENTRY/SOO. An early SF extension is possible versus any unaware adversary, or an earlier generation, tail aspect missile-equipped adversary regardless of awareness. In this early extension, the adversary still has good turn rate and is not yet controlled by the EF, in fact, the adversary may be offensive on the DF. There are two primary techniques the SF can use to "enter" (flow into the hostile's CZ or set up a SOO): from the vertical (above or below) or from outside the hostile's TC. The SF can enter from outside from co-flow (turning in the same direction as the hostile) or counter-flow (turning in the opposite direction of the hostile). Both entries require vertical turning room to be most effective. While maneuvering for an entry, always be alert for SOO.

4.7.7.6.2.1 Vertical Entry. The vertical entry occurs when the SF is directly above or below the fight. This entry requires a large altitude delta, and may be effective because it is difficult for the adversary to keep track of the SF. If attempting a vertical entry from low to high, be aware that the fight is often descending, and additional turning room may be required to complete a conversion.

4.7.7.6.2.2 Entry from Outside the TC. The other type of entry is from the outside the adversary's TC. The SF gets to this position either because the SF is outside the adversary's TC at the initial merge or because the SF passed through the TC after the fight started. There are two types of outside entries: co-flow and counter-flow.

4.7.7.6.2.2.1 Co-Flow Entry. As shown in **Figure 4.95**, Co-Flow Entry, both the SF and the adversary are turning in the same direction with the SF outside the adversary's turn. Lateral spacing outside the flight needs to be at least equal to the range desired for the missile shot/CZ range. No more than 2 NM is required (though more might be desired to deny adversary tally), and just under 1 NM is about the minimum. Begin the co-flow entry when the adversary's extended 3/9 line passes through the aircraft. Another way to visualize this is when the adversary's fuselage is aligned with the SF fuselage. For this entry to be survivable, the SF should be split plane with the adversary. If the SF is in plane, the adversary will probably get tally on the SF prior to the SF's turn-in point and force the SF defensive.

4.7.7.6.2.2.2 Counter-Flow Entry. As shown in **Figure 4.96**, Counter-Flow Entry, the SF's turn direction is opposite the adversary's. Again, insufficient altitude delta may allow a adversary tally, and force a defensive reaction from the SF. The visual cue for the SF to start the turn occurs earlier than for the co-flow Entry, and the range required is slightly greater (about one additional SF turn radius). The turn should be initiated after the adversary's nose passes, but before 3/9 line passage. The SF may begin to turn earlier, if there is more range (i.e., at longer ranges turn just after the adversary's nose passes, at closer ranges turn as the bandit's 3/9 line is passing).

4.7.7.7 Loss of SF Visual. (This section assumes the SF is also “NO JOY”. If “TALLY, BLIND” use the adversary as a reference to quickly regain visual. Regardless of who is in which role, the flight lead is ultimately responsible for ensuring deconfliction in blind situations and must be directive as required). A SF who goes blind with the DF/EF anchored, must take immediate action to regain the visual. The SF will usually have a general idea of the DF/EF’s location. In this case, if the SF just went blind and knows the approximate location of the DF/EF, a call of “VIPER 2, BLIND, 13 THOUSAND, VIPER 1 FLASH FLARE”, should allow a quick visual based on the flare. If the DF/EF has visual when hearing this call, the DF/EF should still drop a flare, but should also give the SF a visual point out, workload permitting. If the SF is still blind, and the DF/EF fails to provide any other directive, a technique is to extend out of the fight as quickly as possible. Any direction will do, but the shortest path away from the flight is best. Reference data link displays to pitch back, or ask the DF/EF for status if not data link-equipped: “VIPER 2 BLIND EXTENDING NORTH. VIPER 1, STATUS.” The most critical part of status information is the DF/EF altitude. Select 10 NM RWS and bracket the DF/EF altitude at 5 NM. After about 30 seconds extension (or 5 NM on A/A TACAN) make a hook turn. The fight will be somewhere close to 5 NM on the radar. Lock, get “head’s up” use the TD box to get tally X, and then sort it out: “VIPER 2, TALLY TWO, HIGH/LOW, STATUS.” (Viper 2 calls whatever the apparent orientation is from Viper 2’s viewpoint). Viper one replies, identifying himself using the same orientation: “VIPER 1 IS LOW”. Viper 2 resumes the SF duties with “VIPER 2, SUPPORTING, TALLY ONE”.

Figure 4.95 Co-Flow Entry.

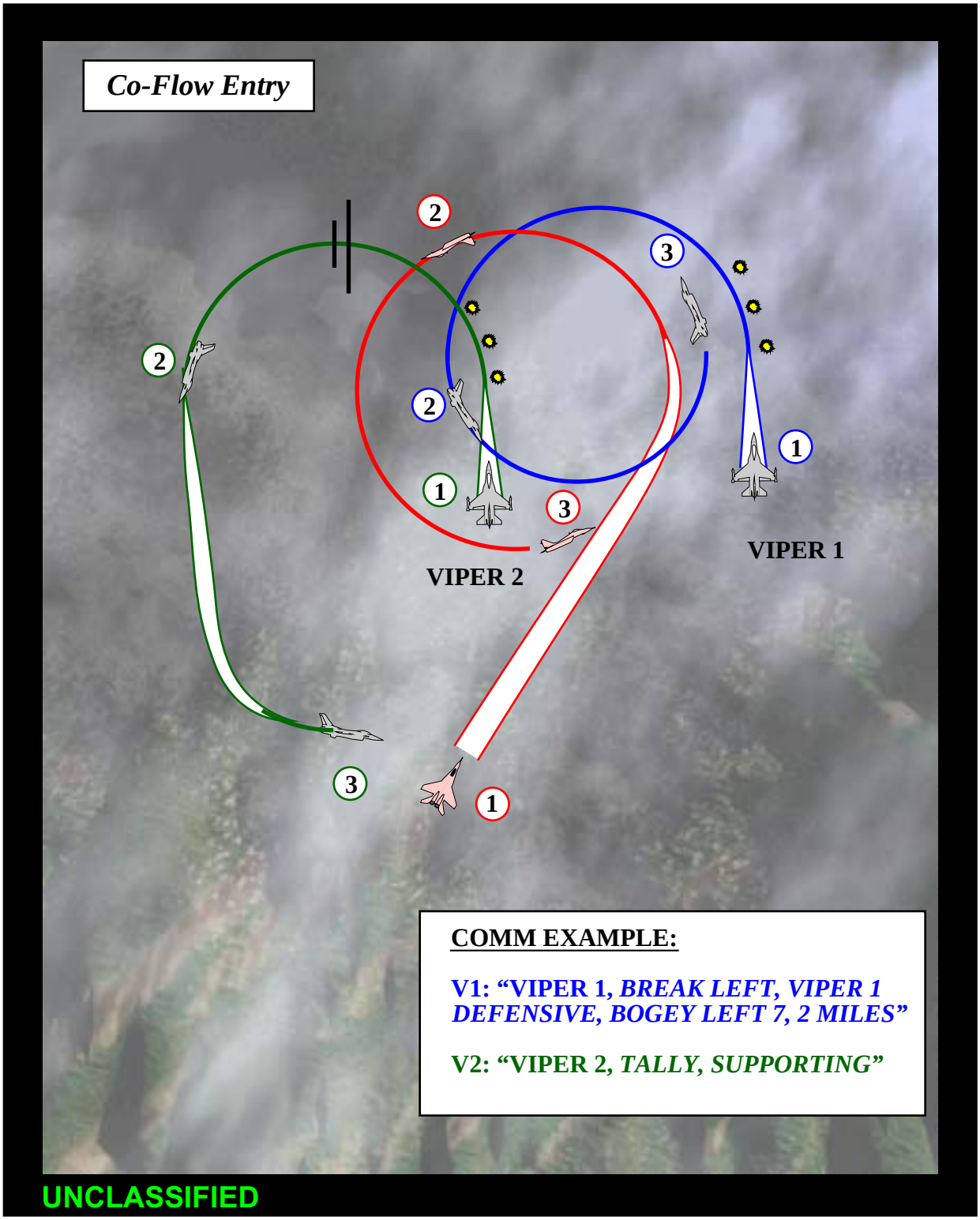
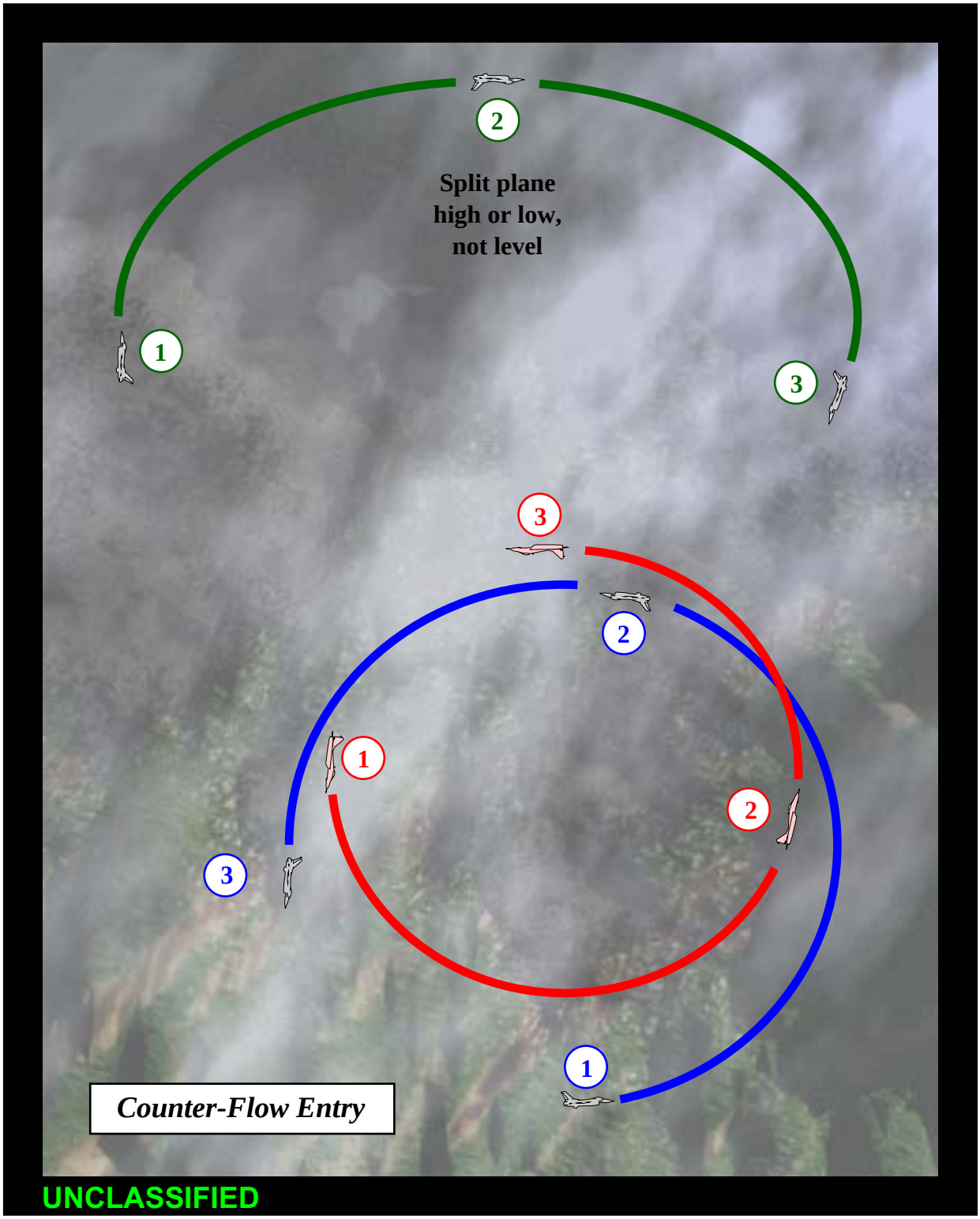


Figure 4.96 Counter-Flow Entry.



4.7.7.8 Egress. The first consideration is to get the flight moving quickly away from the fireball while checking 6. The fighter currently deconflicting is usually in the best position to call the egress after the flight kills all hostiles. For example Viper 1, if the SF, could say “VIPER 2, BUGOUT 150", followed by “VIPER 2, VISUAL LEFT 9, 10 LOW.” When VIPER 2 calls “VIPER 2 VISUAL”, the deconfliction resets to the basic flight lead/wingman contract. The BUGOUT direction is based on the postmerge flow plan, if able (C2 assets are often helpful at this time). Consider making a large change in altitude to isolate potential threats above or below as the flight egresses. Initially the flight should fly the egress heading without regard to precise formation position. Visual and radar warning receiver (RWR) cross-check are crucial during egress. Allow the radar to work in RWS (ideally 10 NM scope) while checking 6 and setting formation. Do not try to bring radar immediately into the cross-check. It will take about 8 seconds for one search frame anyway, and your time is better spent clearing the visual arena. After the egress direction is set and 6:00 is cleared, bring the radar into the cross-check. If there are any threats on the 10 NM scope, target and react as required. If not, bump out to MRS and check the display. Any threats detected between 10 and 20 nm during the egress will be immediately displayed as target histories, but the elevation search volume displayed will be nearly double what it would have been had 20 NM scope been initially selected. Target any displayed threats, or set the Medium Range Search radar contract. Once the flight is well clear of the fireball(s), lead will direct the formation as appropriate.

4.7.7.9 Notch/Attack Contract. An element approaching a merge against a radar missile threat may execute a Notch/Attack game plan. The notching (SPIKED) F-16 assumes the DF role at notch entry, while the attacking (NAKED) F-16 assumes the EF role. Due to divergent flight paths, especially with longer notch ranges, both aircraft will likely lose visual mutual support. Regardless, positive deconfliction must be maintained by the EF. The EF may deconflict using both vertical and horizontal turning room. Lagging off of the adversary to arrive aft of the 3/9 line will build in separation from a DF pitching in and provide the range needed to employ a SOO. One technique is for the notching fighter to merge lower than the adversary altitude, and the attacking fighter to merge above. Realize that this alone is not sufficient to provide aircraft separation in a 3-dimensional fight. Establishing standards on default altitude separation can aid deconfliction responsibilities.

4.7.7.9.1 Spike Discrimination. The F-16 formation should fly in or attain a formation allowing spike discrimination. If both F-16s are spiked, “FLOAT” or “BRACKET” may be called or automatically executed to ensure the F-16s are outside the threat beam width. Spikes may not be the only indication of adversary SA. Aspect and altitude trends can also help determine adversary sort (awareness/targeted status). Ensure the direction of float does not drag the adversary radar through the untargeted fighter

4.7.7.9.2 Notching Fighter. The Notching fighter has DF status and should execute radar missile defense (RMD). Notch direction is generally away from the naked fighter, unless survival dictates otherwise. Notching fighters should communicate intentions “VIPER ONE, SPIKED NORTH, NOTCH 090." Priorities (in order) for the notching fighter should be:

- Fly optimum RMD as required for survival.

- If survival constraints allow, notch away from the element mate to ensure spike discrimination.
- Obtain tally on the threat.
- Maintain visual with the element mate.

After the notch is established, the Notching fighter should reference data link displays or initiate an IDT round to aid the element MS and to help maintain/regain the visual with the element mate. If still spiked and remaining in the notch until the expiration of notch timing or naked but still pursued by the threat, the DF will transmit a "(C/S) DEFENSIVE IN" at the pitch in. If the notching fighter loses the spike and pitches in early, the notching fighter calls "(C/S), NAKED, IN." The addition of a "PRESS" or "SUPPORTING" call relieves the attacking EF of deconfliction responsibilities and affects a role swap. A DF that goes naked and pitches in without the visual, adds BLIND with ANGELS, to the "NAKED, IN" call, and attempts to gain SA on the fight via visual search, radio, radar, Data Link, or A/A TACAN.

4.7.7.9.3 Attack Fighter. Depending on SA, the attack fighter has the option of continuing to the merge or notching to support the DF. In order to have the SA necessary to go to the merge, the attack fighter should have a tallyho and/or a sensor contact on the group. Time and range permitting, the attack fighter should be targeted to the adversary group using Bullseye or BRAA (e.g., "VIPER 2, TARGET LEAD GROUP, BULLSEYE 180, 12, 15 THOUSAND, SPADES") or Data Link (e.g. "VIPER 2 TARGET VIPER 1's TAD") format. If not directed, the attack fighter will still select a 20-NM scope, bracketing the altitude at the range and azimuth dictated. Upon finding the group, sort to flow to the group maximizing an offensive potential while ensuring no "belly-up" intercepts.

4.7.7.9.4 WVR Notch/Attack Execution.

4.7.7.9.4.1 Attack Fighter with Situation Awareness. The attack fighter with adequate SA from prior targeting, sorting, or tally can leave the formation and continue the intercept as the attacking fighter. Depending on the range from the adversary, acknowledge with or "(C/S) ENGAGED" or callsign only (e.g., "VIPER 2"). The attacking fighter's goal is completing the intercept and complying with all requirements to employ valid ordnance IAW ROE. The attacking fighter may have enough SA to direct the notching fighter to update the notch or execute a break or hard turn into the threat. If the notching fighter calls, "(C/S) NAKED IN, BLIND, ANGLES X", that is a request for further information in order to assume a supporting role. The naked fighter should continue the attack while providing the notching fighter with additional information about the pending merge (e.g. core information, altitude, angels, georef).

4.7.7.9.4.2 Pursuit Course. The attacking fighter's intercept should ensure adequate vertical and horizontal turning room. With a tally, consider completing the intercept covertly to increase the chances of remaining undetected. The attacking fighter's pursuit course (lead, pure, or lag) will determine aspect and subsequent ID range. Slight lag pursuit takes longest but preserves range for a WEZ or a valid ID.

Pure pursuit presents the adversary with the smallest chance of seeing the attacking fighter. Lead pursuit provides the quickest intercept but puts the attacking fighter slightly belly-up to the adversaries. Notch/Attacks begun at notch range will generally result in the attacking fighter, adversary, and notching fighter all merging near simultaneously. If the attacker uses lag pursuit, the notching fighter may merge first and make the ID call. A Notch/Attack initiated at decision range (DR), should allow the attacking fighter to ID and kill the threat before the threat achieves an IR missile WEZ on the notching fighter. Additionally, starting a Notch/Attack at DR retains an abort option for the notching fighter assuming mutual support requirements permit. (See **paragraph 4.7.7.9.5**, Abort/Attack).

4.7.7.9.4.3 Attack Fighter Without Situation Awareness. A attack fighter that reaches visual limits without achieving SA to target the adversary(s) turns in the same direction as the notching fighter to maintain element mutual support and assumes the SF role. If the attack fighter joining the DF in the notch is a wingman, the call is, “VIPER 2 CLEAN, SUPPORTING.” If the attack fighter is a flight lead, the call is simply, “VIPER 1 CLEAN, VIPER 2 PRESS.” While in the notch together, the trail fighter (SF) should strive for separation in range and altitude to decrease likelihood of adversary tallies. Some situations may result in the attack fighter becoming spiked. In this case, the attack fighter makes the appropriate “NOTCHING” call and should notch for survival. If this notch is in the same direction as the first notching fighter, the fighter now in trail is now responsible for deconfliction. An adversary that flies a pure pursuit attack on the notching fighter should cross the nose of the attack fighter. ACM slewable in the direction and altitude of the adversary may aid in detection and provide SA on one contact but is not a substitute for aggressive visual lookout to find all aircraft at the merge. ACM contracts are in effect at the merge. If the notching fighter becomes naked, the formation should simultaneously pitch-in towards the adversary in a bracket formation. If geometry would optimize a fan entry for weapons separation (reduced adversary aspect), then the flight lead will direct the wingman to “DEPLOY” when desiring a WEZ in depth (WID) formation at the merge. See **Table 4.14**, Notch Attack Comm Examples.

Table 4.14 Notch Attack Comm Examples.

Viper 1: "VIPER 1, TARGET BRAA 330/13, 15 THOUSAND," "VIPER 1 SPIKED NORTHWEST, NOTCH 230"
Viper 2: "VIPER 2, TARGETED"
Viper 1 loses the spike and pitches in to support
Viper 1: "VIPER 2, PRESS, VIPER 1'S NAKED IN LEFT 7, 3 MILES, LOW"
Viper 2: "VIPER 2, ENGAGED" OR "VIPER 2", (range/adversary intent dependent)
The assumption is that Viper 2 was targeted at range
Viper 1: "VIPER 1 SPIKED NORTHWEST, NOTCH 230"
Viper 2: "VIPER 2"
Viper 1 remains spiked and continues the notch
Viper 1: "VIPER 1's ANGELS 7, UPDATE 270"
Viper 2: "VIPER 2 TALLY ONE, ENGAGED HOSTILE, FLANKER"
Viper 1: "VIPER 1, DEFENSIVE IN, TALLY ONE"
Viper 2 lags off until visual
Viper 2: "VIPER 2, FOX-2"
Viper 1: "VIPER 2, TARGET BRAA 330/13, 15 THOUSAND, BOGEY." "VIPER 1 SPIKED NORTHWEST 230"
Viper 2 is unable to target the group and turns to flow with lead
Viper 2: "VIPER 2, CLEAN, SUPPORTING"
Viper 1 loses the spike and pitches in
Viper 1: "VIPER 1's TALLY ONE, NAKED IN, VIPER 2, BRACKET RIGHT"
Viper 1 sees the bogey leaning towards Viper 2
Viper 1: "VIPER 2, PRESS"
Viper 2: "VIPER 2, ENGAAGED, TALLY ONE"
At the merge
Viper 2: "VIPER 2, HOSTILE, FLANKER"
Viper 1: "VIPER 1, FOX-2"... "VIPER 2, BUGOUT NORTH, VISUAL RIGHT 3, 20 LOW"
Viper 2: "VIPER 2, VISUAL"
Original Roles are restored
UNCLASSIFIED

4.7.7.9.5 Abort/Attack. This gameplan differs from a Notch/Attack in that the spiked fighter executes an abort while the attack fighter continues the attack. The spiked fighter may notch at DR and subsequently abort or execute an immediate abort at minimum abort range (MAR). The notching fighter assumes the DF role until the abort while the attacking fighter assumes the EF role. At the "ABORT" call the EF is relieved

of deconfliction duties. Detached mutual support and positional SA is maintained via datalink, GCI, and A/A TACAN and comm. See **Table 4.15**, Abort/ Attack Comm Examples.

Table 4.15 Abort/Attack Comm Examples.

Abort/Attack with DR Notch to Abort
Viper 1: "VIPER 2, TARGET VIPER 1's TAD" "VIPER 1 SPIKED NORTHWEST, NOTCH 230"
Viper 1 is DF
Viper 2: "VIPER 2, TARGETED"
Viper 1 remains spiked and aborts
Viper 1: "VIPER 1, ABORTING 180"
Viper 2 is relived of deconfliction responsibilities
Viper 2: "VIPER 2 ENGAGED, BULLSEYE 180, 12, 13 THOUSAND, TALLY ONE"
Viper 2: "VIPER 1, PITCHBACK"
Viper 1 pitches back, picks up tally on the fight, but cannot determine ID
Viper 1: "VIPER 1, NAKED IN, TALLY 2, EAST/WEST, STATUS"
Viper 2: "VIPER 2 IS WEST"
Viper 1: "VIPER 2, PRESS"
Abort/Attack MAR to Abort
Viper 1: "VIPER 2, TARGET BRAA 330/13, 15 THOUSAND."
Viper 2: "VIPER 2, TARGETED"
Viper 1: "VIPER 1, ABORTING 160"
Viper 2: "VIPER 2"
Viper 2: "VIPER 2 ENGAGED, BULLSEYE 180, 12, 13 THOUSAND, TALLY TWO"
Viper 2 runs an excessively cold intercept which delays VID until Viper 1 MUST pitch back due to fuel, MEZ, flow requirement, etc.
Viper 1: "VIPER 1 SPIKED NORTHWEST, NOTCH 050"
Viper 1 is now the DF, Viper 2 must deconflict
Viper 2: "VIPER 2, BLIND, ANGELS 14, THREE-MILE TAILCHASE"
Viper 1: "VIPER 1, DEFENSIVE IN, TALLY"
At the merge
Viper 1: "VIPER 1, HOSTILE FULCRUM"
Viper 2: "VIPER 2, FOX 3 EASTERN" . . . etc.
UNCLASSIFIED

4.7.7.9.5.1 Aborting Fighter. Abort away from the attack fighter, unless survival dictates otherwise. The abort fighter should communicate intentions "VIPER 2,

ABORTING 090." After the abort is established, the aborting fighter should initiate an IDT round and/or tag his element mate with data link (if available) for situational awareness and visual pick-ups once a pitchback is initiated. If the aborting fighter is still spiked after the merge occurs with the EF, continue to run cold until a pitchback is warranted. In this situation, it is important for the aborting fighter to stay outside of a WEZ.

4.7.7.9.5.2 Pitchback Decision. Consider the following:

- Has the EF has transitioned to a defensive status
- Directive to pitchback by the EF
- Number of bandit's EF is anchored with
- Proximity of next nearest threat to element / additional threat inside FR

4.7.7.9.5.2.1 Aborting fighter naked. The aborting fighter attempts to assume the SF role upon pitchback. The aborting fighter calls "(C/S) NAKED IN." If the aborting fighter calls, "(C/S) NAKED IN, BLIND, ANGLES X", that is a request for further information in order to assume a supporting role. The naked fighter should continue the attack while providing the pitchback fighter with additional information about the merge (e.g. core information, altitude, angels, geographical reference).

4.7.7.9.5.2.2 Aborting fighter spiked and continuing cold is not possible. In this case, the aborting fighter initiates a notch, assumes the DF role, and executes IAW the notch/attack section **paragraph 4.7.7.9.2**, Notching Fighter.

4.7.7.9.5.3 Attack Fighter. Depending on SA, the attack fighter has the option of continuing to the merge or aborting to maintain mutual support with the spiked fighter. With the exception of pursuit course, naked fighter considerations are the same as described in **paragraph 4.7.7.9.3**, Attack Fighter, and **paragraph 4.7.7.9.4.1**, Attack Fighter with Situation Awareness.

4.7.7.9.5.3.1 Abort/Attack Pursuit Course. Abort/attack allows more latitude in choosing pursuit course than notch/attack. The attacking fighter's pursuit course (lead, pure, or lag) will determine aspect and subsequent ID range. Lag pursuit takes longest but preserves range for a WEZ or a valid ID. Pure pursuit presents the adversary with the smallest chance of seeing the attacking fighter. Lead pursuit provides the quickest intercept but puts the attacking fighter slightly belly-up to the adversaries. Abort/Attacks executed no later than MAR will generally result in the attacking fighter merging with the adversary(s) with the aborting fighter established approximately 6-9 nm distance from the merge.

4.7.7.10 Air Combat Maneuver in Multiple Adversary Scenarios. All of the ACM contracts still apply, but there are several more considerations. If more than one adversary survives the initial merge, the element must aggressively maneuver to quickly kill the adversaries. It is imperative for the SF to rapidly assess and take SOOs, while retaining deconfliction responsibilities. The SF must not sacrifice supporting responsibilities unless directed or required to prevent becoming defensive. However, one of the supporting responsibilities is to engage other factor adversaries. If the SF is forced to maneuver

against an additional adversary in the same visual merge, it is possible to have two 1v1 engagements in close proximity. The SF must communicate this immediately with a split and possibly an engaged call with reference to the additional adversary. In this scenario, there can be two engaged fighters within visual range (WVR), both flying their best BFM to kill their bandit. Ideally, at least one of the fighters will be visual and able to deconflict. Since there is not a clearly defined SF to ensure flight path deconfliction, the responsibility rests upon both EFs. Additionally, both fighters must remain alert for SOO into the other fight, as well as shots from the other bandit.

4.7.7.11 Four-Ship ACM Considerations. With one element adhering to the ACM contracts, another element can flow to support the engagement. This element will assume the supporting role.

4.7.7.11.1 ACM role hierarchy within a 4-ship. One element is engaged with an adversary group. Within that engaged element there are DF, EF, or SF roles with contracts already described. The supporting element (SE) lead must ensure the SE deconflicts from all fighters in the engaged element and from the adversary(s).

4.7.7.11.1.1 Engaged Element. This is the element that is actively engaged. This element probably cannot deconflict with any other blue fighters and execute its ACM roles as an element. The engaged element's responsibility is to fly their best 2vX ACM to kill and survive. With a SE present and sanitizing the surrounding airspace, the SF within the engaged element may be able to place increased priority on assisting the EF killing the bandit(s) and less on sanitizing.

4.7.7.11.1.2 Supporting Element Lead. The SE lead is responsible for deconflicting the SE. The SE wingman will probably be unable to fly formation, keep tally and visual on all players and ensure deconfliction from them all. Thus, the SE lead takes full responsibility or he keeps his element out of the fight until he can. The supporting element lead may have to perform several tasks at once while avoiding the threat and must clearly understand the responsibilities and priorities. The SE lead's priorities will change depending on the engaged element's status. The SE lead's responsibilities are:

- Maintain visual and ensure flight path deconfliction between his element, the engaged element, and the adversary(s).
- Maintain tally and do not become defensive.
- Maneuver for a shot of opportunity (SOO).
- Sanitize the area around the flight.
- Engage other factor threats.
- Maintain overall SA to include sanitizing for additional threats; monitoring fuel and weapons state; and looking for separation opportunities.
- Direct the bugout and subsequent 4-ship reform.

4.7.7.11.1.3 Supporting Element Wingman. The wingman's roles are unchanged from basic tactical formation responsibilities. In the case where the SE wingman has higher SA than the SE lead, the SE lead may consider assuming the deconflic-

tion duties within the element ("VIPER 4, PRESS"). SE wingmen must understand that this new deconfliction contract applies only within their element and does not authorize the SE wingman to enter the mature fight without ensuring positive deconfliction from all members of the engaged element.

4.7.7.11.1.4 Supporting element actions.

4.7.7.11.1.4.1 4-ship merge. If the SE is in a position to take immediate shots, do so. Otherwise, if AMR permits, the SE's best course of action is to maneuver to maintain adequate separation from the engaged element to visually sort the furball and employ shots prior to minimum range.

4.7.7.11.1.4.2 Approaching a mature furball. If comm allows, inform the engaged element that you are approaching the fight and determine their status. Take SOO if able and avoid turning in the furball. Be ready to direct the 4-ship egress and call the visual for the engaged element to follow. With one element adhering to the ACM contracts, an additional element can flow to support the engagement. This element will assume the supporting role. In this situation, there may be a defensive fighter, engaged fighter, and a supporting element.

4.7.7.11.2 4-ship defensive break. The defensive 4-ship is a worst-case deconfliction scenario that challenges deconfliction discipline. This is a "target-rich environment" for the adversary, with an accompanying compelling requirement to kill the adversary as soon as possible. Contracts for establishing DF status are unchanged from the element ACM discussion (the fighter receiving a directive break call is the DF unless otherwise specified). However, EF and SF(s) must pay strict attention to deconfliction, both from the DF and from each other. The nature of our formations and the natural manner an aware adversary would tend to attack them often allows for the DF and EF to be within the same element. In this case, absent further comm, the remaining element assumes the supporting role with the SE wingman deconflicting from the SE flight lead. When in doubt as to deconfliction, default to the basic contracts of wingmen deconflicting from flight leads, #3 element deconflicting from the #1 element, and the trailing fighter in a break turn deconflicting from the fighter in front. Immediate directive comm is needed to establish roles and get the flight moving before the adversary can exploit confusion. For example, Viper 1 might call "VIPER 2, BREAK RIGHT, BOGEY RIGHT 5, 2 MILES. (pause) "VIPER 1's ENGAGED, VIPER 3 SUPPORTING." If the situation does not precisely fit a prebriefed situation use plain english, for example, Viper 3 might call "VIPER 2, BREAK RIGHT, BOGEY RIGHT 5, 2 MILES. (pause) VIPER 3's ENGAGED, VIPER 4, DECONFLICT FROM VIPER 1 and 3." In this example, Viper 2 is the DF, Viper 3 is the EF, and Viper 1 and 4 are SFs. Everyone deconflicts from Viper 2, Viper 1 deconflicts from Viper 3, and Viper 4 deconflicts from everyone.

4.8 Tactical Intercepts. An intercept is the series of maneuvers, which places the aircraft in a position to employ a weapon, make a visual identification (VID), or to initiate a visual engagement. The fighter pilot can use a combination of on-board systems, ground or airborne weapons directors (WD) and dead reckoning (DR) to achieve this result. The tactical decision to "commit" to an intercept is based on guidance and criteria established in Mission Planning

Manual (MPM). The type of intercept geometry is based on experience, proficiency, avionics, weather, night/day, electronic countermeasures (ECM), and type of target aircraft, Command and Control (C^2) level, and other tactical considerations. This section will review intercept basics and the single side offset (SSO) intercept. Some tactical considerations are also discussed; however, reference to MPM is necessary for a complete understanding of tactical intercepts.

4.8.1 Intercept Concepts. In the F-16, the intercept problem involves using the radar to detect a specific target, then flying to arrive at a position from which the target can be identified (if required) and weapons fired. (See **Figure 4.97**, Baseline Intercept.) To achieve this, the fighter pilot must accomplish these tasks:

- Detect the target
- Close on the target.
- Establish identification (may be a continuous process).
- Acquire sufficient displacement from the target (room for the conversion turn) if a beam or stern conversion is required.
- Go pure pursuit.
- Obtain a tally (if required).
- Establish a VID, if required.
- Maneuver to weapons parameters.

4.8.2 Intercept Terminology. A thorough knowledge and understanding of BFM principles and geometric terms will aid in intercept execution.

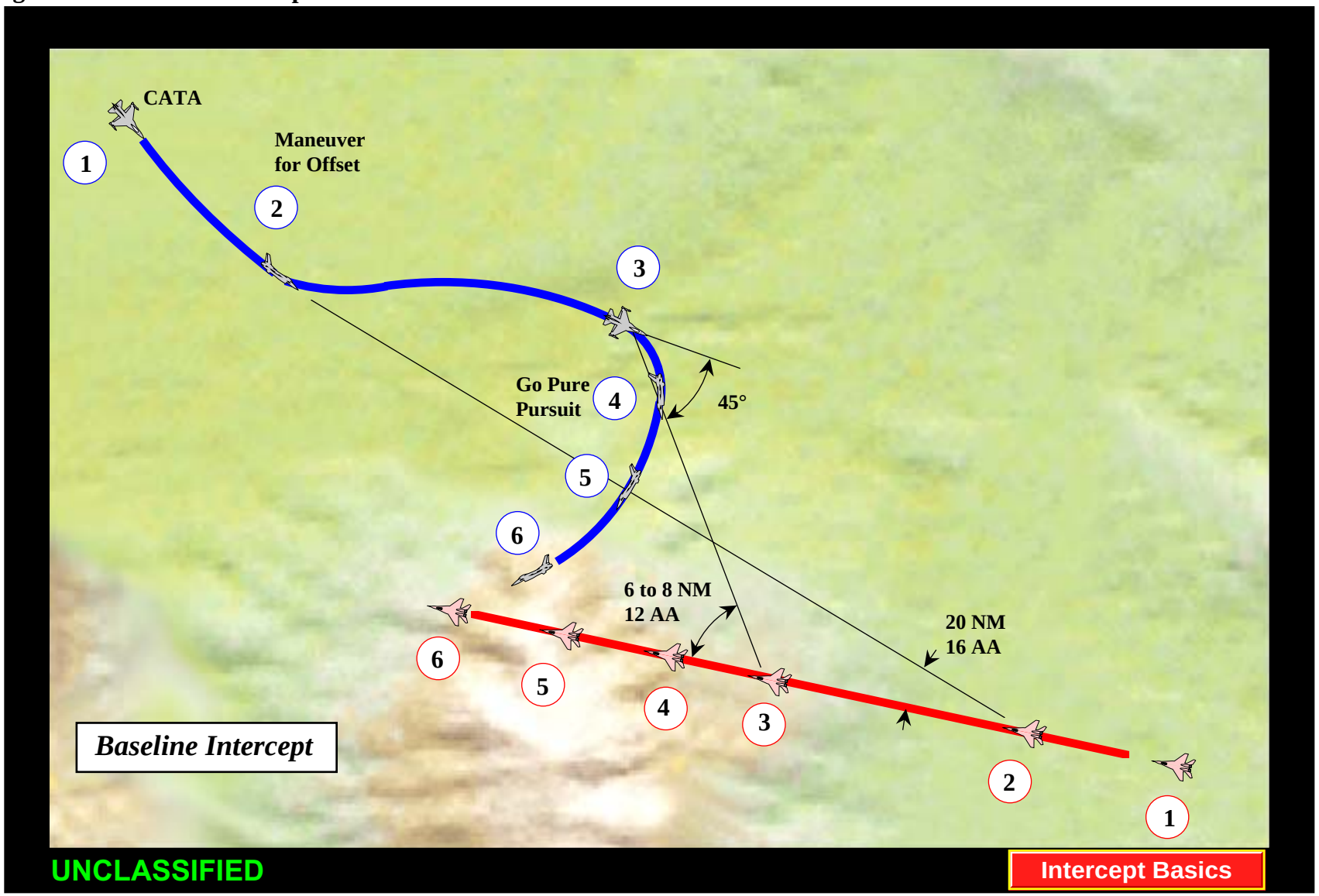
4.8.2.1 Baseline Intercept. The baseline is a technique for accomplishing an intercept. This is the foundation upon which more complicated tactical game plans are built.

4.8.2.2 Tactical Single Side Offset (SSO) Intercept. This is an intercept option that takes earlier lateral and greater vertical offset than the baseline, in an attempt to decrease the chances of the fighters being detected by the threat.

4.8.2.3 Aspect Angle (AA). The angle between the longitudinal axis of the target (projected rearward) and the LOS to the fighter, measured from the tail of the target. The fighter's heading is not a consideration. (See **Figure 4.3**, Positional Geometry.)

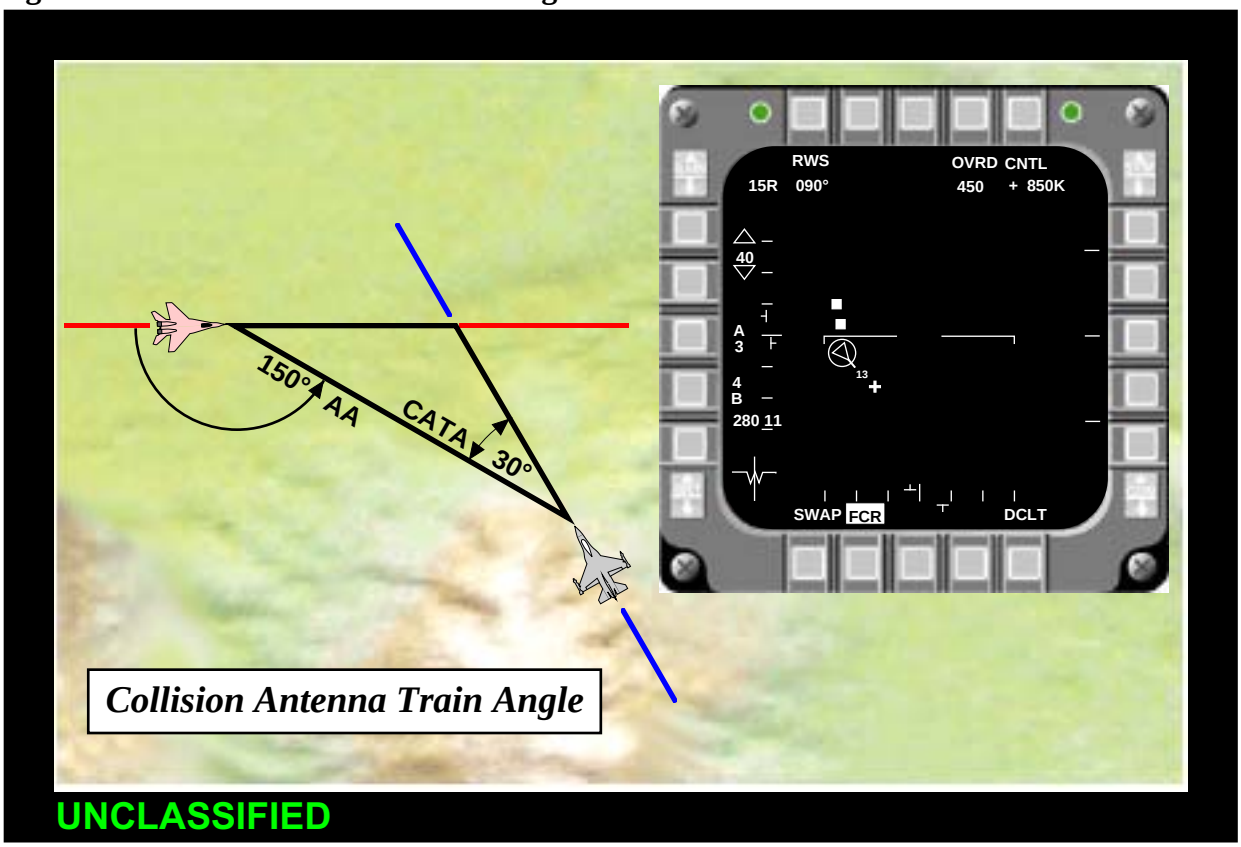
4.8.2.4 Antenna Train Angle (ATA). This is the angle between the nose of the fighter and the radar LOS to the target. ATA is referenced in degrees left or right of 0-degree azimuth on the MFD. (See **Figure 4.3**, Positional Geometry.) Said another way, ATA is the number of degrees the target is off the boresight of the fighter.

Figure 4.97 Baseline Intercept.



4.8.2.5 Collision Antenna Train Angle (CATA). CATA is the azimuth of the radar antenna when tracking a target that is on a collision course with the fighter. This is the fighter's quickest route to an intercept/collision with the target. A target on a collision course drifts straight down the MFD. Its azimuth never changes. An easy way to determine CATA for a co-speed target is to subtract AA from 180 degrees. For example, the CATA for a target with a 150-degree AA is 30 degrees (180 to 150 degrees). Angular relationships are shown in **Figure 4.98**, Collision Antenna Train Angle.

Figure 4.98 Collision Antenna Train Angle.



4.8.3 The Baseline Intercept. The baseline intercept has the advantage of making the merge happen about as far away from the commit point as possible and still achieve a stern conversion with mild enough maneuvering to do it in IMC. The baseline provides almost no concealment from a radar equipped adversary, but is a good choice when intercepting a non-radar-equipped target. This section will provide a very basic and simple review of the baseline intercept. For this discussion, it is assumed that the intent is to acquire some turning room (offset) to complete a conversion turn to the target's beam or stern. There are five steps in the baseline intercept.

4.8.3.1 Step One: Detect and close on the target. The easiest method of getting on the CATA requires the radar to track the target (single target track [STT], situation awareness mode [SAM], or track-while-scan [TWS]). Simply turn toward the intercept steering symbol, or steering cross, until it is centered at 0-degree azimuth. The target is on the CATA when the cross is centered. Some target aspects and speeds will not allow CATA steering

without gimballing the contact-do not gimbal. The simplest approach for range to turn from CATA is to use 20 NM. Longer ranges are often used when target aspect is high (160 to 180 degrees) or when dictated by the tactical situation. Shorter ranges could be used when initial aspect is lower if the situation allows.

4.8.3.2 Step Two: Gain Altitude Separation and a Speed Advantage. Vertical offset, or vertical turning room, can actually be obtained as soon as you know target altitude (could be from offboard sources such as your WD). An altitude delta of 1,000 feet for each 1 mile from the target will keep you off the horizon and increase target aspect to assist in VID at merge. A pure vertical stern conversion requires 8,000 to 10,000 feet from below or 5,000 to 7,000 feet from above. The following advantages of an altitude split may or may not apply to each situation:

4.8.3.2.1 Advantages:

- To get out of adversary radar coverage vertically.
- To use the ground clutter to help hide from the adversary radar.
- To get the most favorable background to pick up the adversary visually.
- To get the most favorable background to hide your aircraft visually.
- To get an energy advantage.
- To hide in the adversary's blind areas.
- To reduce the horizontal turning room required; makes you less susceptible to a maneuvering target.

4.8.3.2.2 Disadvantages:

- Radar antenna elevation control is more difficult at high look-up/look-down angles.
- If your radar breaks lock, it is harder to reacquire the target at closer ranges due to rapid vertical LOS rates.
- It is easier to lose radar contact during a no-lock intercept due to rapid vertical LOS rates.

4.8.3.2.3 Airspeed. A good ROT for speed advantage is to have a 150 KCAS advantage if coming from below, and 50 to 100 KCAS advantage if coming from above. These ROTs are for medium altitude and may have to be adjusted for high-altitude intercepts.

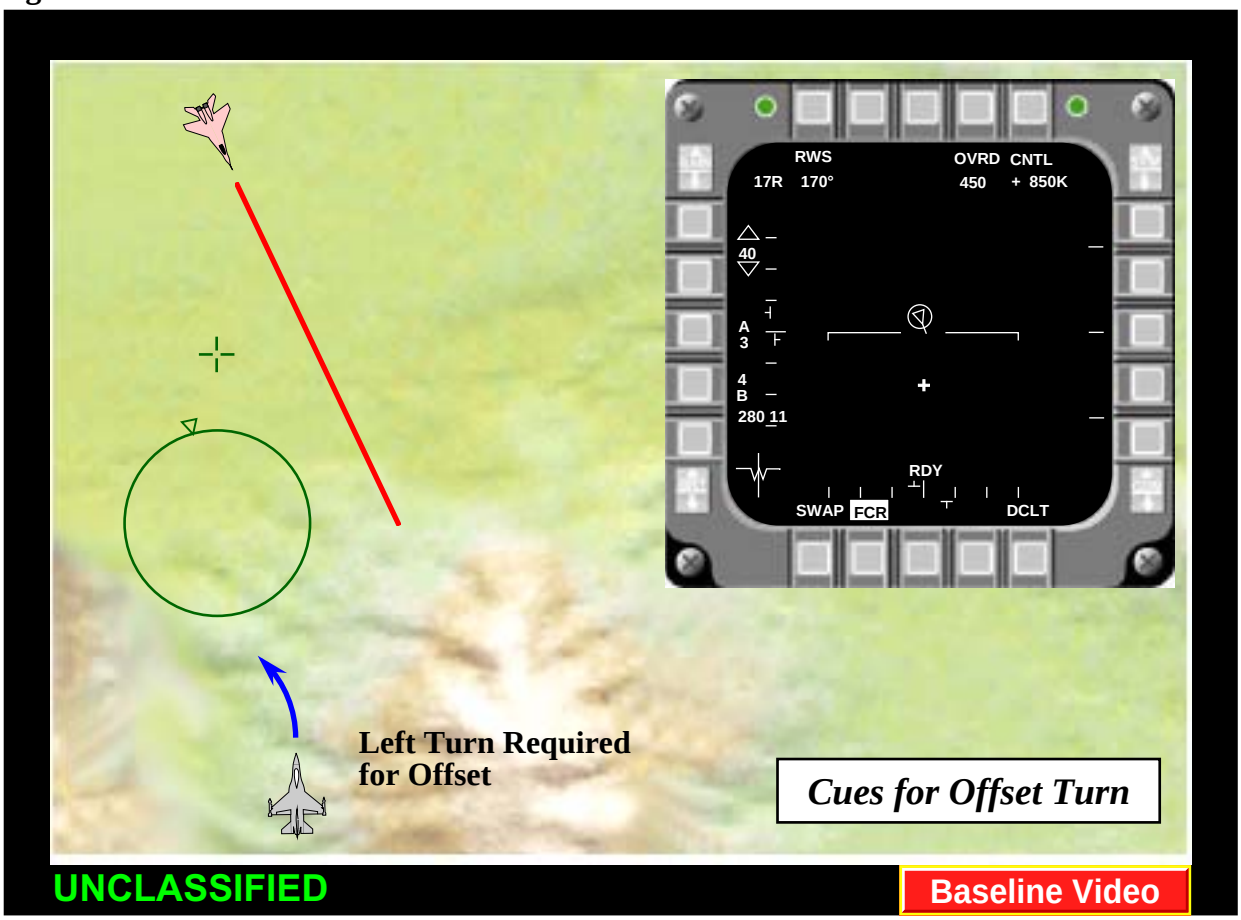
4.8.3.3 Step Three: Offset at 20 NM. Getting horizontal offset or horizontal turning room, requires analysis of the target AA. The AA is most easily read from the MFD, although the aspect symbol in the HUD is also useful. Remember, the offset range may vary according to the situation but 20 NM should be the minimum used for a horizontal conversion from high aspect.

4.8.3.3.1 High Aspect. If AA is more than 120 degrees, turn to displace the target 10 to 50 degrees off the nose (10 to 50 degrees from the center of the MFD). The larger offset is used at higher aspects, and the smaller offset is used at lower aspects. An additional technique is to limit total displacement (total of target and fighter ATA) to

60 degrees. (See **Figure 4.99**, Cues for Offset Turn.) Determine which way to turn and refer to the following:

- If aspect says “right” (e.g., 16R), turn to put target on the right side of the MFD.
- Assuming lead or pure pursuit was held prior to the turn: look at the aspect caret in the HUD. If it is right of center, turn right, and if it is left of center, turn left.
- Look at the aspect readout in the MFD. Turn opposite of the letter at the end of the aspect readout (e.g., if the aspect says “15R,” turn “L” or left).

Figure 4.99 Cues for Offset Turn.



4.8.3.3.2 Holding Offset. Once offset is established, the target will drift further towards the edge of the MFD and bank into the target will be required to maintain the offset on the scope. The drift rate will increase as range and aspect decreases. During this phase, avoid gimballing the target off the scope (and losing contact) by reference to the HUD TLL. Avoid letting the TLL exceed 50 degrees.

4.8.3.3.3 Beam Aspect. If initial AA is 120 degrees or less, remain as close to the CATA as possible without gimballing and proceed to subsequent steps of the Baseline intercept.

4.8.3.4 Step Four: Monitor Aspect. Provided the target does not maneuver, AA will decrease continuously after the fighter has taken the correct horizontal offset. As the aspect

approaches 120 degrees the offset may be reduced. If 120 degrees aspect is reached beyond approximately 10 NM, CATA is necessary to prevent the aspect from decreasing further. An increase in AA means the target is turning into the fighter. A rapid decrease in AA means that the target has turned away.

4.8.3.5 Step Five: Go Pure Pursuit. Once desired turning room has been achieved, pure pursuit should be established in anticipation of target visual. A stern conversion turn using pure pursuit from 120 degrees aspect and 6 to 8 NM can be conformably employed even during night and IMC intercepts. Other aspect and range combinations may be used in tactical situations to achieve other desired effects. Pure pursuit will yield a stern conversion if commenced with 150 AA at 20 NM, 140AA at 14 NM, 130AA at 10 NM. No matter what the aspect, go pure pursuit no later than 5 NM. Pure pursuit takes extra advantage of F-16 avionics and small size. Use the HUD TLL to bring the target into the HUD FOV. During conversion from 120-degree aspect and 6 to 8 NM, at 3 to 4 NM range there should be approximately 90 degrees remaining to turn. The fighter may already have a tally and be in parameters for a missile shot. When a higher aspect merge is desired, the SSO 120-degree aspect and 6 to 8 NM will be modified to use pure pursuit at higher aspects at longer ranges. Use BFM as required to maneuver into weapons parameters.

4.8.4 Tactical Single-Side Offset Intercept. Offset is taken at 30 to 40 NM along with 10,000 feet or more vertical offset. Initial offset may even take the target location off the F-16 radar scope. If using this option, remain oriented via WD comm, and turn in to bring the target back into the radar FOR between 20 and 30 NM. The objective is to get out of the enemy's radar field of regard (FOR) prior to the enemy detecting you. Then, the fighters can go pure pursuit much earlier and fly into the same basic final conversion window as was used in the baseline. A good early SSO began at 40 NM and 180 AA against an unaware group will yield a 150 AA by about 20 NM. Pure pursuit can be used for the remainder of the intercept and the final conversion window of 120 AA at 6 to 8 NM will be achieved. (See **Figure 4.100**, Tactical Single Side Offset.)

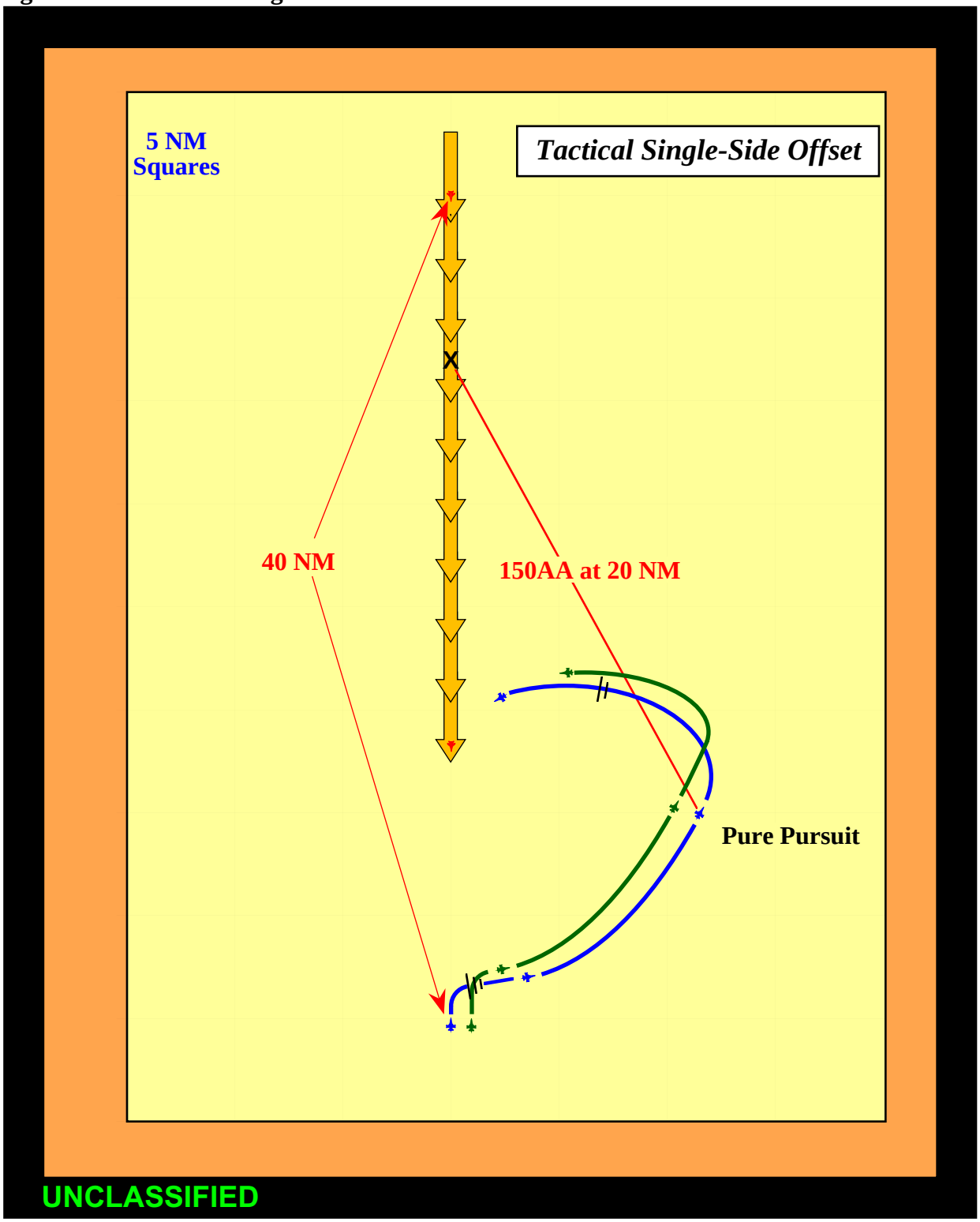
4.8.4.1 Early SSO Advantages:

- Minimizes enemy detection probability.
- Minimizes chance of being committed on if the enemy does detect you (your low aspect at long range may not meet their commit criteria).
- Provides very early indications of enemy awareness [they must turn toward you well outside your intercept abort ranges or risk gimballing you. This allows assessment of their awareness level prior to reaching minimum abort range (MAR)].

4.8.4.2 Early SSO Disadvantages:

- Requires off-board C^2 support versus small RCS targets (you will not have contact until too close to execute the option).
- Compared to the Baseline, results in a merge point closer to the point from which the intercept commenced (merge may be too close to the point being defended).

Figure 4.100 Tactical Single Side Offset.



4.8.5 Intercept Responsibilities and Contracts. The rest of this chapter deals with search, target, sort, formation and flow contracts the flight uses as a team to survive and kill in the intercept environment. These intercept contracts deal primarily with our actions in the BVR

arena, and allow a seamless transition to WVR using the Fan, Bracket, Notch/Attack, and Notch/Abort contracts from the ACM section above.

4.8.6 Fire Control Radar Contracts. This section assumes APG-68 use. This search game plan is the basis for all F-16 A/A tactics; therefore, its importance cannot be overemphasized.

4.8.6.1 Altitude Search. The briefed altitude search responsibilities ensure that an adequate vertical volume of airspace is sanitized at designated ranges. All flight members must exercise discipline and follow their search responsibilities. It is necessary to search and sanitize each altitude block to guard against undetected attack. Normally, wingmen must not abandon their assigned search block until they meet the briefed targeting responsibility or they are directed by the flight lead. It is imperative that flight leads keep track of wingman's search responsibilities and reallocate as required to avoid unsanitized airspace.

4.8.6.2 Long-Range Search (LRS). Assuming previously sanitized airspace, initial search, detection, and targeting employs LRS techniques using RWS with 80-/40-NM range scale, ±60 degrees, and 4-bar elevation. The importance of adhering to search discipline and covering the entire altitude block at expected contact range cannot be overemphasized. One example of setting LRS responsibilities is to have Number One and while Number Two and Number Three search 15,000 feet MSL and up. Assuming a cursor correlation range (CCR) of 30 NM, the low search covers surface to 36,000 feet MSL, while the high search covers 15,000 feet MSL to 51,000 feet MSL.

4.8.6.3 Medium-Range Search (MRS). Recommit or short-range commit situations employ a 15-NM CCR with ±60 degrees search and 4-bar. Scope range is 20 NM, with a transition to LRS after two complete 4-bar scans (two frames per 15 seconds) if no threats are detected. From the previous example, search responsibilities remain the same. For known threats within 20 NM, ensure bogey altitude is bracketed.

4.8.6.4 Short-Range Search (SRS). SRS is usually employed in four instances: when coming out of a Notch against a known threat, when exiting a merge lAW the tactical flow plan, during an uncorrelated spike reaction, and during ridge crossings. ACM or a 10-NM scope can be used. ACM will provide a heads-out lock without a sort. Take care to avoid buddy spikes. A 10-NM scope requires heads-down time but allows selective targeting/sorting and avoids buddy spikes. Remain in a 10-NM scope at least one complete frame (8 seconds) after setting your altitude responsibility before transitioning to MRS.

4.8.6.5 Search Techniques. Threat type, threat range, and wingman capability drive techniques. Frequent cross-checks of altitude coverage at CCR and ranges inside CCR will ensure proper long-range and short-range altitude coverage. Use search altitude display (SAD) cuts to adjust elevation strobe position around groups.

4.8.6.6 Sampling. Sampling target formations should be consistent with intercept closure and the need to develop a radar picture prior to targeting. Using RWS data/SAD to determine intercept flow maximizes AOR sanitization. Sampling implies looking at or locking a particular group to receive accurate information on the group for short periods of time. Avoid long-range locks unless specific information is needed or AIM-120 employment is imminent. Long-range locks tie up the radar, may trigger enemy RWR or EA, and could reduce radar SA on additional groups. Sampling in SAM provides information on one tar-

get and allows for the search of additional groups but may still trigger enemy RWR/EA. SAD can be used for altitude estimates with digital bullseye for position. Using TWS will enable radar sampling while maintaining SA on other aircraft but is very limited in azimuth coverage and has problems accurately tracking maneuvering aircraft. Based on closure, stop sampling early enough to build radar SA for the targeting phase. After sanitizing AORs, concentrate on adjusting elevation coverage to ensure adversary formations remain within the radar coverage.

4.8.6.7 Radar Interpretation. To target properly, accurately identify and label pictures using standardized comm format. For example, a range formation flying nearly perpendicular to the aircraft's course may appear on the radar as a azimuth. **Figure 4.101**, Standard Radar Pictures, give examples of common adversary formations and comm.

4.8.6.8 Sort Technique. Once a group is detected, determine its numbers and formation. Threat formations may be difficult to break out on the radar at desired sort ranges. Spotlighting the group can enhance a group breakout and determine proper sort. Additional techniques to determine formation and sort/lock the appropriate target are ACQ symbol positioning, RWS/TWS expand, and visually sorting the group at the merge.

4.8.6.9 Lock-On ACQ Symbol Positioning. Command a brief (1- to 2-second) spotlight while placing the center of the ACQ symbol over the contact you wish to lock but biased away from any undesired contact. The radar will attempt to lock the closest return to the center of the cursor position. (See **Figure 4.102**, SAM/STT Lock-On Technique.)

4.8.6.10 Expand. If a SAM-bugged target is obscuring another contact, an option is to select RWS/TWS expand to separate contacts and achieve the sort. Once sorted, deselect expand. However, in order for expand to be useful, there must be multiple radar contacts on the scope before going to expand, not just one contact If there is only one contact in RWS/TWS, there will only be one contact in expand.

Figure 4.101 Standard Radar Pictures (1 of 2).

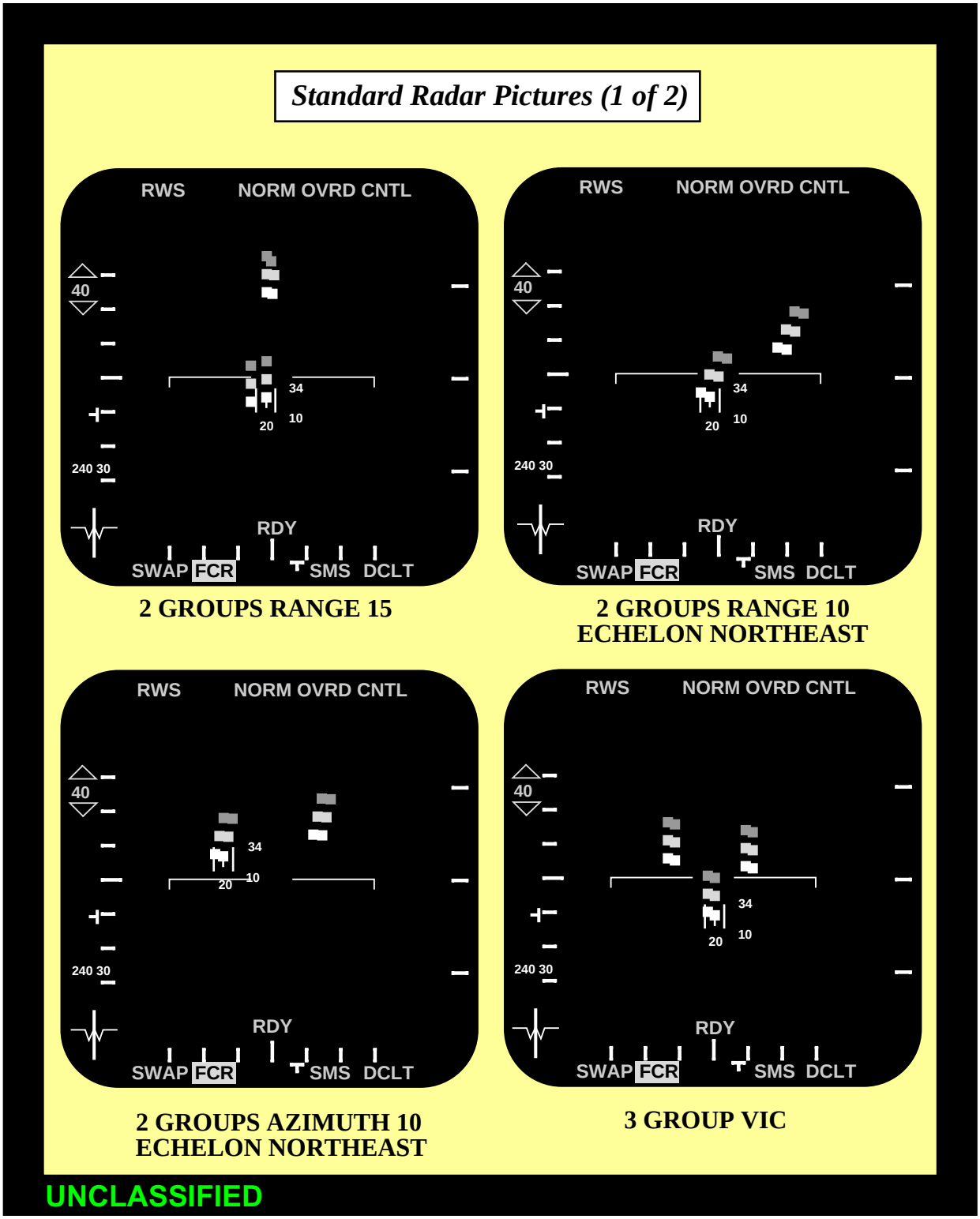


Figure 4.101 Standard Radar Pictures (2 of 2).

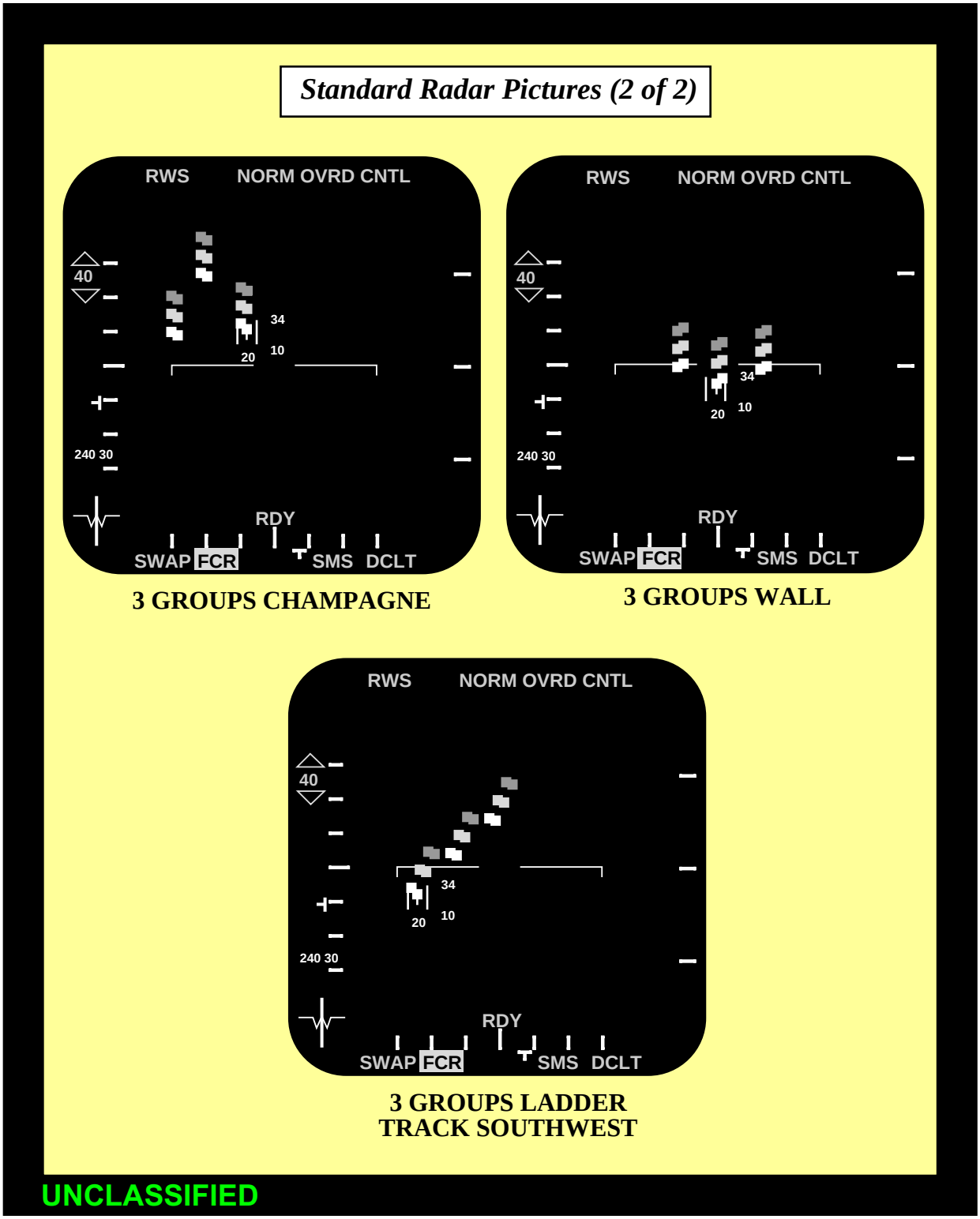
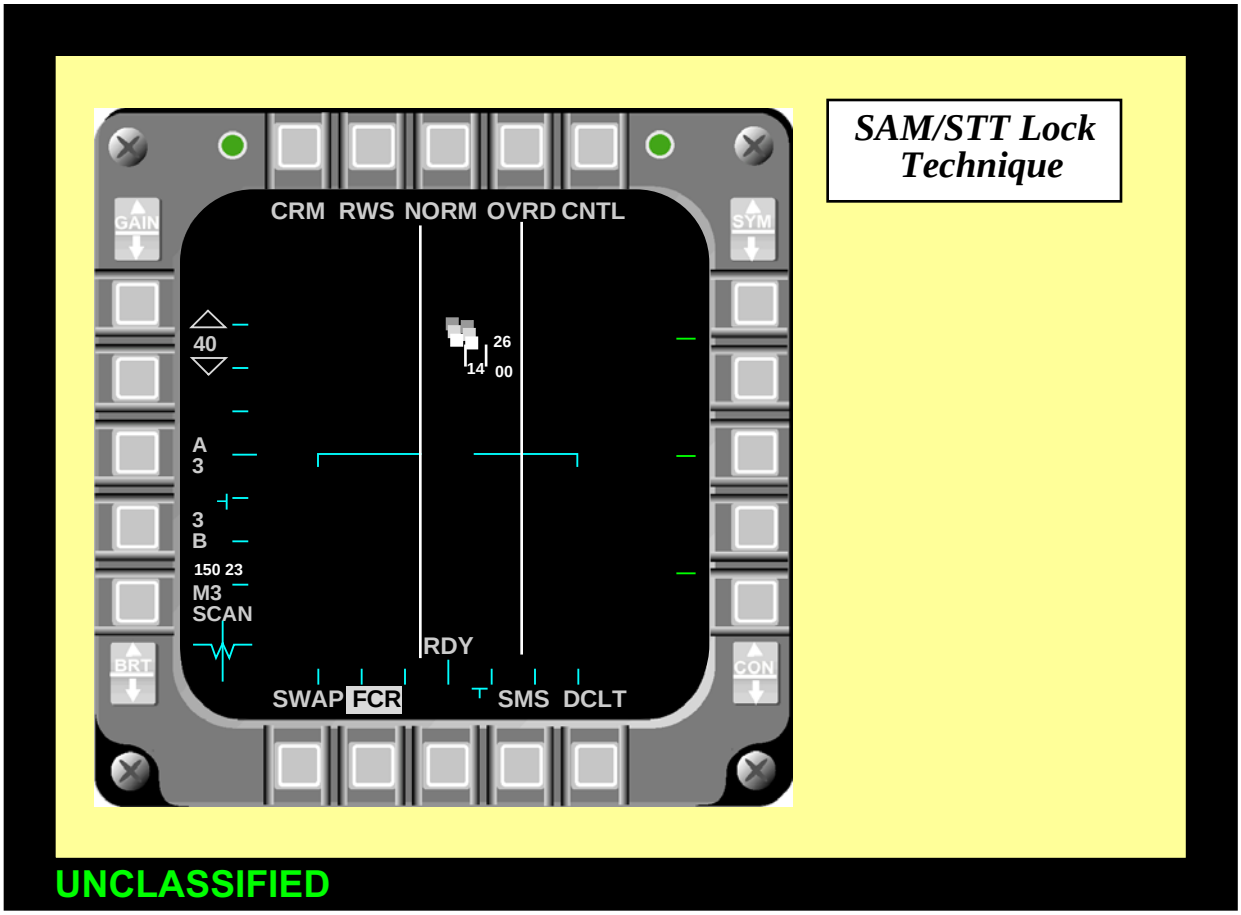


Figure 4.102 SAM/STT Lock-On Techniques.



4.8.7 Air-to-Air Tactical Execution Ranges. Reference the AEM for a more detailed discussion of the following concepts. These definitions are included here to facilitate the subsequent discussion of targeting plans, not as a substitute for classified tactics manual study.

4.8.7.1 Picture Range. Picture range (PR) is the range at which fighters want GCI or AWACS to assist flight execution by either re-labeling the picture if it has been previously labeled, or providing core bullseye information for all groups to include IDs if they have not met labeling criteria. PR will vary based on the given tactic.

4.8.7.2 Targeting Range. Targeting range (TR) is the range from the nearest group where the fighters assign or accept responsibility for groups. Targeting Range is a pacing tool for flight leads to weigh the reduction of sanitization versus high fidelity radar information. TR should be far enough to allow for execution of the tactic and allow targeting to occur outside of shot doctrine ranges.

4.8.7.3 Targeting Depth. Targeting depth (TD) is the maximum distance from the leading edge of a targeted group that a flight member can expect to target. Beyond this range, GCI/AWACS owns targeting responsibility.

4.8.7.4 Shot Depth. Shot depth (SD) is the maximum range behind the closest group within which trailing groups will be shot IAW the briefed Shot Doctrine. SD will vary based on the tactic being executed (Skate, Short Skate, Banzai) as well as the expected

range which shots may be taken (threat RCS, ownship altitude and airspeed).

4.8.7.5 Factor Range. Factor range (FR) is normally used when a visual merge is the planned end state of the intercept. FR is the minimum acceptable distance between the group being merged with and another group. Select FR so groups outside of this range are unlikely to affect the merge with the targeted group. FR should allow engaging and killing the targeted group, egressing tail aspect to the second group, and remaining outside that group's maximum stern WEZ. In determining FR, consider the adversary WEZ and expected adversary SA. If the adversaries are expected to be aware and some turning may be required with the targeted group, the flight lead should increase FR. Conversely, if the adversaries are expected to be unaware or non-proficient, the flight lead can set a smaller, more aggressive FR. Additional FR considerations are inner-group formation, acceptable level of risk (ALR), and F-16 missile load. Example FRs below assumes approximately 360 degrees of turning with the targeted group:

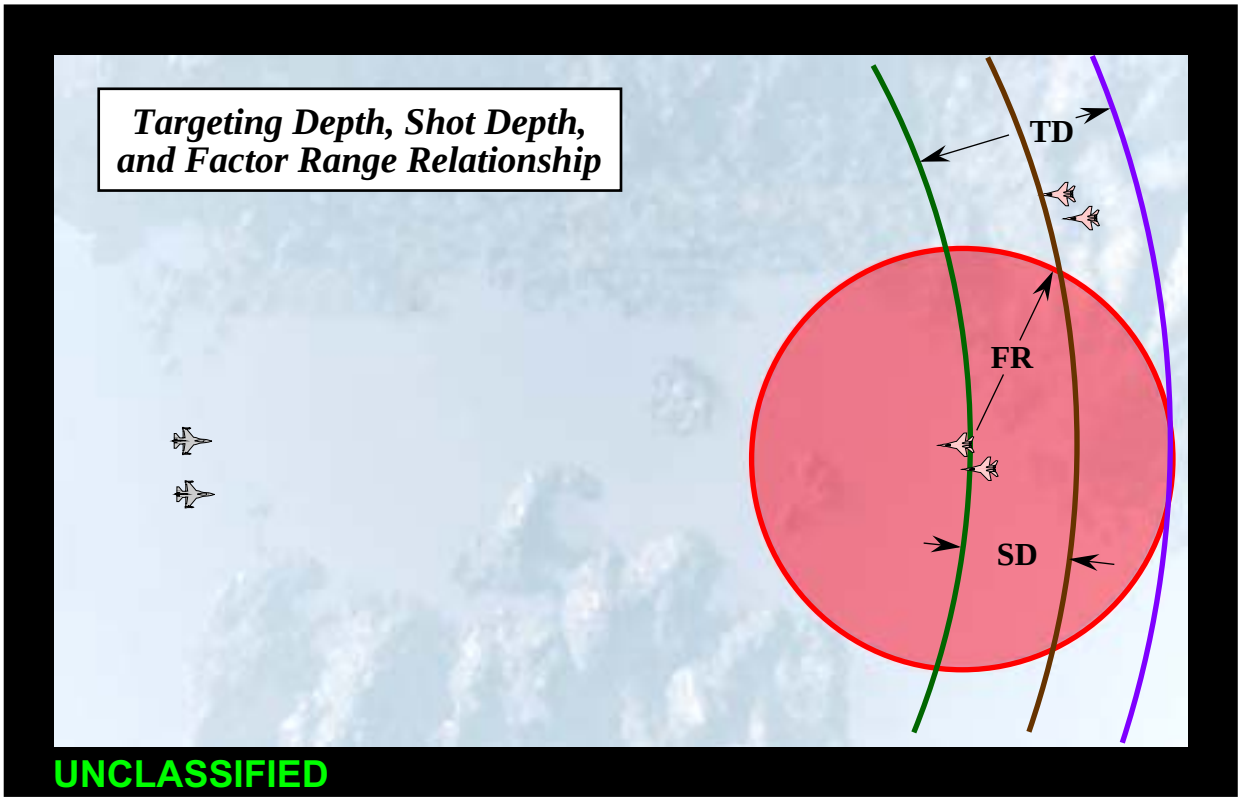
- Heat only threat—10 NM.
- Radar threat—10 to 15 NM.

4.8.7.6 TD, SD, and FR relationship. Even though TD and FR may sometimes have the same *value*, they are not the same thing. **Figure 4.103,** Targeting Depth, Shot Depth and Factor Range Relationship, shows an example where TD and FR are both the same value, with SD about half of TD. Note that the north group of the azimuth formation is within TD, but outside FR.

4.8.7.7 Minimum Targeting Range. Minimum targeting range (MTR) is the range that the element lead needs to target or share a group to ensure group elimination or support planned intercept flow. MTR is also where wingmen may auto-target IAW the gameplan any group in their AOR coverage not currently targeted. At MTR, the flight lead must be reasonably confident that all groups less than TD (SD or FR depending on tactic) have been accounted for. MTR is based on the ability of flight leads to target or sort, assess the intercept time line for the planned tactic, make decisions on the flight flow (e.g., shot status, crank direction, SSO intercept geometry, engagement decisions, out/abort/DR/NR), and position the element/flight for a successful and survivable engagement. An experienced flight lead may be able to execute these tasks at shorter ranges, and an inexperienced flight lead may need more time and, therefore, a longer range MTR

4.8.7.8 Minimum Abort Range. Minimum abort range (MAR) is the minimum range to execute a standard abort. A standard abort is a 5-G constant speed slice to tail aspect. In many configurations, this will require AB. It is based on FLO shot by the adversary aircraft with no crank. Aborting at MAR will defeat the adversary’s first shots and ensure the F-16 initially remains outside the tail aspect WEZ of the threat. See AEM, for MAR values versus specific threats.

Figure 4.103 Targeting Depth, Shot Depth and Factor Range Relationship.



4.8.7.9 Decision Range. Decision range (DR) is the minimum range between a fighter and the closest threat which will allow the fighter to execute a turn to the Notch, remain there for up to 15 seconds, then abort if spiked or continue to the merge if naked. See AEM for DR values versus specific threats.

4.8.7.10 Split Criteria. Split criteria are a briefed aspect and range where threats may force the flight lead to choose between staying together or separating the element to engage separate groups. The decision to split the flight is an offensive reaction to a potentially defensive situation. The range should be at or inside FR. Base split criteria on F-16 ordnance, ID criteria, spike status, MAR, and mission objectives. Split criteria may be liberal on a defensive counterair (DCA) or escort mission and very tight for a wingman with bombs as part of a strike package.

4.8.8 Intercept Flow, Targeting, and Sorting Plans.

4.8.8.1 Targeting and Sorting Definitions.

4.8.8.1.1 Targeting. Targeting is the process of assigning fighters responsibility for groups. These responsibilities may include supporting BVR missile shots, completing electronic identification (EID), measuring highly accurate target heading direction, or preparing to engage and VID. A fighter who is targeted to a group is said to “own” the group. If another fighter sorts into the group to assist the owner, that fighter is said to “share” the group. These two fighters are collectively called the owner and the sharer.

4.8.8.1.2 Sorting. Sorting is the process of determining the “inner-group picture”, establishing track files on the appropriate contacts, and (if applicable) allocating the owner and sharer radars within the group. There may be a difference between a radar sort and a visual sort. In some VID cases, once the flight lead is tally-ho he may elect to change to a visual sort based on the imminent merge geometry. See **Attachment 1** for definitions of inner-group pictures.

4.8.8.2 Intercept Flow and Element Targeting. F-16 air-to-air targeting is based on element intercept flow for maximizing mutual support (MS). The targeting plan is flexible in nature, allowing the flight leads to control the flight's assets (i.e., radars, missiles, AIFF, etc.), while allowing the wingman to maintain the primary responsibilities of maintaining the visual, flying formation, and listening. Our discussion will begin with a general overview of tactical intercept flow, then progress through a discussion of 2-ship element employment, and conclude with an overview of 4-ship targeting. All discussion herein is aligned with the standard Element Targeting contract from AEM. Although this plan codifies the contracts between flight leads, element leads, and wingmen to standardize air-to-air employment, it is not intended to dictate who in the element (leader or wingman) will be targeted; this decision is left to individual fighter wings to decide based on their specific hardware, software, threat, or missions. This section is designed with the new F-16 wingmen as the primary reader, and will present the most common situations and applications of standard Element Targeting.

4.8.8.3 Basic Element Flow. The basis of element targeting is that flight leads/element leads will maintain leading edge situational awareness (SA) throughout the course of the intercept. Outside of MTR, flight leads' primary responsibilities are building the picture, radar allocation IAW the plan, and anticipating element flows. Once the leading edge reaches MTR, leading edge destruction (or avoidance) takes priority over airspace sanitization. No later than MTR, flight leads (Numbers One and Three) target the nearest group to their element and/or sort around other flight members' radars to ensure leading edge destruction or proper VID flows. If BVR missiles have been launched against all contacts in the nearest group prior to MTR, flight leads may choose to target a “Next Nearest” group if required to support intercept flow.

4.8.8.3.1 BVR Employment Flow. In general, if ROE, ID criteria, and weapons load allow BVR missile employment, F-16 intercept flow makes little effort at concealment. The flight lead will allocate radars as appropriate to ensure mission success. Depending on the tactical situation, this may include targeting only his radar or using the wingman’s radar as well to maximize enemy destruction. The wingmen’s radar may be assigned to take long-range missile shots, or complete EID functions on partially identified groups. Flight leads may stay in search until MTR, watching the entire picture “mature”, assuring there are no untargeted groups, and generally striving to ensure fighter survival. If any new groups are detected, Flight leads target and/or update intercept flow as required. When the leading edge of the picture reaches MTR, and no additional groups have been detected, flight leads will ensure leading edge destruction by either targeting the lead group, sorting other contacts in the lead group or continue searching if all contacts in the leading edge are engaged. The fighters may either

launch and leave or continue flowing to the merge based on the tactical situation and the flight leader's decisions.

4.8.8.3.2 WVR Employment Flow. If ROE, ID criteria or weapons load preclude BVR missile launches, and the fighters must flow to VID and kill the enemy, intercept flow is generally to trail groups within FR on range pictures, or to the near side of azimuth pictures. Flight lead radar tasks are unchanged; they stay in search, maintain leading edge SA while building the picture. The intercept itself may look much different though. In a two-ship, it will probably be a Tactical SSO attempting to remain undetected while targeting radars as required to support the merge. If the picture is a single group the flight lead will target the group near MTR and direct FAN, BRACKET, or Notch/Attack contracts as required to merge. In range pictures less than FR, the flight lead will maintain leading edge SA in an attempt to bypass the lead group and flow to the trail group. For azimuth pictures, the flight will flow to the near side group.

4.8.8.4 Intercept Responsibilities. This section is divided into three parts; wingman responsibilities, flight/element lead responsibilities, and group owner responsibilities. Wingman and flight lead responsibilities are always in force. Group owner responsibilities exist in addition to basic flight lead and wingman responsibilities. Remember that group ownership has nothing to do with deconfliction contracts and in no way relieves SFs of their basic responsibility to deconflict.

4.8.8.4.1 Wingmen's Responsibilities. The flight lead has a great many critical decisions to make throughout this process. The wingman's job is relatively simple:

4.8.8.4.1.1 Stay visual! Never forget your flight path deconfliction duties. Nothing will hurt the team more than forcing your flight lead to take critical time away from primary duties to perform the "housekeeping" task of reorienting or deconflicting from a blind wingman. It doesn't help the wingman much either. Odds are you won't be doing too good a job monitoring your shot status if you're trying to regain the visual. If you are task-saturated to the point that complying with a flight lead's directive will likely cause you to go blind, it is better to reply "Viper 2, unable, padlocked", than to accept the task and go blind doing it. A good flight lead will instantly adapt to this limitation and overall element effectiveness will be better than the alternative.

4.8.8.4.1.2 Fly the briefed formation, so the flight lead can stay visual on you. Your flight lead is probably not watching you as much as you are watching your flight lead. Be where you are expected to be so that during the critical tasks where the flight lead needs to monitor your position it's easy to do so.

4.8.8.4.1.3 Search your assigned radar AOR. Listen to the picture and report any factor groups not previously reported by C2 or other flight members.

4.8.8.4.1.4 Target the group you are told to target. This is a listening exercise. Know the targeting plan, listen to the picture, and keep your radar cursor oriented over the group you anticipate targeting. If that group is outside your altitude search AOR, don't change the elevation setting, just keep up with the bullseye bearing and

range. As soon as you are directed to target, simply rolling the elevation wheel should result in a quick contact.

4.8.8.4.1.5 Don't get yourself killed. Although you are bound to stay visual and fly formation as long as you are in the supporting fighter role, the defensive fighter (DF) role, correctly established, frees you of this. Report any spikes with direction of arrival and try to maintain SA on DR/MAR/NR from the threat. Approaching minimum notch range with a spike drives you to DF status. Apply the Notch/Attack contracts IAW the ACM section.

4.8.8.4.1.6 Call Gimbals/Split as required. As previously emphasized, stay visual at all times. If maintaining your targeting responsibility is pulling you too far from your flight lead to stay visual, assess split criteria. If split criteria are met, call "SPLIT" with group name and BRA ("Viper 2, split trail group, BRA 230/8 12,000"). If split criteria are not met, call "GIMBALS" using the same format ("Viper 2, gimbals trail group, BRA 060/15 14,000"). Make these calls before you lose the visual!

4.8.8.4.1.6.1 Split/Gimbals responses and actions. The flight lead will respond to the Split or Gimbals call with one of three options.

- "Negative"...this means stay visual with lead even if it means dropping the group.
- "Cleared"...this means you may drop visual to continue the targeting/ intercept. You must deconflict from lead until clear of any potential flight path conflict.
- "Press"...this means continue the attack, the flight lead is coming with you and assuming the supporting role.

4.8.8.4.1.6.2 Wingmen Split/Gimbals actions. If the flight lead responds to your Split or Gimbals call, just obey the directive. If the flight lead fails to respond (or you don't hear a response), stay with lead if split criteria are not met, and split if split criteria are met.

4.8.8.4.2 Flight Lead Responsibilities.

4.8.8.4.2.1 Survivability and Lethality. The flight lead is responsible for executing the appropriate intercept flow to maximize lethality and survivability for the flight and element. The basis of this contract is that flight leads/element leads must maintain leading edge situational awareness (SA) during the intercept flow. This responsibility is never vacated during the course of the intercept regardless of group ownership.

4.8.8.4.2.2 Targeting and Radar Allocation. Second, the flight lead is responsible for targeting the picture and allocating radars. In deciding who will target and/or lock, the flight lead must weigh the importance of sanitizing the airspace for undetected groups, the importance of fighter-radar-quality-track fidelity (high fidelity) information, and weapons employment. Sanitization is most important outside of minimum targeting range (MTR) since all factor groups need to be detected by this

range. The general concept is that when a radar is targeted, sanitizing the airspace outside of MTR falls to the untargeted element mate. Flight leads must directively swap searches for their wingmen in cases where the element leads are targeted to ensure the airspace within targeting depth (TD)/factor range (FR)/shot depth (SD) is sanitized.

4.8.8.4.2.3 Intercept Time Line. Third, flight leads are responsible for maintaining an appropriate intercept time line for effective tactics execution. This time line includes radar bracket ranges, element fan and/or bracket ranges, pump ranges, outs, aborts, decision range (DR), notch range (NR), shot doctrine and timing, minimum shot range (MSR), targeting ranges (TR/MTR), and skate/short skate. This intercept time line is briefed for the specific scenario and mission of the day based on factors such as level of risk or possibility of gaining full declarations IAW the ROE and is the primary means of maintaining the appropriate level of survivability and lethality.

4.8.8.4.2.4 Formation Position and Responsibilities. Fourth, the flight lead is responsible for knowing the element mate's formation position during the intercept and flying the aircraft to ease the wingman's workload during task-intensive points of the intercept. Extra attention should be placed on wingman position during the following critical times:

- During shots (regardless of who is shooting).
- Stabilizing the formation while attempting to gain declarations.
- Offsetting the formation for SSO or four-ship radar bracket.
- Directing wingman to target.
- Directing wingmen to sort.
- Directing fan/bracket geometry.
- At out/abort/notch/decision range.
- At anytime before picking up the supporting role.

4.8.8.4.2.5 Direct Flight/Element Flow and Reforms. Finally, the flight lead must be able to direct tactically sound element and flight flows, reforms, and resets. An element's flow may change many times throughout the course of the intercept. For instance, Number Three may direct a crank in a specific direction only to have the targeted group maneuver outside of WEZs and/or shot doctrine. The element lead may then recognize the picture is changing, assess whether the element's radars are targeted correctly (and fix the targeting if they are not) and finally update the element flow to help the Number One element. The successful flight lead will always assess picture, targeting, and flow throughout the course of the intercept to influence the overall lethality and survivability of the flight.

4.8.8.4.3 Group Owner Responsibilities.

4.8.8.4.3.1 Radar Mechanics. Once targeted, the owner is responsible for executing the proper radar mechanics. If ROE allows the owner must take BVR shots IAW the shot doctrine and ROE. If the group has an incomplete ID owner is

responsible for upgrading the ID. The owner is responsible for maintaining high fidelity information on the owned group and communicating position, inner-group picture, maneuvers, leans, and track direction IAW briefed contracts.

4.8.8.4.3.1.1 For the new wingman, shooting multiple contacts within a hostile group may seem challenging at first. It really isn't and excellent ground training devices exist to develop your expertise. You can get as many passes shooting multi-contact groups in an hour in the WTT, DMT or OFT as you are likely to get in a year of operational deployments and flying. Use them!

4.8.8.4.3.2 Maintain Situational Awareness on the Intercept Time Line. Once targeted, the owner is responsible for maintaining SA on the intercept time line for the targeted group. The wingman must understand the flight lead's plan for flight and element flow enough to know when to be executing the tactic the flight lead wishes to execute (e.g., lock range, shot doctrine, minimum shot range, etc.).

4.8.8.5 Targeting Plans Relative to MTR.

4.8.8.5.1 Targeting Beyond Minimum Targeting Range. Although the targeting contracts are based on execution at MTR, there are often times when it is appropriate and desirable to target radars beyond that range. The range at which this may begin is targeting range (TR). TR is a pacing tool to help flight leads maintain the intercept time line.

4.8.8.5.1.1 Flight lead targeting beyond MTR. There are situations where it is appropriate and necessary for flight leads to target with their own radars beyond MTR to maximize lethality over sanitization of the AOR. This is a classic operational risk management decision the flight lead must make in the interest of maximizing mission effectiveness, achieving a proper balance between survivability and lethality. Such situations include but are not limited to the following:

- Complex ID requirements exceeding the wingman's decision making or sensor operations ability.
- Homeland defense or Air Sovereignty missions.
- Deployed air base defense.
- High fast flyer (HFF) profiles.
- Self-escort when the air threat may prevent ordnance on target.
- Communication jamming environment.
- Leaker in large force execution.

4.8.8.5.1.2 Targeting Wingmen beyond MTR. If the situations "bulleted" in **paragraph 4.8.8.5.1.1**, Flight lead targeting beyond MTR, do not exist, flight leads may use their wingmen's radars to accomplish the flight's objectives outside MTR. Since all of the reasons below imply a radar lock, when a flight lead targets a wingman to a group for any of the reasons stated below, the wingman should take a lock. The primary tasks for wingmen radars beyond MTR are:

- Shooting hostile groups

- Completing EID requirements
- Measuring high fidelity group track/lean direction (most commonly for trail groups within factor range during VID operations)
- Influencing defensive reactions by RWR-aware adversaries

4.8.8.5.1.3 Targeting Priority Based on ID. Because the targeting priority is based on the ID of the groups, the flight lead must decide who should target to enhance the lethality of the flight. As such, targeting against mixed declarations pictures may not follow any rigid targeting matrix that can be easily depicted in a table. However, based on targeting priorities outside MTR, mixed declaration targeting can be broken down into an easily understood hierarchy: Wingmen can expect to target hostile groups, partially ID'd groups and lastly bogey groups.

4.8.8.6 Two-Ship Targeting. Two-ship targeting is designed to maximize survivability and lethality while maintaining element mutual support. The desire to maintain visual mutual support precludes splitting the element unless absolutely required. Compared to four-ship operations, this significantly reduces the element's ability to present the enemy with an azimuth problem. Under four-ship employment, there is an assumption (except for 4-ship SSO intercepts) of some type of bracket tactic, which lends itself to "hot side" or azimuth-primary targeting. Two-ship employment assumes element mutual support with an element crank or single side offset and thus drives more of a range (nearest, next nearest) targeting philosophy. To maintain proper two-ship flow and mutual support, the flight lead must maintain situational awareness (SA) on the leading edge regardless of group ownership or ownship radar track status. Having only two radars available makes the two-ship flight lead's task challenging. (See **Table 4.16**, Two-Ship Targeting Matrix.)

Table 4.16 Two-Ship Targeting Matrix.

1	2	C^2
N	NN	NN untargeted
	As directed	As directed
UNCLASSIFIED		

4.8.8.6.1 Two-Ship Targeting Flow Examples. **Figure 4.104**, Targeting Legend contains an explanation of targeting examples. **Figure 4.105**, Two-Ship Targeting Examples, contains examples of the element targeting plan for single and multiple groups of varying IDs. The TR and MTR lines show the adversaries closing on the fighters, and the radar allocation as range decreases to MTR. The figures assume a two-ship tactical single-side offset versus bogey groups and a post-shot crank for hostile groups. In all examples, the flight lead is responsible for maintaining leading edge SA regardless of group ownership or radar track status. The examples show scenarios where the flight lead will target groups outside MTR and other examples where the wingman is targeted beyond MTR. Application of the targeting plan within each example is dependent on the fidelity of command and control (C2), the number of contacts expected in

each group, group ID and the complexity of the ID matrix, and expected adversary tactics. (See AEM Chapter 16 for further examples)

4.8.8.7 Four-Ship Targeting. (See **Table 4.17**, Four-Ship Targeting Matrix) The four-ship is subdivided into the Number One and Number Three elements. The elements are responsible for targeting primarily in azimuth, then in range and for groups that lean to threaten the element (i.e., hot side targeting). Each element targets to support the element's initial flow gameplan. If the picture changes, targeting and flow may also need to change to optimize lethality. **Figure 4.106**, Four-Ship Targeting Examples, contains examples of the element targeting plan for single and multiple groups of varying IDs.

Table 4.17 Four-Ship Targeting Matrix.

1/2	3/4	C^2
S N	S NN	NNu as directed drops/gimbals
UNCLASSIFIED		

4.8.8.7.1 Four-Ship Radar Bracket Flow. The Number One element targets their side while the Number Three element targets theirs. If groups are in range, the Number One element targets the near group, and the Number Three element targets the next nearest group. Wingmen radars may be used outside of MTR to accomplish targeting exactly as with two-ship targeting. This contract does not alleviate the flight lead of the Number Three element from monitoring the leading edge and targeting it if required (i.e., hot side target). The flight lead may even sample lock the leading edge for high fidelity information. Examples where near group targeting/sorting for Number Three may be required include the following:

- The leading edge is leaning on the Number Three element (nearest group).
- The leading edge is leaning on the Number One element and the Number One element must defend or abort. This assumes the next nearest group is beyond TD/FR/SD based on the ID and game plan.
- The leading edge is untargeted at or inside MTR.
- Leading edge is bogey and must be engaged.

4.8.8.7.2 Four-Ship Single Side Offset (SSO). For single side offset tactics, the Number One element targets the nearest group while the Number Three element targets the next nearest. For groups in azimuth, the Number Three element will target the next nearest group while maintaining SA on the nearest group.

Figure 4.104 Targeting Legend.

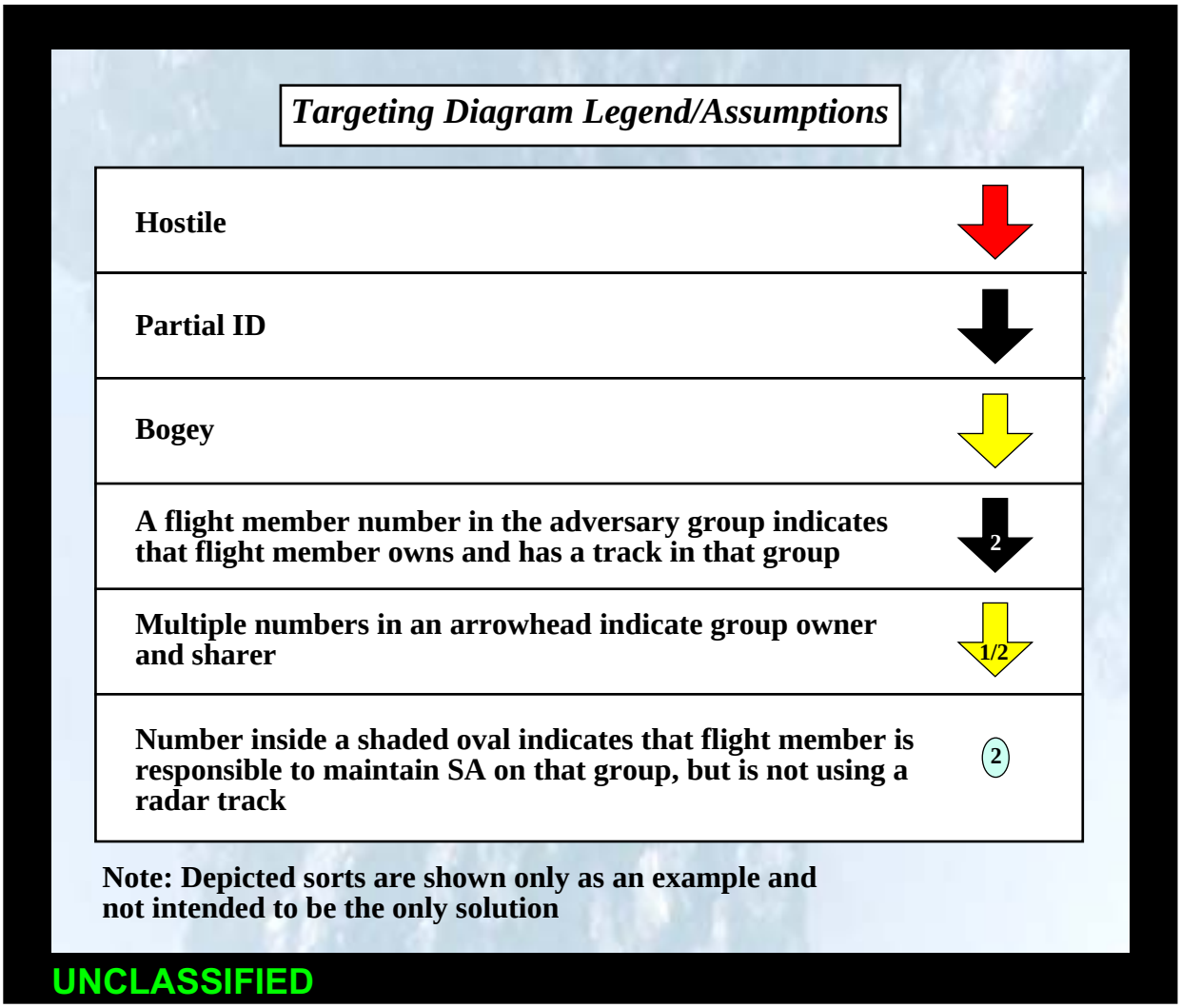


Figure 4.105 Two-Ship Targeting Examples (1 of 2).

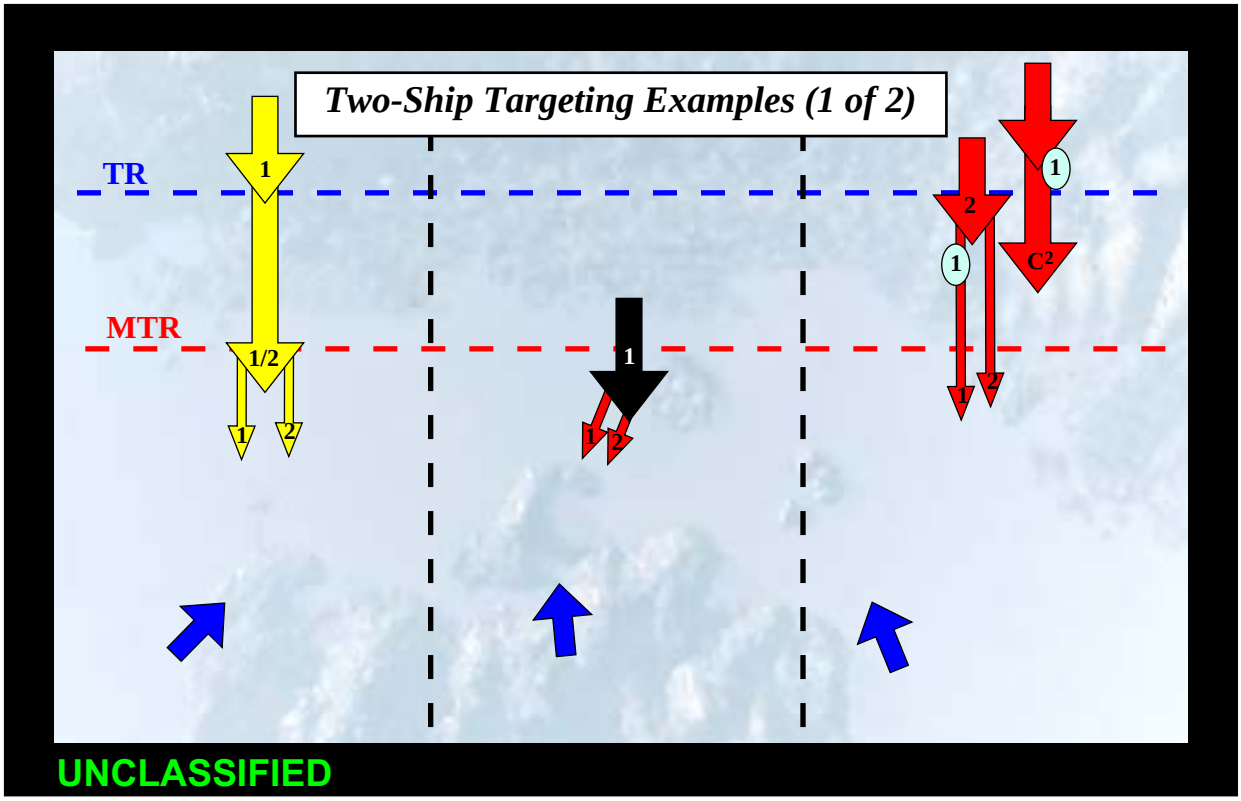


Figure 4.105 Two-Ship Targeting Examples (2 of 2).

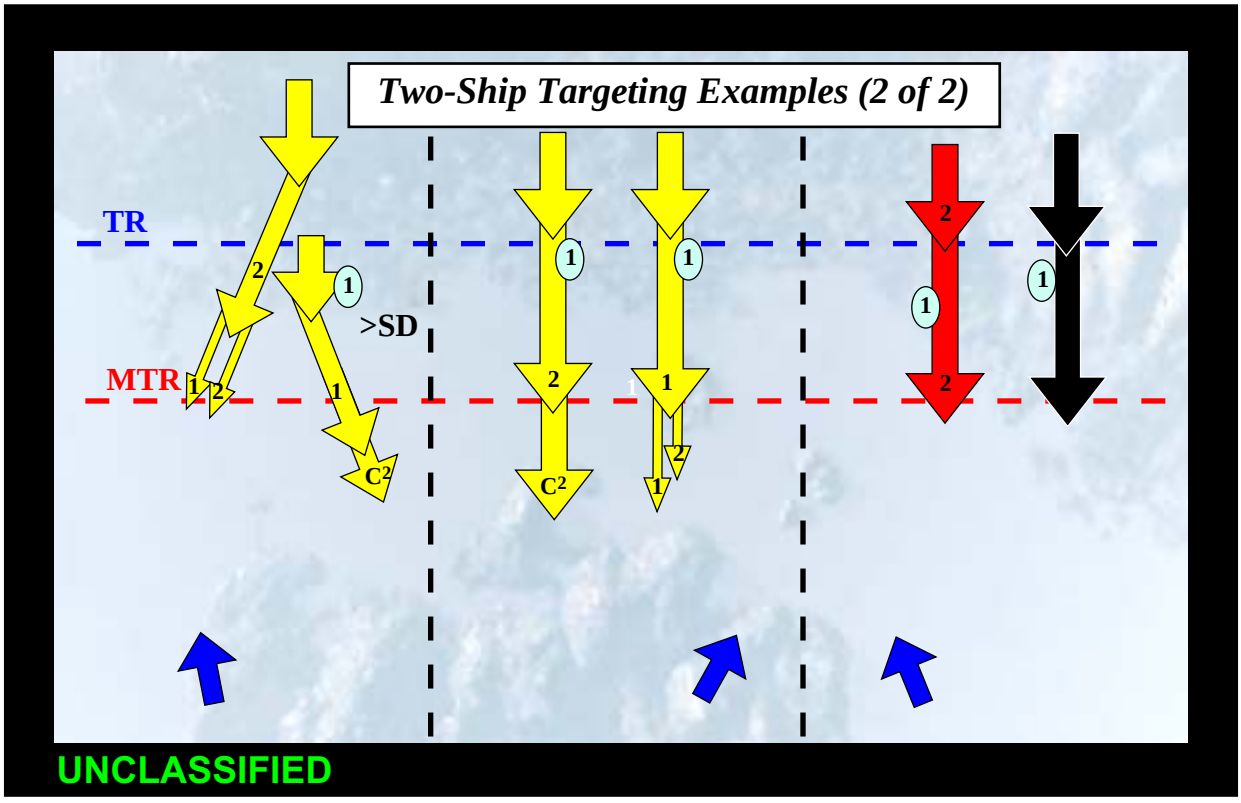


Figure 4.106 Four-Ship Targeting Examples (1 of 2).

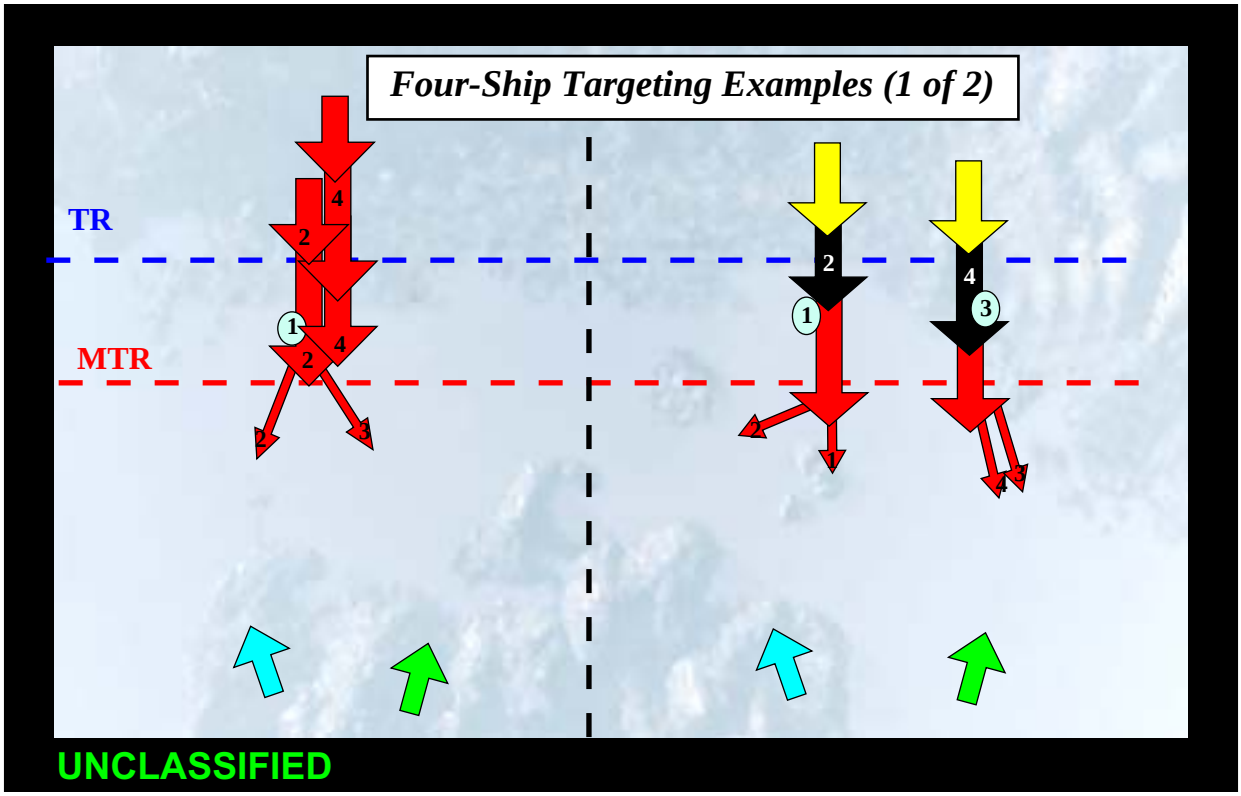
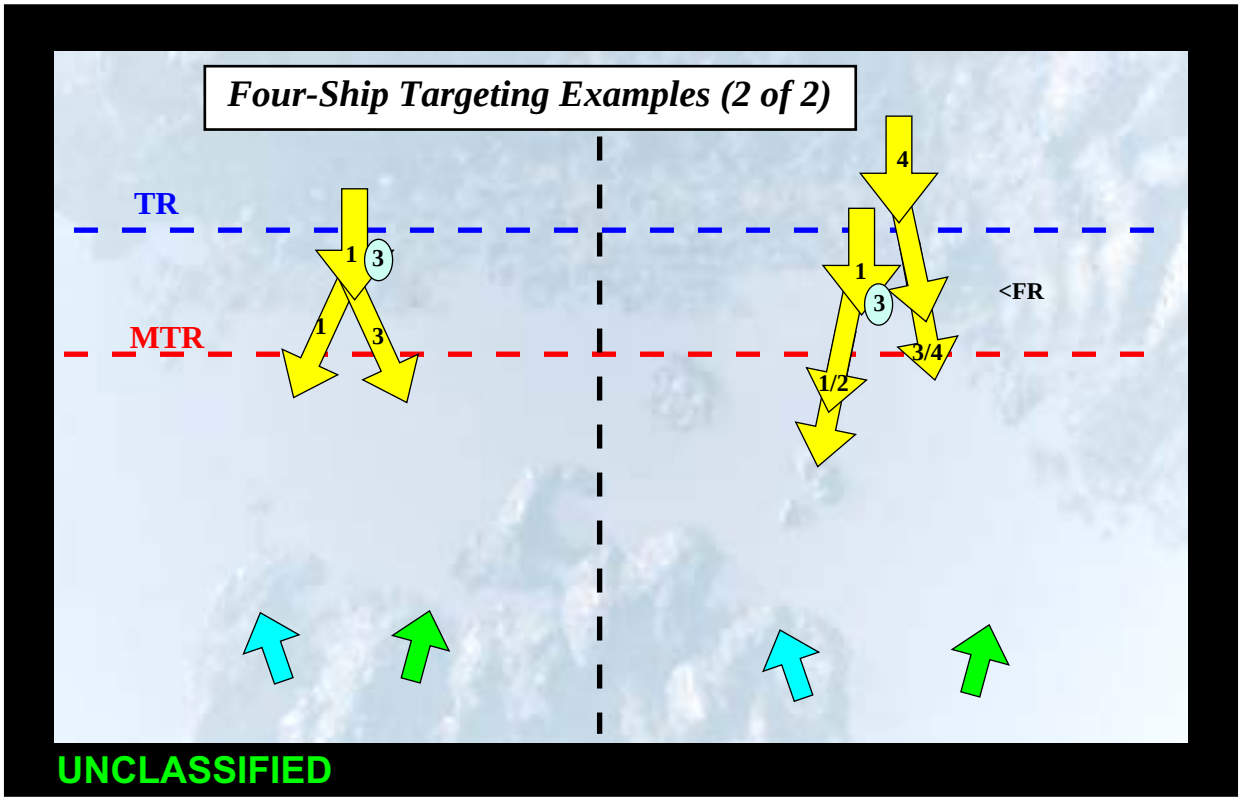


Figure 4.106 Four-Ship Targeting Examples (2 of 2).



4.8.8.7.3 Targeting Contract. At MTR the element leads (Numbers One and Three) must ensure the picture is targeted IAW the plan. If the picture is not already targeted by MTR, element leads (Numbers One and Three) must target the picture prioritizing the nearest and hottest groups to their particular element.

4.8.8.7.3.1 Untargeted Groups at MTR. There should be no untargeted groups inside of MTR. As such, flight members with sanitization responsibility (i.e., not targeted) must target pop-up groups inside of MTR, report their presence with a targeting and/or declaration call (e.g., “CLUBHOUSE, SNAKE 2, DECLARE POP-UP GROUP BULLSEYE 230/18, 15,000), and begin to execute the responsibilities of the group owner. If the group is already targeted at MTR, element leads may direct sorts at this time to ensure high SA for wingman. If the wingman is the targeted flight member at MTR, flight leads may share into the groups with their wingman or take over targeting responsibility.

4.8.8.7.4 Flow Examples at MTR.

4.8.8.7.4.1 Single Group. Elements (Numbers One and Three) target single groups at MTR to ensure leading edge SA. If a single group leans toward one element, that element lead must target/sort at MTR to enable proper flight flow. The element lead not being leaned on should target the single group and update the element's flow to support the other element and engage via an unobserved entry.

4.8.8.7.4.2 Two Groups Azimuth. The elements target the group that will be closest to them based on the planned flow priority. If the flight brackets, the elements target their side of the picture. At MTR, flight leads target or sort the groups closest to their element and therefore maintain SA on the closest group to them. If the flight executes an SSO, the Number One element targets the nearest group to the side of the offset while the Number Three element targets the next nearest group from the offset.

4.8.8.7.4.3 Two Groups Range. The Number One element targets the near group. If the near group is leaning on the Number Three element, Number Three targets the near group (i.e., hot side target). If the near group is leaning on the Number One element and the trail group is greater than factor range, Number Three targets the lead group to support the Number One element. If the near group is leaning on the Number One element and there is a trail group within factor range, the Number Three element must target and flow to the trail group while the Number One element aborts or engages. If the groups lean in opposite directions, the flight leads target the group leaning on their respective element.

4.8.8.7.4.4 SSO. In all cases the Number One element targets the near group and the Number Three element targets the next nearest group. If groups are outside FR, Number Three targets the near group at MTR to support the Number One element if required. If groups are inside FR, Number One attempts to maneuver the flight to isolate one group outside FR for merger considerations. If greater than two groups are encountered, the flight should be maneuvered to maximize firepower on one part of the presentation.

4.8.9 Sorting. The purpose of sorting is to assign responsibilities within groups to individual flight members. Sort plans may vary based on anticipated hostile/bogey declaration or the need to merge prior to shooting. A group is defined as shared when two or more pilots are designated to sort within an individual group. In a shared situation, both pilots are responsible for shooting and/or monitoring that group IAW the sort plan. Meeting the owner/sharer sort responsibility within a group does not establish engaged or supporting roles, it merely assigns radars within the group. Deconfliction roles are established and altered IAW the ACM section of this document. A sharer sort for BVR missile employment is normally established at MTR. Final sort for a visual merge is ideally established between MTR and DR.

4.8.9.1 Sorting Execution. Sorting can be done IAW a briefed plan or directively. Using radar bullseye data alone may aid sorting within a group, but a far better technique is to sort via standard inner-group names with both fighters observing the same radar picture. A directive example would be “VIPER 2, SORT WESTERN, LEAD GROUP, BULLSEYE 260/15, 22,000, HOSTILE” . . . “VIPER 2 SORTED.” The wingman in the example must be able to detect the formation within the group and inform the lead of being SORTED, unable, or LOCKED. Flight members calling “locked” should amplify the call with group name if known and bullseye position of the locked contact to allow targeting and sorting QC. For example, “VIPER 2 LOCKED LEAD GROUP, BULLSEYE 260/15, 22,000, HOSTILE.” The flight lead may respond “VIPER 2, YOU’RE SORTED WESTERN.”

4.8.9.2 Sorting “Around”. A commonly encountered situation is when the targeted flight member locks outside of MTR, launches, and still has only one contact at MTR. This may be because there really is only one contact, track symbology may be occluding another contact or because of poor radar mech. Communicating the target’s position prior to MTR with a B/E call may elevate sorting confusion.

4.8.9.2.1 Example Sort Plan Number One. (See **Table 4.18**, Example Sort Plan Number One.)

- With BVR launch clearance, allows owner to kill leading edges outward, while sharer (if required) kills trailing edges inward.
- Maximizes the probability of the owner obtaining a tallyho on the nearest bogey at the merge.
- May result in fewer immediate shots at the merge, possibly resulting in a more lengthy engagement.

Table 4.18 Example Sort Plan Number One.

Owner	Sharer
Near	Far
Side	Side
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4.8.9.2.2 Example Sort Plan Number Two. (See **Table 4.19**, Example Sort Plan Number Two.)

- May be able to shoot two hostiles near simultaneously at a visual merge.

- Requires increased radar and visual lookout proficiency from the owner.
- The owner must visually acquire the near bogey for the hostile declaration while planning to employ versus the farthest bogey.

Table 4.19 Example Sort Plan Number Two.

Owner	Sharer
Trailer	Leader
Side far	Side near
Vertical near	Vertical far
UNCLASSIFIED	

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CHAPTER 5

AIR-TO-SURFACE

5.1 Air-to-Surface Mission. Surface attack is the “core” mission of the F-16. Given current surface-to-air (S/A) and air-to-air (A/A) threat capabilities, “hauling iron” is a challenging mission requiring a complete knowledge of the aircraft systems, handling characteristics, and ordnance. This chapter presents discussions on premission planning, delivery parameters, surface attack checks, low- and medium-altitude attack considerations, visual and non-visual bombing, controlled range patterns, and pop-up deliveries.

5.2 Preparation.

5.2.1 Air-to-Surface Specifics. Contact the flight lead the day prior to the mission and allow sufficient mission planning time prior to brief time. The game plan and subsequent execution is a direct reflection of the effort put into mission planning. Considerations include, but are not limited to the following:

- Target and desired objectives.
- Threats (surface, air, en route, and target area).
- Aircraft configuration and ordnance load.

5.2.2 Air-to-Surface Planning and Products. With this information, the planning phase can begin. It is important that everyone in the flight participates in the mission planning. Expect duties to be delegated to each member of the flight. Data required and produced include the following:

- Weather. Note winds, ceilings, visibilities, and sun angles for the target area and route. Obtain tactical decision aid (TDA) for electro-optical (EO) weapon planning and employment.
- Takeoff and landing data reflecting the actual aircraft configuration.
- Review aircraft bomb footprint logs to determine if there are any trends that would affect bombing accuracy.
- Weapons data (carriage, employment, and jettison).
- Route and target maps.
- Attack parameters.

5.3 Air-to-Ground Mission Planning.

5.3.1 Planning Factors. Several factors must be considered when planning air-to-ground (A/G) weapons employment. First, a thorough threat analysis must be accomplished to determine attack axis and maximize survivability by minimizing exposure. Second, target and munitions compatibility must be determined. For example, dropping cluster bomb units (CBU) to destroy a concrete bridge will not provide the required munition effects. Third, the delivery must achieve the desired weapons' effect. If a 60-degree impact angle is required, it is easy to see that a 10-degree low-angle low-drag (LALD) delivery will not suffice. Refer to allied conven-

tional employment (ACE) planning programs for further weapons effects considerations.

5.3.2 Delivery Parameters. A/S attacks must allow for both safe delivery specifics and effective weapons effects. Release altitude is based on trade offs between weapons arming, threat avoidance, system accuracy, terrain avoidance, and safe escape from weapon fragmentation. Additional training restrictions and regulations may also impact attack planning. Refer to computed weapons delivery software (CWDS), for an in-depth discussion on these topics.

5.3.3 Fuze Arm Categories and F-16 Avionics.

5.3.3.1 Arming Delay (AD) (CAT 1). For CAT 1 (impact fuze) weapons, the value of the AD entered into the stores management system (SMS) should be IAW the following formula:

F-16C:

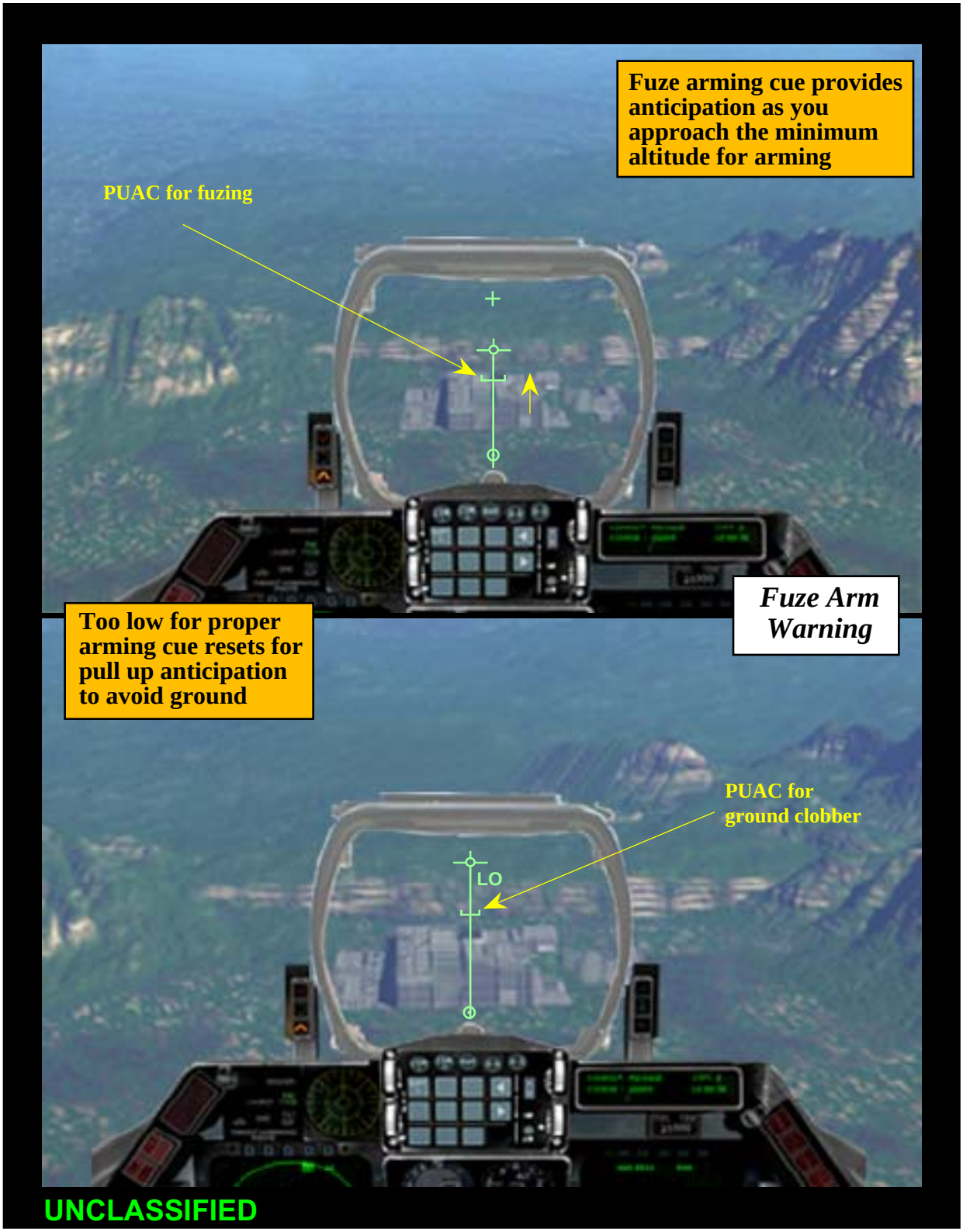
AD + fuze arm tolerance + any inherent delays = SMS AD time

5.3.3.1.1 For example, using a fuze arm time of 4.0 seconds plus 20 percent (0.8) tolerance, the AD entered in the SMS of a Block 50 would be 4.8 seconds. If the fire control computer (FCC) computes a bomb TOF less than 4.8 seconds, the pull-up anticipation cue (PUAC) resets to provide ground clobber information and “LOW” flashes next to the flight path marker (FPM) in the F-16C. (See **Figure 5.1**, Fuze Arm Warning.)

5.3.3.1.2 For Block 30 avionics, some time must also be added for ripple deliveries. The Block 30 FCC computes fuze arm for each individual release in a ripple. In order for the cue to indicate arming for the entire string before the release, the difference between the time of fall (TOF) of the first and last bomb should be added to the formula used above. Both TOFs are available from CWDS. Block 50 aircraft do not require this since the AD is computed for the last weapon to be released.

5.3.3.1.3 As long as the release (of the first bomb in case of a ripple delivery) occurs prior to the “LOW” indication, the fuzes should have time to arm before impact. It is possible that the fuzes may arm with less TOF or that bombs may go off “low order,” so prudence dictates that safe escape criteria be met. Do not depend on the fuze not arming as a means to frag avoidance.

Figure 5.1 Fuze Arm Warning.



5.3.3.2 CAT 2. For CAT 2 (proximity fuzed) weapons, burst altitude (BA) values are used to provide the FCC with information as to where the weapon ballistics will change. The FCC assumes the weapons will fall in a certain trajectory until the BA conditions are met and the fuze functions to change the ballistics. For CAT 2 weapons, the BA determines where the pipper is displayed, and the AD determines PUAC information. Therefore, the BA in the SMS must be the same as the value set on the weapon fuze to ensure an accurate pipper.

NOTE: For CBU-87B with nose tail (NSTL) selected (FZU-39 proximity fuze), the SMS assumes an approximate 3-second AD and will not use the CAT 2 AD value the pilot enters into the SMS. Therefore, no ripple adjustment can be made to the PUAC with these weapons.

5.3.3.3 CAT 3. For CAT 3 (timer) weapons, the AD positions the pipper in the head-up display (HUD). This is due to the fact that the weapons function at the expiration of the arming time versus a proximity fuze function as in a CAT 2 weapon. The BA with this type of weapon now drives the PUAC display. With the software capabilities upgrade (SCU) FCC, the altitude lost in the ripple could be used to adjust the BA if a minimum opening altitude is required. (See **Figure 5.2**, Fuze Categories.)

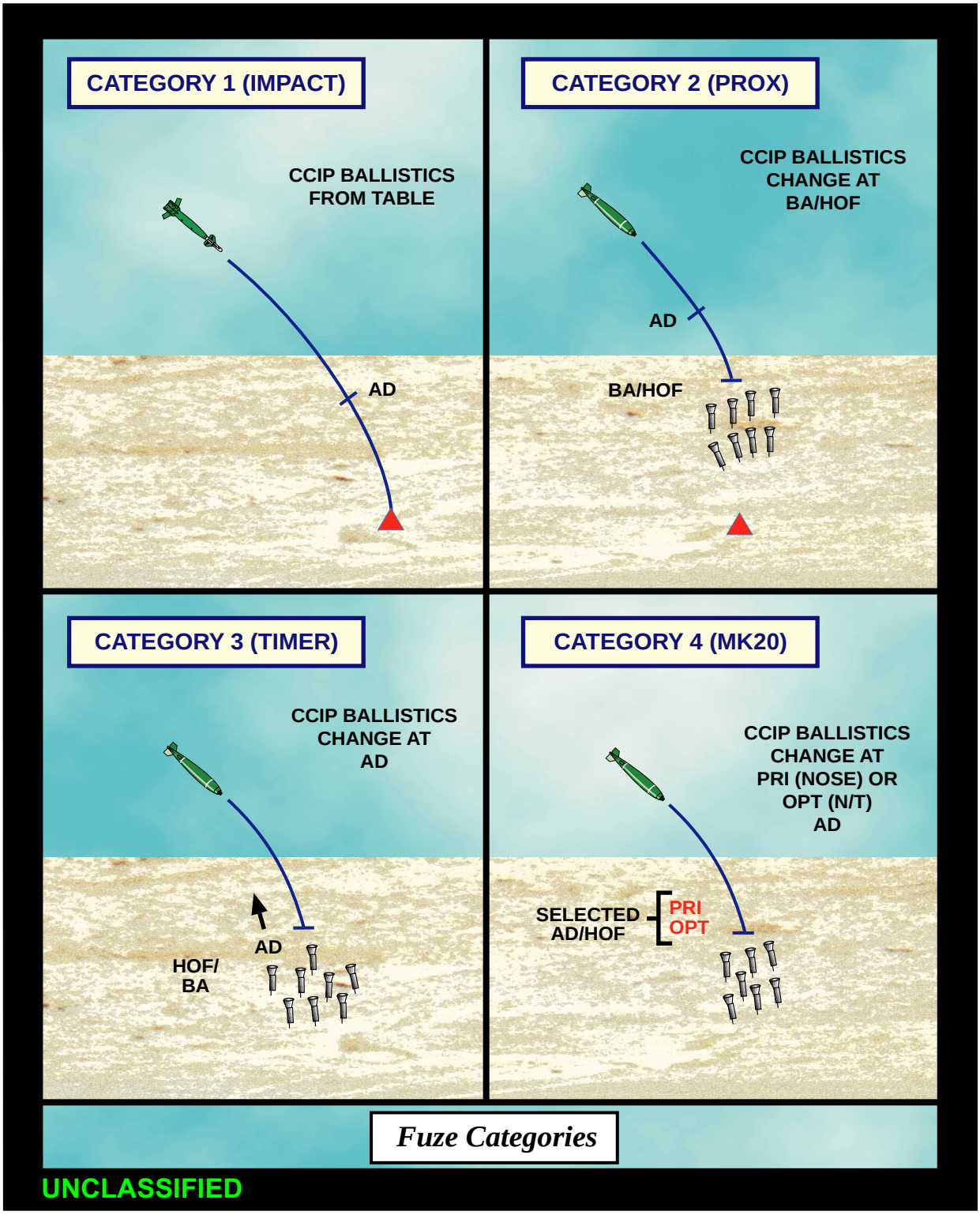
5.3.4 Safe Escape and F-16 Avionics. The F-16 HUD and radar displays provide an indication of when a recovery is required to avoid ground impact. Load an AD/BA in the SMS to provide a HUD display (“LOW”) when release parameters result in bomb TOF less than that required for fuze arm/function. The FCC does not compute a minimum altitude for safe escape. This is the pilot's responsibility and can be done only by reference to the safe escape tables in CWDS. For example, if an AD of 4.4 seconds is loaded into the SMS and a level delivery (straight and level escape maneuver) was performed at 500 KTAS and 500 feet AGL; the delivery would be below minimum frag clearance (safe escape) criteria. There are no HUD warnings, and the fuze would have sufficient time to arm prior to impact. It is the pilot’s responsibility to ensure minimum release altitudes (MRA) are not exceeded and valid safe escape maneuvers are always accomplished.

5.4 Surface Attack Checks.

5.4.1 Preflight. Allow extra time for ordnance preflight. If you find a problem, you need time to have the weapons shop correct the problem and still start on time. Since munitions problems are not uncommon, do your weapons preflight as soon as you arrive at the aircraft. Contact the weapons supervisor immediately and inform your flight lead of any problems.

- Be sure the load matches the planned configuration.
- Use the checklist to preflight ordnance.
- If a hot gun is required, ensure the gun electrical safety pin is installed outside the purge door, the safety tool/wire is removed, rounds counter set, and rounds limiter switch set as required.
- Note camera and canopy coefficients prior to start, from the AF Form 781.

Figure 5.2 Fuze Categories.



5.4.2 After Start Checks.

5.4.2.1 INS “Swing” Check. First, get the most accurate alignment you can. Ring Laser Gyro (RLG) equipped F-16s should perform an enhanced interrupted alignment (EIA) if time and taxi routing allow. When the inertial navigation system (INS) alignment is complete, it is a good technique to run through all the programmed destinations and compare bearing and distance from present positions with pre-computed values on your card.

5.4.2.2 Ground Speed (GS) Check. GS on the INS should read zero after alignment. Any GS reading other than zero when you are still in the chocks indicates errors in the horizontal accelerometers. These errors result in navigation and bombing errors. If GS reads greater than zero immediately after alignment, consider doing another alignment.

5.4.2.3 Vertical Velocity Indicator (VVI) Check. Note the position of the VVI in the HUD or VVI gauge. Any reading other than zero indicates a bad vertical accelerometer which results in erratic 12 and 6 o'clock errors.

5.4.2.4 Camera Check. In order to verify proper camera coefficients, a ground stabilized camera check is recommended on every sortie in which videotape recorder (VTR) assessment is used. Turn the VTR to HUD; switch on, turn the Master Arm switch to SIMULATE, and select A/G Master mode with dive toss (DTOS) symbology displayed. Also, display the HUD and camera coefficients in the data entry display (DED) with DED displayed in the HUD. Move the DTOS box to the lower portion of the HUD, approximately 5 to 10 degrees nose low, where planned release conditions occur, and slew it onto some discernible point (the intersection of two expansion joints in the taxiway concrete, a pre-painted reference, etc.). Repeat this for various other points in the HUD FOV. An airborne check should also be accomplished. This provides a more accurate assessment of the camera alignment due to the increase in slant range to the reference point. Postflight review of this check enables the pilot to determine mil displacement if the camera coefficients are in error. Camera coefficients should only be changed from airborne camera checks.

5.4.3 End of Runway Check. After stopping at end of runway (EOR), confirm all weapons switches safe and keep hands in full view during arming. Remember that aircraft should not taxi in front of aircraft with forward firing ordnance being armed or de-armed.

5.4.3.1 Verify correct SMS loading and inventory. If simulated deliveries or A/S weapons check are accomplished, select an uncarted station and load zero quantity weapons there.

5.4.3.2 As soon as you stop in the arming area, check your GS and HUD VVI. If GS is excessive (equal to or greater than 3 knots), consider accomplishing another alignment.

5.4.3.3 Ring laser gyro (RLG)-equipped aircraft can perform an EIA if desired.

5.4.3.4 Select desired backup ranging mode for passive ranging continuously computed release point (CCRP) and air-to-ground ranging (AGR) mode (CCIP/STRF/DTOS). Actual options vary based on aircraft block avionics. See **paragraph 5.6.8.6** Ranging Mode Selection, for Passive Ranging (PR) considerations.

5.4.4 Airborne Ordnance Check. The bomb check or battle damage check is normally done shortly after takeoff and when leaving the range. It is done only in daytime, or with NVGs (if qualified), and is a visual confirmation of bomb condition and expenditure. The checking pilot

visually inspects each aircraft for hung ordnance, “spinners” (activated fuzes), and battle damage. After completing the inspection, the pilot returns to the original position and is inspected by another pilot in the flight. A battle damage check should also be done on every sortie when clear of the target area and outside the threat area.

5.4.5 Airborne Computed Checks.

5.4.5.1 Air-to-Air TD Box Check. With a STT radar lock on a WVR airborne target ***(if carrying live missiles, do this in NAV mode without an air-to-air missile selected!)***, the pilot should note the position of the target aircraft in the target designator (TD) box. A target not centered in the TD box could indicate either a bad radar boresight or a bad HUD boresight.

NOTE: In track-while-scan (TWS) mode, the TD box may drift around the designated target, therefore, do this check in single target track (STT).

5.4.5.2 Air-to-Ground System Check. After takeoff, during the descent to a low level, or while entering a range, the pilot should check all A/G modes. With the Master Arm switch in SIMULATE and with an uncarted station selected, select CCIP and observe the pipper while flying over relatively smooth terrain. The pipper should track smoothly and valid AGR should be displayed in the HUD. If not, the radar is not providing consistent data for the weapons solution. The fire control radar (FCR) should indicate a valid lock-on to the ground by displaying a diamond symbol on the multifunction display (MFD). Slant range should be displayed in the HUD and remain relatively constant. At medium altitude, a roll-in can be accomplished to determine the quality of the AGR track. Check DTOS and verify backup ranging (radar override). Set the ground map (GM) display and verify desired gains and MFD tuning while in CCRP.

5.4.5.3 Altitude Calibration (ACAL). Perform an ACAL before bombing anytime you suspect errors in system altitude. A correctly performed ACAL will not harm your system in any way regardless of system altitude accuracy before the ACAL was performed. There are only two accurate means of evaluating system altitude: (1) Flying abeam or directly toward a point of known elevation and comparing displayed A/C system altitude to the known point. (2) Observing the forward or aft movement of the TD box relative to the actual steerpoint on the ground. Depending on specific F-16 capabilities there are several options available for a proper update. Avoid a HUD ACAL if you have known AGR radar problems. Taking into consideration the weapons on board, airframe Block, and GPS satellite position, several additional options are listed below.

- GPS medium altitude ingress-consider running AUTO acal with a system High/High
- DTS AUTO acal is an excellent option at low altitude with the correct DTS data base loaded.
- RALT ACAL is very reliable especially during low altitude ingress, and can be performed over any terrain having the same elevation as the currently selected steerpoint (no need to specifically overfly a steerpoint if adjacent terrain is level.) Over level terrain, this allows a wingman in tactical formation to do an accurate RALT ACAL abeam the turnpoint without having to collapse the formation. The FCR can remain in air search while doing RALT ACAL

- HUD (AGR) ACAL is most reliable if the update point is located in a relatively flat terrain due to the F-16's radar foot print. Numerous factors preclude a HUD ACAL from being as accurate as a RALT ACAL, but it is still an acceptable method. No FCR air search is possible during a HUD ACAL.
- FCR ACAL uses the various ground mapping functions (GM, DBS, FTT) to define steerpoint location, and then computes system altitude using non-AGR slant range. This is usable at night or in IMC. If planning to actually overfly the steerpoint in IMC, a better technique could be to define the steerpoint as accurately as possible using the GM functions, then perform a RALT ACAL when the HSI/HSD indicates you are directly overflying the steerpoint.
- G-Induced Loss of Consciousness (G-LOC), and Preparation. A dedicated G-awareness exercise should be conducted IAW **Chapter 3**, "Transition," on all missions when required.

5.5 Ingress and Egress.

5.5.1 FENCE Check. Certain items should be checked to ensure that switches and avionics are set up properly prior to entering a hostile area. This may be just beyond the field boundary, so it may be necessary to do some of these checks prior to takeoff. Others may be delayed until just prior to the push out of orbit, mission dependent.

5.5.1.1 One way to ensure a thorough check is made of your combat capabilities and you are ready to fight, is by using the word FENCE as an acronym. An example of the minimum items to be checked is shown in **Table 5.1**, FENCE Checks. These items can be accomplished in any order.

5.5.1.2 A complex surface attack mission will also have a complex FENCE check. Omission of even a single item could result in a dry pass, a missed shot opportunity, or even risk being shot down due to unarmed flares or electronic countermeasure (ECM) systems. It may be helpful to write down critical FENCE check items on your mission card.

5.5.2 Low-Altitude Considerations. Low-altitude flight in rough terrain provides masking opportunities to degrade enemy radar acquisition, limits visual detection, and contributes to tactical surprise. However one should not fly lower than the threat, mission objectives, or comfort level dictates.

- The map should be of such scale and quality that terrain features, hazards, and chart annotations are of sufficient detail to allow for safe mission accomplishment.
- Maps will be updated from the Chart Update Manual (CHUM), either manually or electronically.
- Time and/or distance tick-marks should be annotated on the low-level map to insure positional awareness.
- Highlight obstacles to the flight route such as towers and power lines.
- Annotate the minimum safe altitude (MSA) or route abort altitude (RAA).
- Determine planned fuel as well as continuation fuels at each point.

Table 5.1 FENCE Checks.

FENCE		CLEMSHIRT G	
F	Firepower, fuel (balanced and inert)	C	Chaff/flare, Comm, and Camera
E	Emitters	L	Lights
	T—TACAN	E	ECM
	R—RALT and Radios	M	Master arm and missile
	A—ALR and ALQ	S	SMS
	I—IFF	H	HUD, HSI, and HSD
	L—Lights	I	INS and IFF
N	Navigation	R	Radar and RWR
C	Chaff/flare, Comm, and Camera	T	TACAN, Tank inert, and TAD
E	ECM		
	Employ: Master Arm	G	G-suit

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5.5.3 Low-Level Route Study.

5.5.3.1 To ensure success in low-level missions, thoroughly study the route. Know how every major point appears, either visually or on radar. Analyze the visual references to use in flight and points to avoid. Correlate point descriptions with visual expectations:

- Haze, smoke, dust, and fires.
- Sun position.
- Environmental variations (snow or leaves on trees).

5.5.3.2 Analyze the route; predict A/A or A/G radar use. Determine if deviations from course will be appropriate (masking or threats.). Select update points (position and altitude). A good technique is to actually pre-assign deconflicted flight lead and wingman pre-IP update/ACAL points. This helps ensure at least one radar is in search all the time and lets element mates better support one another during anticipated head's down cockpit tasks. Review the altitude, restrictions, headings, and timing references.

5.5.4 Low-Altitude Awareness.

5.5.4.1 F-16C Combined Altitude Radar Altimeter (CARA). The F-16C CARA system can be used for altitude management during low-level operations. CARA is an aid to supplement visual capabilities and common sense. Ensure the system is on and set to the appropriate altitude. Enter an altitude no lower than the minimum approved altitude for day operations. Visual warnings are provided on the HUD and MFD.

5.5.4.2 Digital Terrain System (DTS). Set DBTC to the desired altitude and mode select as desired (set the desired AGL "terrain following" altitude. ***NOTE:*** DBTC is not a TF system, it merely provides visual cues to manually fly a set altitude above the digital terrain model.). Set ALOW, then PGCAS as desired. PGCAS is not intended to be set to the desired AGL cruise altitude. If you do this, the built in lead points to allow pilot reaction/

reorientation will result in many “false” PULL UP warnings while flying normal low altitude flight profiles. This is why PGCAS normally defaults to 25 percent of ALOW value.

5.5.4.3 Low-Altitude Hazards. Be keenly and constantly aware of low-level hazards.

5.5.4.3.1 Visibility Restrictions, Visual Illusions, and Low Sun Angles. These can affect low-altitude perceptions. Terrain contours directly in front of you may be lost against the horizon. When in doubt, put the flight path marker (FPM) into “blue sky.”

5.5.4.3.2 Subtle Rises in Terrain. Maintaining level flight and a constant altitude may result in significantly reduced ground clearance. Constantly check NEAR ROCKS then FAR ROCKS.

5.5.4.3.3 Task Saturation/Fixation. The key to successful operation in the low-altitude environment is a solid cross-check, appropriate task prioritization, and situation awareness (SA). Cross-check should remain the same, only the time spent performing its various counterparts' changes with altitude changes. Proper mission planning and selective use of low-altitude structure helps reduce the number of high task situations that occur while low.

5.5.4.3.4 Unperceived Descents, Overbanked Turns. Small descent angles or an unplanned increase in bank angles can result in significant descent rates and ground impact. Attention to the velocity vector (FPM) and altitude awareness cannot be overemphasized. Controlled flight into the ground is, in most cases, the result of mis-prioritization and task saturation. Regardless of assigned or perceived tasks, pilot distraction at low altitude is deadly.

5.5.4.4 Low-Altitude Task Prioritization. Misplaced priorities occur when a task is accomplished at the wrong place or time. Operating at low altitude is a hazardous proposition; it significantly reduces the time available to divert attention away from basic aircraft control while handling other tasks. The danger of channelized attention and task saturation is diverting attention away from the pilot's first priority—terrain avoidance.

5.5.4.4.1 Cockpit tasking varies at different times throughout a low-level route. It is important to re-establish priorities when mission tasking starts to override critical tasks. The following items illustrate techniques for minimizing low-altitude task saturation problems.

- Terrain clearance is the critical task and should be the first task performed. Climb to cope with high mission task loads.
- Accomplish avionics setup and checks as early in the flight profile as possible. Many avionics items can be set prior to takeoff, thus reducing workload at low altitude.
- Accomplish critical tasks first. Accomplish lesser tasks at lower cockpit tasking levels.
- Higher altitude allows less concentration on terrain avoidance and more time to accomplish other tasks. Flying below 500 feet is more demanding than above 1,000 feet.

- Pilots must be acutely aware of their flight path at all times. Head down avionics tasks are not appropriate if the aircraft is descending or turning.

5.5.4.4.2 Initial Descent. A particularly busy time during low-level flight is at the low-level start point. While descending and possibly turning, tasking may also include timing control, steerpoint selection, avionics updates, radar search, formation, and terrain avoidance. Problems can be insidious. Arrival at low altitude, with little or no warm-up, and then beginning the demanding workload required for low-altitude operations can be perilous. Flight leads should consider accomplishing tasks prior to descending to their minimum altitude, or by delaying tasks until established on the route. The start route point should be planned so that reduced tasking is tactically feasible.

5.5.4.4.3 IP-to-Target. Another demanding time is during the approach to the target. Pilots must finalize attack avionics and switchology, sanitize the target area, and establish the briefed attack formation. Each pilot must continually anticipate situations of increased tasking and keep task priorities in order to accomplish the mission safely and effectively.

5.5.4.5 Absolute Dive Recoveries. The following chart is a guide for pilots to cease all non-critical mission task and initiate a wings level dive recovery at 4 Gs in 2 seconds. These recovery altitudes along with their associated dive angles will insure that a pilot will recover prior to 500' AGL. If at anytime you are unsure of your parameters or find yourself behind the cross-check, execute an immediate dive recovery to level flight. These recovery altitudes show in **Table 5.2**, Absolute Dive Recovery, hold true up to 560KTAS.

Table 5.2 Absolute Dive Recovery.

Dive Angle (Degrees)	5	10	15	20	25	30	45
AGL Recovery (feet)	600	750	900	1,000	1,500	3,000	4,500

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5.5.4.6 Low-Altitude Training. This section includes a discussion of low-altitude hazard awareness and low-altitude step down training (LASDT). Several types of maneuvers have been developed to acquaint the pilot with maneuvering in the low-altitude arena. Units will have a low-altitude step down training program consisting of both academics and flying. The following exercises are provided both for practice and optional low-altitude awareness training events. A description of the F-16 low-altitude warning is also provided.

5.5.4.6.1 Descent Awareness Training. This exercise shows the amount of altitude that may be lost in a short period of time due to inattention or channelized attention at low altitude. Beginning at 1,000 feet AGL or higher and 420 to 480 KCAS, establish a wings-level 1-degree nose-low descent. Time how long it takes to lose 100 feet, 300 feet, and 500 feet of altitude. Repeat the exercise with a 3-degree descent and again

with a 5-degree descent. Do not descend below the minimum altitude established for the route/mission you are flying. Reference **Table 5.3**, Time-to-Impact (Seconds) Wings-Level Descent/Overbank Turns, for examples.

5.5.4.6.2 Level Turn. This exercise gives the pilot practice at maintaining altitude while maneuvering in turns at various bank angles and G-loading. Beginning at 500 feet AGL, 420 to 480 KCAS, establish various bank angles between 30 and 80 degrees and set G to maintain level flight. Monitor the HUD FPM, altimeter, and visual cues to maintain level flight. Correct drops in altitude by first decreasing bank and then increasing G. With practice, the pilot should be able to perform a 360-degree level turn using 5 to 6 Gs without varying altitude more than +100 feet and -50 feet. If authorized, repeat this exercise at 300 feet AGL.

5.5.4.6.3 CAT III Maneuvering. This exercise shows the airspeed and AOA effects of sustained maneuvering in a high drag/heavyweight configuration and is more pronounced when flown at gross weights of 30,000 pounds or greater. At 1,000 feet AGL or greater, perform a Mil power 180 degrees level turn using 5 to 6 Gs, starting at 420 to 480 KCAS (note the airspeed loss and AOA increase during the turn). Do not slow below the low-altitude minimum airspeed. After performing the turn in Mil power, select AB and accelerate to 420 to 480 KCAS. With full AB selected, perform another 180-degree turn at 5 to 6 Gs (note airspeed and AOA changes during this turn and compare them with the Mil power turn).

5.5.4.6.4 Turning Room Demonstration.

5.5.4.6.4.1 This exercise trains the pilot to visualize the horizontal turning room required for the F-16 to complete a low-altitude turn at employment airspeeds. At 500 feet AGL or greater, 450 to 500 KCAS, fly perpendicular to a known ground reference line (road, railroad, power line, or river). When approaching the reference line, perform a level 4- to 5-G turn using cockpit and outside visual references so as to roll out exactly over the reference line. Repeat this exercise until you no longer overshoot or undershoot the reference.

Table 5.3 Time-to-Impact (Seconds) Wings-Level Descent/Overbank Turns.

Dive Angle (degrees)	Altitude (feet) AGL	KTAS		
		400	450	500
1	700	59.5	52.9	47.6
	500	42.5	37.8	34.0
	300	26.1	23.2	20.9
26	700	14.2	12.6	11.4
	500	19.9	17.7	15.9
	300	8.5	7.6	6.8
5	700	11.9	10.6	9.5
	500	8.5	7.6	6.8
	300	5.1	4.5	4.1
10	700	6.0	5.3	4.8
	500	4.2	3.7	3.3
	300	2.6	2.3	2.0
Overbank (degrees)	**Altitude (feet)**	**Bank/G Required for Level Flight Time (seconds)**		
		75 Degrees/4-G	**79 Degrees/5-G**	**81 Degrees/6-G**
5	500	12.0	9.8	8.5
	300	9.2	7.0	6.1
	100	4.3	3.8	3.3
10	500	7.0	6.2	5.4
	300	5.2	4.5	4.2
	100	3.0	2.6	2.4
15	500	5.5	5.0	4.5
	300	4.3	4.0	3.8
	100	2.2	2.0	1.9

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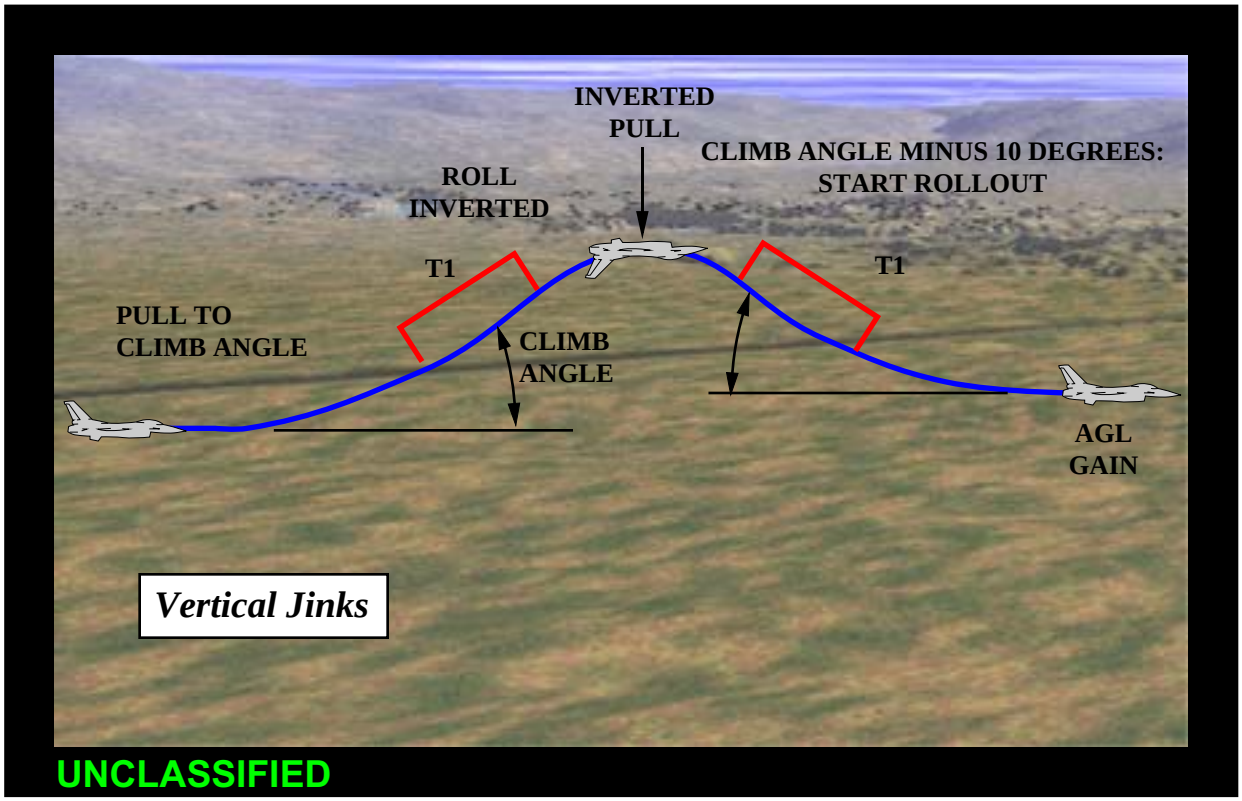
5.5.4.6.4.2 Another technique to develop turning room perception is to pick out an object to one side of the aircraft that you think is close to the turning flight path of the jet as you begin the turn. Observe the relative canopy movement of this object as you turn. If the aircraft is going to pass “outside” the reference object, the object will appear to move aft along the canopy during the turn. If the turn radius will pass “inside” the object, the object will appear to move forward towards the HUD, and then pass below the nose of the aircraft. These cues are subtle, but perceptible, during the initial part of the turn. The objective is to learn how to recognize, as early as possible during the turn, what the future flight path of your turning aircraft will be relative to terrain, and learn to adjust early-on to avoid terrain.

5.5.4.6.5 Vertical Jinks. Beginning at or above 400 KCAS, pull to a planned climb angle (not more than 30 degrees, delay 3 to 5 seconds) roll unloaded to inverted and pull through level flight to a dive angle 10 degrees less than the highest climb angle attained. (See **Figure 5.3**, Vertical Jinks.) Roll upright, hold the same delay as in the climb, and pull to straight and level. (***NOTE:*** Use the HUD pitch ladders to reliably determine dive angles. Use caution with high-pitch rates, because rapidly moving pitch lines are often difficult to read.) Accomplish multiple jinks up to 30 degrees and attain flight path angles within ±2 degrees and match all climb and dive delays within 1 second. This may also be accomplished in the oblique with a planned offset turn/bank. During the descent back to low altitude, apply the absolute dive recovery from **Table 5.2**, Absolute Dive Recoveries to recover to 500 feet AGL.

Figure 5.3 Vertical Jinks.



5.5.4.6.6 Reversals. Begin at planned altitude, level flight, and 400 KCAS minimum. The flight lead calls "(CALL SIGN), LEFT/RIGHT TURN," check turns or comeback calls to initiate level turns. Each pilot should concentrate on flying the directed maneuvers while usually monitoring the other aircraft. Emphasis must be placed on awareness of overbank and subsequent descent potential. Roll rates will be smooth and controlled with bank angle stabilized momentarily at 45 and 60 degrees before proceeding to 3 to 4 Gs.

5.5.4.6.7 Acceleration and Deceleration. Starting at 350 KCAS, accelerate in AB to 500 KCAS at 500 feet AGL. Maintain altitude while decelerating with speedbrakes and

then idle power until 300 KCAS. Select Mil power, close speedbrakes, and accelerate while maintaining altitude.

5.5.4.6.8 Visual Look-Out Exercise. This is designed to train pilots to visually clear the 6 o'clock area while maintaining a low-altitude profile. From straight and level flight at or above 500 feet AGL and 400 KCAS, keep track of flight lead position as flight lead maneuvers in a 45-degree cone 2,000 feet to 2 NM behind, from level to 4,000 feet high on the trainee. Strong emphasis must be placed on altitude, terrain changes, trim, stick pressure when looking aft, and task prioritization while checking six. The pilot must remain within ±50 KCAS with no descent rate. The pilot should also be able to visually keep track of flight lead position and estimate range within 1,000 feet. ***Do not sacrifice aircraft control to maintain the tally!***

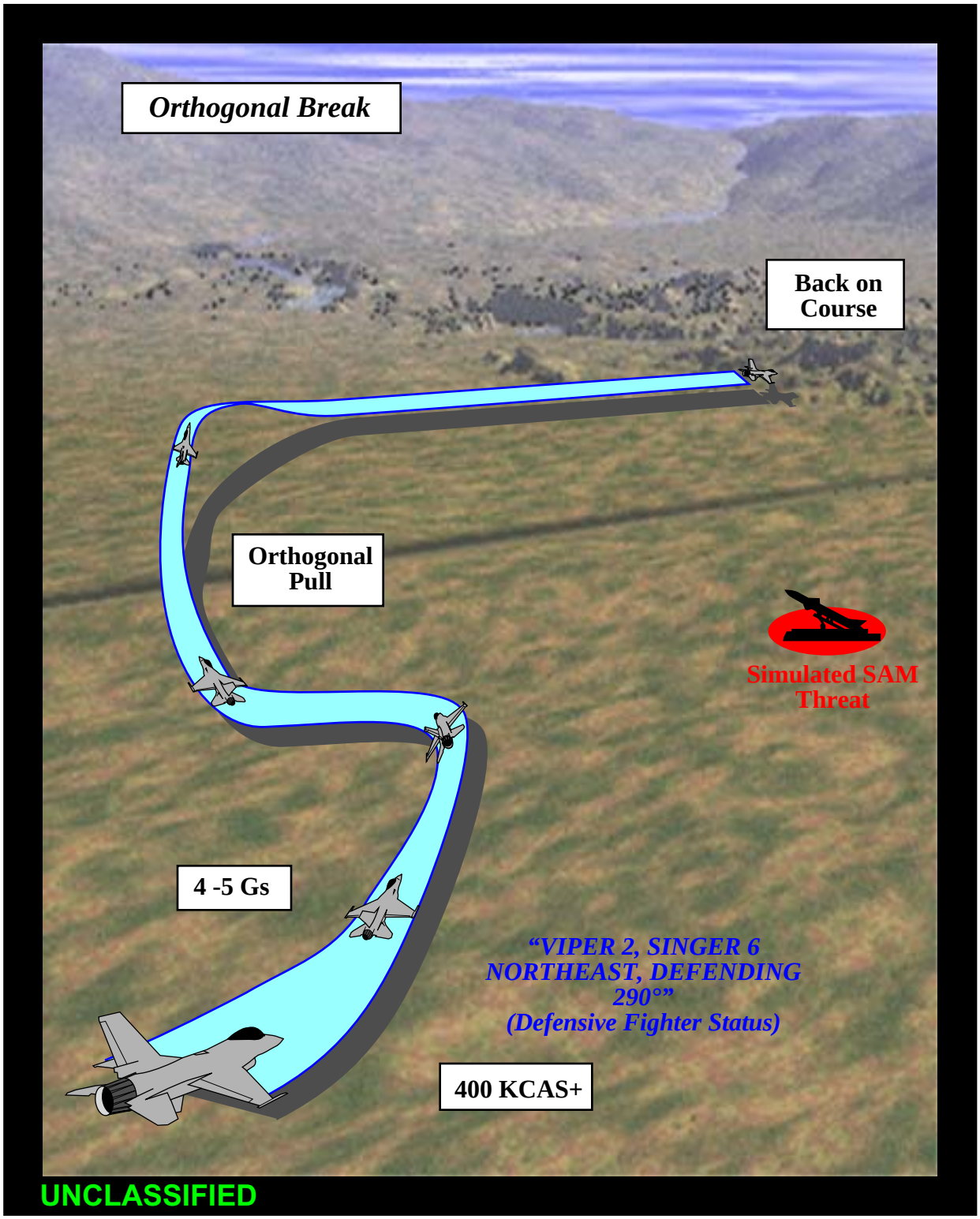
5.5.4.6.9 "S" Turns. This is a series of banked turns linked by unloaded reversals as defensive reactions to ground threats. Establish level flight and 400 KCAS minimum, roll to 60 to 70 degrees of bank and make a level turn away from the threat. Continue the turn for 90 degrees, perform an unloaded reversal to 60 to 70 degrees of bank and continue turn for another 90 degrees of turn. Perform an unloaded reversal and turn to the original heading. Altitude control should be within +100 feet/-25 feet of starting altitude.

5.5.4.6.10 Orthogonal Break. This maneuver is similar to the "last ditch" maneuver used to defeat a Surface-to-Air missile (SAM) that you have confirmed is guiding on your aircraft. From straight and level flight, 400 KCAS minimum, initiate a level hard turn to place the simulated threat at 3 or 9 o'clock. (See **Figure 5.4**, Orthogonal Break.) Simulating visual contact with the threat, start a hard out-of-plane pull perpendicular to the intercept axis of the threat. The perpendicular pull resembles part of a barrel roll as you continue to pull and roll to keep the threat at 3 or 9 o'clock until threat overshoot. Following the simulated "overshoot", you will be nose-high and probably between 30 and 90 degrees of bank. Note the maximum degrees nose high you got, and apply the 10 degree rule to drop your nose back below the horizon. Apply the dive recovery numbers applicable to the resultant dive angle.

5.5.5 Low-Level Navigation.

5.5.5.1 Dead Reckoning (DR). DR is a basic method for navigation and is based on flying a precise heading, at a precise airspeed, for a precise amount of time. With F-16 avionics, DR is not required as the primary method for navigation, but do not be led astray when the system points in the wrong direction (either through failure or incorrect steerpoint selection). Turning at the identified turn point is obviously the maneuver of choice. However, if the turn point is not found, the turn to the next destination must be made based on timing or on-board navigation systems.

Figure 5.4 Orthogonal Break.



5.5.5.2 Visually Assisted Navigation (Map Reading). Map reading (also called "pilotage") is the determination of aircraft position by matching checkpoints on a map with their corresponding terrain or man-made features on the ground. Checkpoints should be features or

groups of features which stand out from the background, are easily identifiable, and avoid known threats as much as possible. Over enemy territory, avoid large towns and lines of communication (LOC). The basic procedure is to select a feature on the map and then find it on the ground, rather than work from the ground to the map. Steps for success follow.

- In flight, align the course line on the map with the nose of the aircraft so that features on the map appear in the same relative position as landmarks on the ground.
- Determine the approximate map position of the aircraft by cross-checking elapsed time on the clock versus the time marked on the map, as well as INS mileage from programmed turn points.
- Cross-check your location with a significant checkpoint near this approximate position.
- It is important to work from the map to the ground since the map may not portray all features on the ground.
- If you are uncertain of your position, check every detail before confirming a checkpoint. Where a landmark is not available as a ground reference, fall back to DR/INS procedures and turn on time/INS.

5.5.5.3 Computer-Assisted Navigation. The INS provides information to aid navigation and may be relied upon to assist navigation once it is proven reliable. Considerations when verifying navigation systems are as follows:

5.5.5.3.1 Heading. To verify the precomputed heading, turn to the planned heading and then cross-check the destination bearing on the horizontal situation indicator (HSI). The HUD NAV steering bar/symbol is wind corrected and will be centered on the FPM when tracking directly for the destination.

5.5.5.3.2 Ground Speed (GS). Cross-check adjusted indicated airspeed/Mach against GS. At usual low-level density altitudes, GS will be slightly higher (approximately 5 to 10 percent) than indicated. Also, verify GS by comparing INS miles-to-go versus time-to-go. For example, at 480 knots GS, when the distance measuring equipment (DME) indicates 24 NM to go to the destination, elapsed time should be 3 minutes less than the turn-point time. Adjust indicated airspeed only after confirming that the computer speed is reliable.

5.5.5.3.3 Position. The distance readout on the HSI (NAV) can be used to confirm the distance-to-go to a particular turn point or target and help to confirm present position.

5.5.5.3.4 Time. Time-to-go (TTG) information on the HUD should also correspond to the map and NAV DME versus GS. In addition, FCC/general avionics computer (GAC) time-over-steerpoint (TOS)/time-over-target (TOT) can be compared with computed real-times for very accurate timing adjustment.

5.5.5.4 Route Timing. The objective is to hit the target on time. Starting the route on time, at the planned airspeed and heading, will help work towards achieving this objective. As a technique, allow some delay time between the planned takeoff and the start-route time. This extra time should compensate for late takeoffs, delays en route, or unforecast winds. Although flying faster than programmed, or cutting off part of the route can be used to

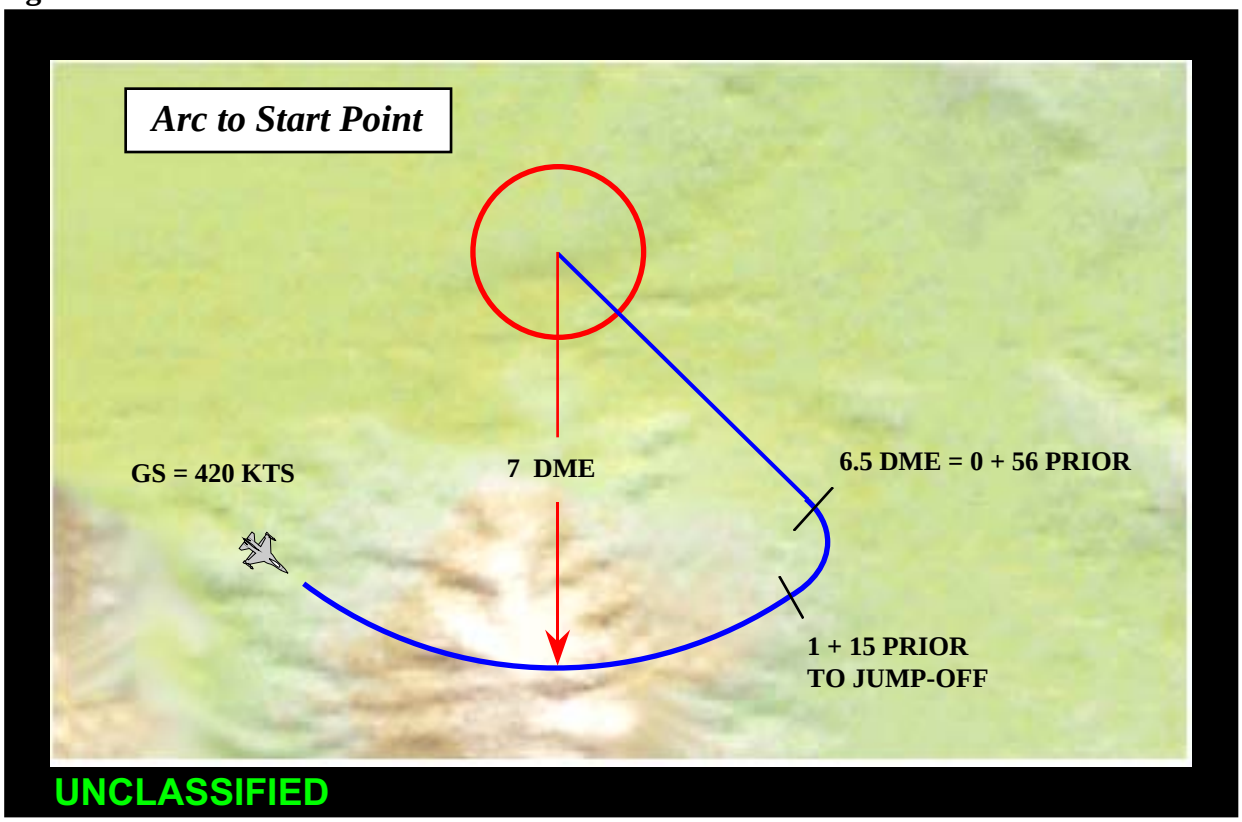
make up time, fuel or threats may not allow it. Depending on the situation, it may be better to adjust TOT/TOS rather than burn excessive fuel to make up time. Be aware of the maximum route adjustment for the mission, both for time and fuel considerations.

5.5.5.4.1 Early Arrival. If you takeoff as planned, or early, delay arriving at the start-route point. Use the TOT/TOS to help pick a speed. If, after slowing to the minimum practical speed for your configuration and threat level, TOS function still displays early arrival, some techniques are:

5.5.5.4.1.1 Start the route early and fly the first few legs slower than planned until on time. Maintain tactically sound airspeed.

5.5.5.4.1.2 Arc around the start point until you compute it, then it is time to turn towards it. Figure the time to fly direct from present DME to the point, add 15 seconds for a 60-degree bank turn of greater than 90 degrees and turn to the start point that much before planned jump-off time. (See **Figure 5.5**, Arc to Start Point.)

Figure 5.5 Arc to Start Point.



5.5.5.4.1.3 Hold in a Racetrack pattern, either en route or at the start-route point. ATC restrictions may require that you fly the pattern in the route structure, so know where you should and should not hold.

5.5.5.4.1.3.1 Method One: A viable variation of the TOT/TOS clock technique is to start the turn inbound, using a steep angle of bank (approximately 60 degrees), when the clock shows a 30-second early arrival. In order for this method to work, holding airspeed must equal route airspeed, and you must plan

to be 180 degrees from the inbound course when 30 seconds early occurs. This method works well when holding in a threat area.

5.5.5.4.1.3.2 Method Two: Use GS required on the TOS page. Turn in and accelerate with 3 to 4 Gs when the required GS is 50 knots below desired route speed. This method also requires you to plan to start 180 degrees from the inbound course, and is best used when holding more than 15 NM from the selected steerpoint. The primary advantage to this method is that holding is accomplished at lower power settings (saves fuel).

5.5.5.4.2 Time Adjustments. If crossing the start point at the hack time, fly the programmed GS. There is a ROT for adjusting speed to get back on time. For example, increase or decrease GS, configuration permitting, by 1/6 (for 480, change 80 knots) and hold the correction 1 minute for every 10 seconds you are off time. Normally, F-16 pilots take a more “macro” view and try to get on time by the next steerpoint, changing speeds until the FCC/GAC computed arrival time matches the planned time. If the required speed change is too great, try for on-time 2 or 3 points further down track. You can also gain or lose time by turning early or overshooting turn points.

5.5.5.5 TOT/TOS Clock. The FCC/GAC projects the elapsed time to a selected event and display it in the HUD. In the NAV mode, the event is TOS overflight, in CCRP it is time-to-release, and in low-angle drogue delivery (LADD) it is time to pull-up followed by time-to-release (TTR) after passing the pull-up point. The FCC/GAC, once given TOS times, can by used to display a real-world time estimate to the next point. Mode selecting the TOT clock then results in an airspeed caret being displayed in the HUD indicating the speed necessary to arrive at the selected point on time.

5.5.5.5.1 Delta TOS. The use of the delta TOS function provides an easy method for making changes to the TOS/TOT. The pilot inputs the correction as a positive or negative value, and the FCC applies the correction to all TOS entries. The brevity code to change the TOT/mission execution time is “ROLEX (plus/minus)”. Remember, IAW MPM, ROLEX commands are always referenced from the original planned TOT/mission execution time. Delta TOS does not work that way! If the mission is “ROLEXed” five minutes, you enter +00:05:00 in the Delta TOS. If the mission is later “ROLEXed” ten minutes (remember, that is ten minutes from the original time) you enter +00:05:00 again, yielding a total addition of ten minutes.

5.5.5.6 Flying the Visual Low-Level Route. Cross your start point at the briefed altitude, on time, on airspeed. Hack the clock if necessary.

5.5.5.6.1 Determine whether or not you have any INS drift with reference to your HUD steerpoint diamond or any initial timing error.

5.5.5.6.2 Establish low-altitude referring to the cockpit altimeter, radar altimeter, and outside references. Emphasis at the start route point should be on the transition to low altitude. Tasks such as formation position, reading the map, hacking the TOS clock, and checking six should be done prior to low-altitude transition, or after you are established at low-altitude wings-level flight. ***NOTE:*** Minimize heads-down time at the start

route point. This is a critical time, during the flight and attention to the velocity vector and altitude awareness cannot be over emphasized.

5.5.5.6.3 Adjust airspeed/GS to remain on time. Cross-check clock time at each turn point to confirm overall timing.

5.5.5.6.4 Remain on course by frequently cross-checking time/map/ground at predetermined points. To update systems, fly over or near the turn point. If an update is not required, flying directly over a point is not necessary. Remember, turn points are references to get to the initial point (IP) and target on time. If you do not visually acquire the turn point, turn when the INS indicates arrival or on-time.

5.5.5.6.5 Avoid these common tendencies:

- Power creep. Set, leave, and cross-check the exact throttle setting desired. Find a fuel flow that holds computed GS and return to this value after any throttle transient.
- Altitude variations. Strive to maintain the pre-briefed AGL altitude for that portion of the mission. Reduce tasking to maintain that altitude. If tasking must override altitude awareness, climb to cope. Cross-check altitude at known steerpoints, then return to “eyes out.”
- Insidious heading changes. Cross-check heading to preclude course deviations resulting from poor heading control. Check aircraft rudder trim to center the “ball.”

5.5.5.7 Flying the Radar Low-Level Route. Although radar navigation is the same as visual navigation in most respects, there are certain differences that require emphasis. Remember that the radar can improve system navigation accuracy.

5.5.5.7.1 Radar MSA. These altitudes must be indicated on the map. Cross the start point on altitude, with the same considerations as in visual navigation. The autopilot can be useful in maintaining above radar MSA while freeing your hands for other tasks. ***Altitudes must be monitored.*** To verify DR calculations of position, when using the radar, use the TIMS checklist as shown at **Table 5.4**, TIMS Checklist.

Table 5.4 TIMS Checklist.

T=Time	Check the time and find your approximate timed position on the map.
I=INS	Check your timed position with the heading and distance to the next turn point.
M=Map	Locate your approximate position on the map and determine the prediction of the point of interest.
S-Scope	Check the radarscope to verify your prediction, thus your position. If nothing can be positively identified, return to the clock and start the procedure over.
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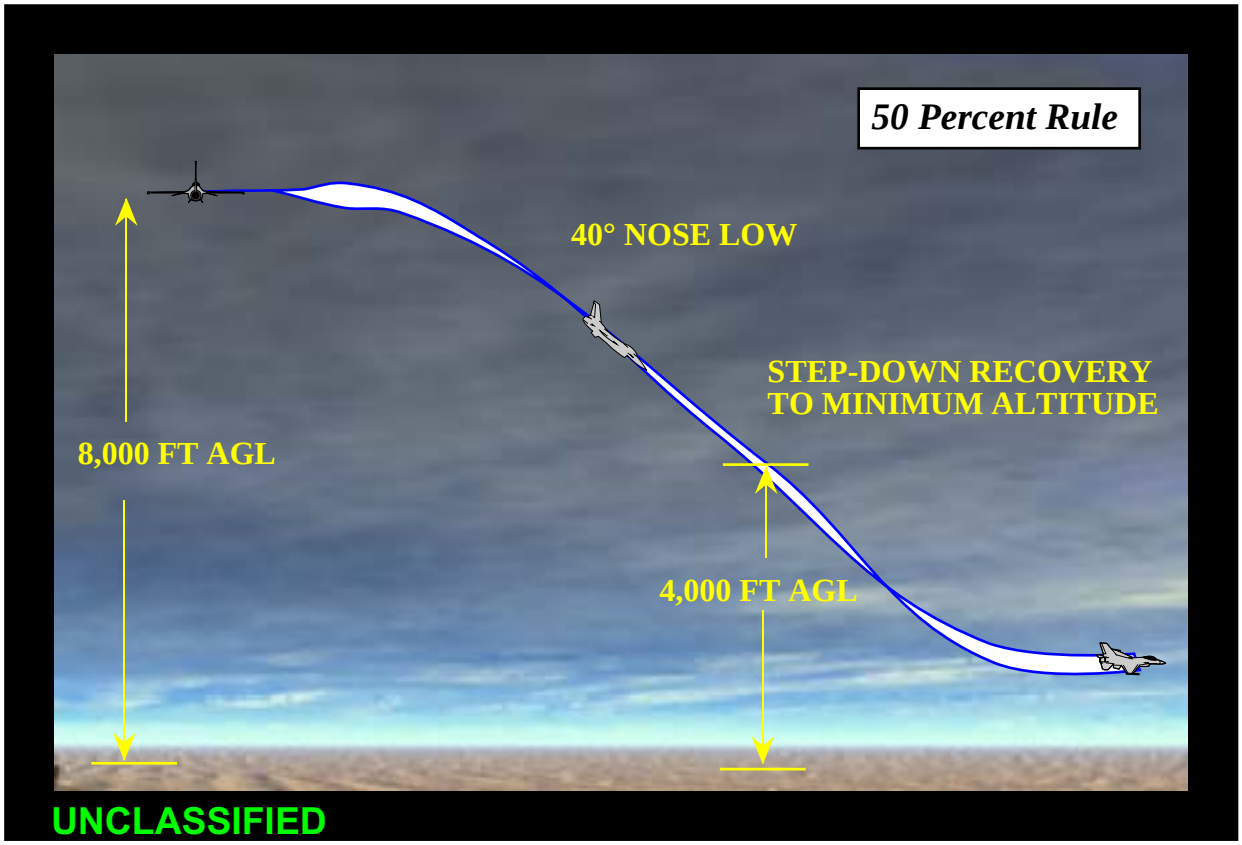
5.5.5.8 Low-Altitude Maneuvering. There are many challenges during low-altitude operations requiring special emphasis due to increased risk for collision with the ground. Descents into the low-altitude structure and ridge crossings are two examples. Although

these are discussed fundamentally, these principles apply when performing additional tasks such as high-to-low intercepts, pop-up bombing attacks, or threat avoidance during ingress and egress.

5.5.5.8.1 The 50 Percent Rule. For high-low transitions, the 50 percent rule is used to determine maximum safe flight path angle for descent into the low altitude structure. Up to a 90-degree turn may be safely accomplished during the 50% rule roll-in. (See **Figure 5.6**, 50 Percent Rule.) The dive angle is equal to 50 percent of the pre-roll-in altitude AGL in hundreds of feet. For example, if your current altitude AGL is 4,000 feet, you can safely accomplish a 90-degree roll-in to a maximum 20-degree dive. If you are 2,000 feet AGL, 10 degrees is the maximum. This rule is easily applied to any situation requiring a rapid descent, such as initiation of All Aspect Missile Defense (AAMD), repositioning on a target from a pop-up, or when rolling in on a tactical target from a Wheel pattern. Obviously, because of the variability associated with roll-in techniques, this rule is not precise. However, the 50 percent rule does prevent the gross incorrect estimates of safe dive angles based on false human perceptions of AGL altitude.

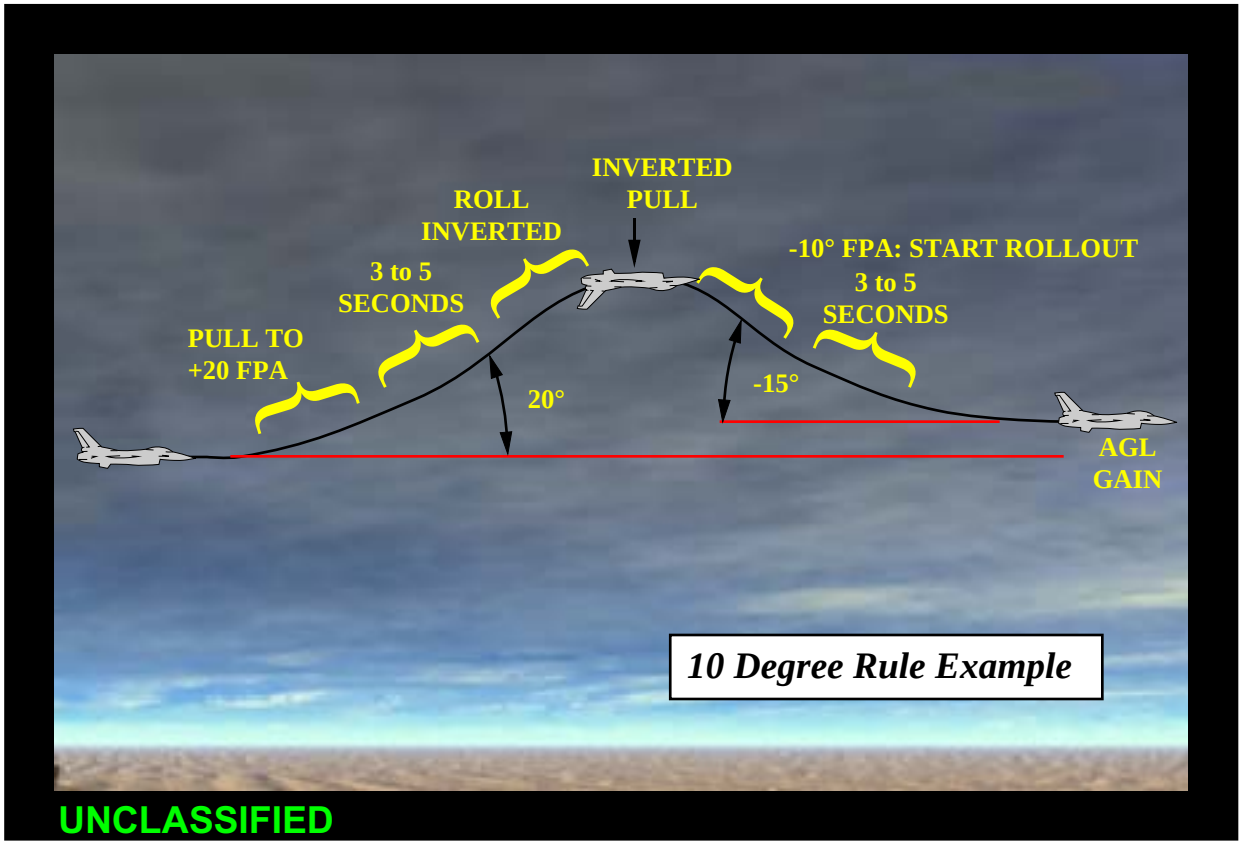
Figure 5.6 50 Percent Rule.



5.5.5.8.2 The 10-Degree Rule. The 10-degree rule applies to low-high-low maneuvering such as pop-ups and vertical jinks over flat terrain. Start altitude is irrelevant; it relies on the control of time and geometry to ensure ending altitude clearance. The 10-degree rule allows a return to low altitude after a timed climb. Climb at a set angle,

for a certain time, roll inverted and pull down to a dive angle 10 degrees less than the climb angle, roll out (dive angle increases 5 degrees during roll), hold the dive for the same number of seconds as in the climb, then recover. In **Figure 5.7**, 10-Degree Rule Example, climb angle is 20 degrees, climb is held for 5 seconds, roll out is started at 10 degrees of dive (the nose drops an additional 5 degrees), the dive is held for 5 seconds, and then the pull out is accomplished. The 10-degree rule allows unlimited tactical use of the aircraft's vertical maneuvering envelope while ensuring safe terrain clearance. The descent is 5 degrees less than the climb, making it an altitude-gaining maneuver. However, there are several factors which define this maneuver's limits. First, the rate of pull down must be equal to or faster than the rate of pull up. Second, airspeed during the pull up and pull down should be similar. Time control is imperative. Simply add extra time to the climb portion of the maneuver in order to give more buffer.

Figure 5.7 10-Degree Rule Example.

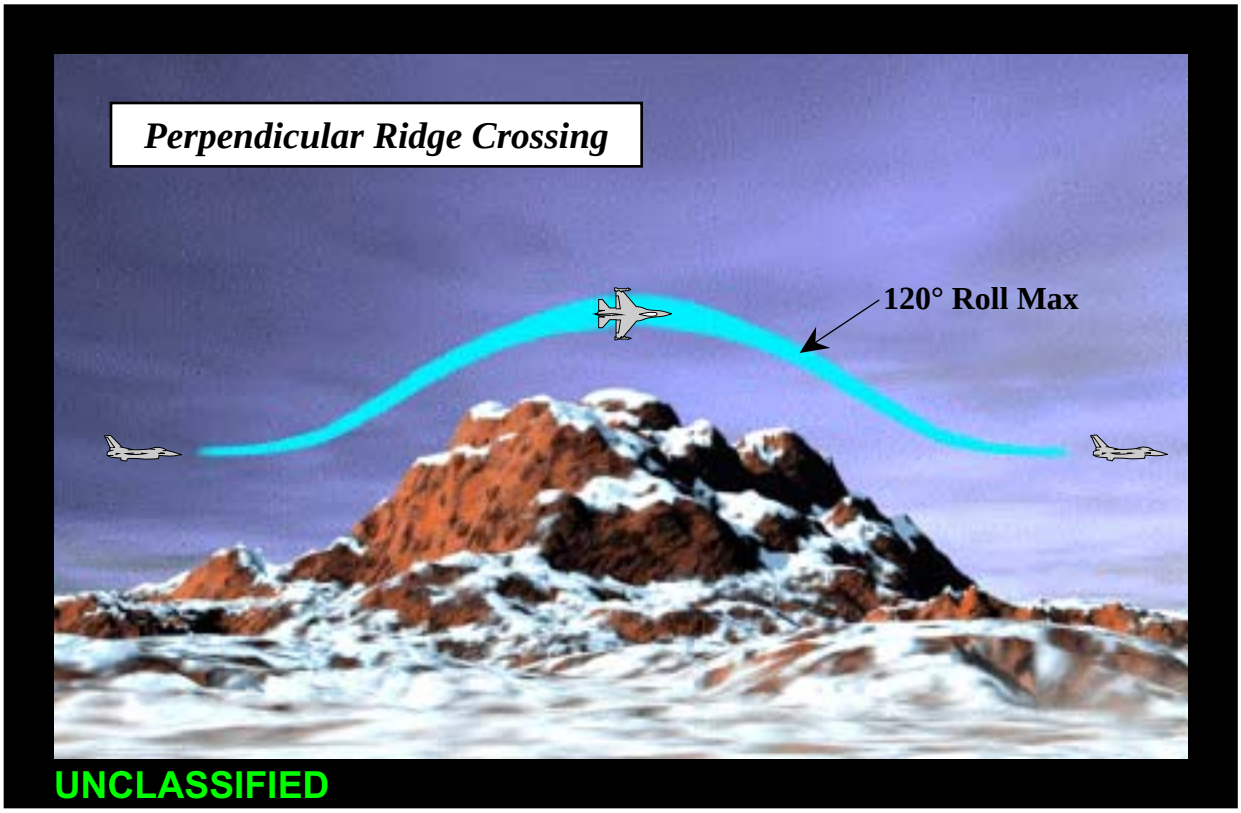


5.5.5.9 Ridge Crossings. Crossing ridgelines is a dangerous move. The aircraft is highlighted to threats, so avoid ridge crossings if at all possible. Many situations force you to cross ridges. If possible, cross a ridge at its lowest point, or in a saddle. Sound planning, and practice of ridge crossing techniques, can be a great aid. Three techniques are commonly employed: perpendicular, parallel, and paddle.

5.5.5.9.1 Perpendicular. This crossing minimizes enemy radar or visual acquisition but should be done only when you know your six is clear. Use power as required to maintain tactical airspeed during the pull up. Pull early to avoid a large overshoot

crossing the ridge, and crest the ridge at your specified minimum low-level altitude. Go down the back side and either bunt or roll and pull. Totally inverted pull downs are prohibited. At the crest, unload and roll to approximately 135 degrees, then slice down. At the desired nose-low position, roll out and resume low-level flight. Initial attempts at this technique should be limited to a 15-degree nose-low attitude. Do not bury the nose in the new valley. This maneuver may put you belly up to unexpected high terrain on the other side of the mountain, and the wing flash during the maneuver is highly visible to threats. The roll and pull technique is most effective when crossing large, steep, and isolated ridgelines. A bunt or pushover is more appropriate over milder, rolling terrain. The pull-up for a bunt or pushover should be initiated early enough to avoid excessive ballooning over the ridge. The advantages of the bunt are straight-line navigation, no wing flash, and less disorientation. (See **Figure 5.8**, Perpendicular Ridge Crossing.)

Figure 5.8 Perpendicular Ridge Crossing.



5.5.5.9.2 Parallel. Use this type of approach if your six is, or may be, threatened. It can deny the bandit a blue-sky background and provide a difficult guns environment. Turn to arrive at the pull-up point with approximately 45 degrees of crossing angle to the ridge. Pull up later than for a perpendicular crossing, and continue to turn in the climb to end parallel to the ridge crest just below the top. Roll and pull into the ridge; cross the crest at your specific minimum altitude. Continue a loaded roll to fly down the backside of the ridge, on a heading 90 to 135 degrees from the ridgeline. Roll out and continue. (See **Figure 5.9**, Parallel Ridge Crossing.)

5.5.5.9.3 Saddle. The saddle type ridge crossing is similar to the parallel and can be used when threatened. Turn to parallel the ridgeline below the crest until you can use a saddle, canyon, or the end of the ridge to cross to the other side. The exact maneuver is dictated by the terrain characteristics, but can be similar to a level turn. (See **Figure 5.10**, Saddle Ridge Crossing.)

Figure 5.9 Parallel Ridge Crossing.

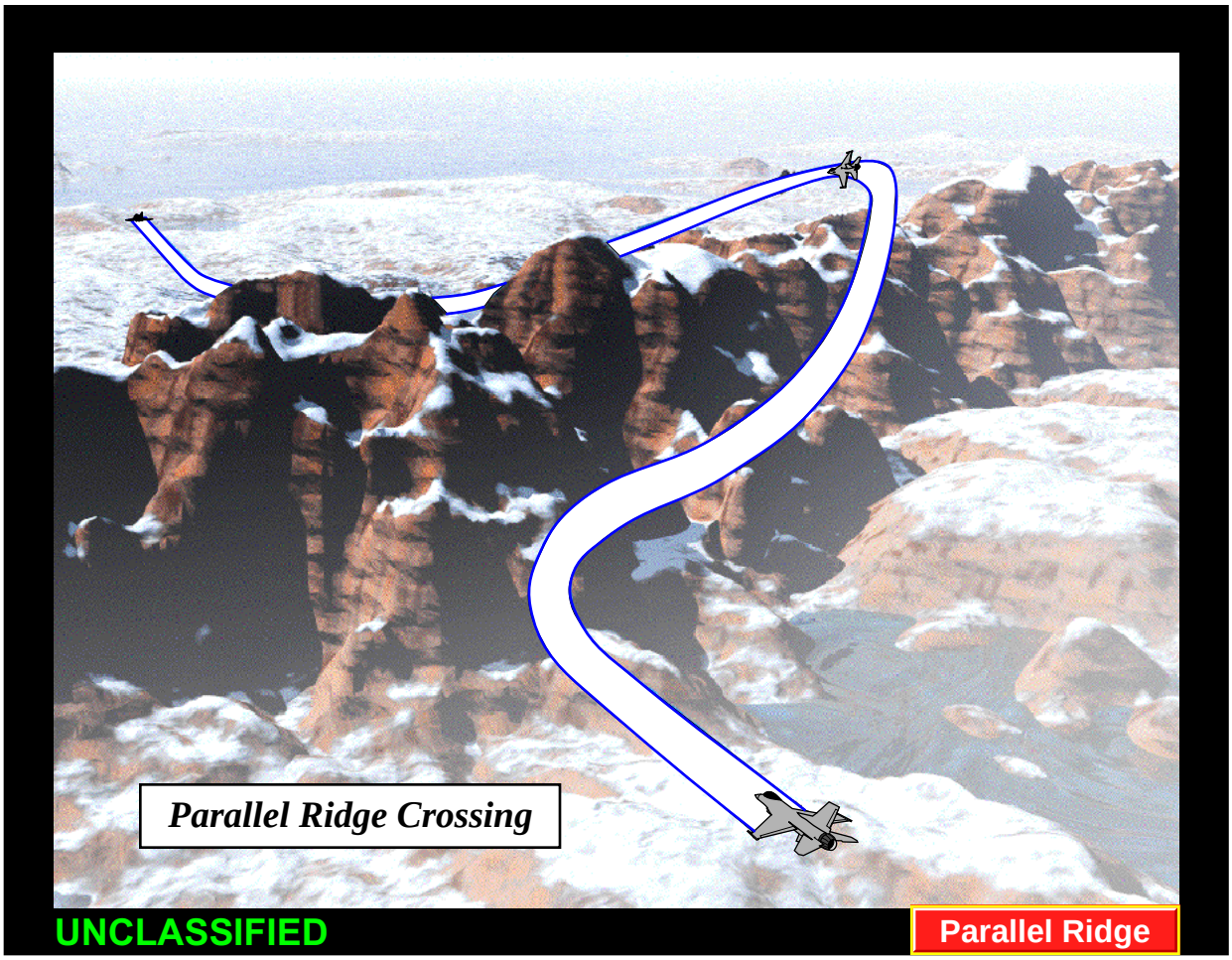
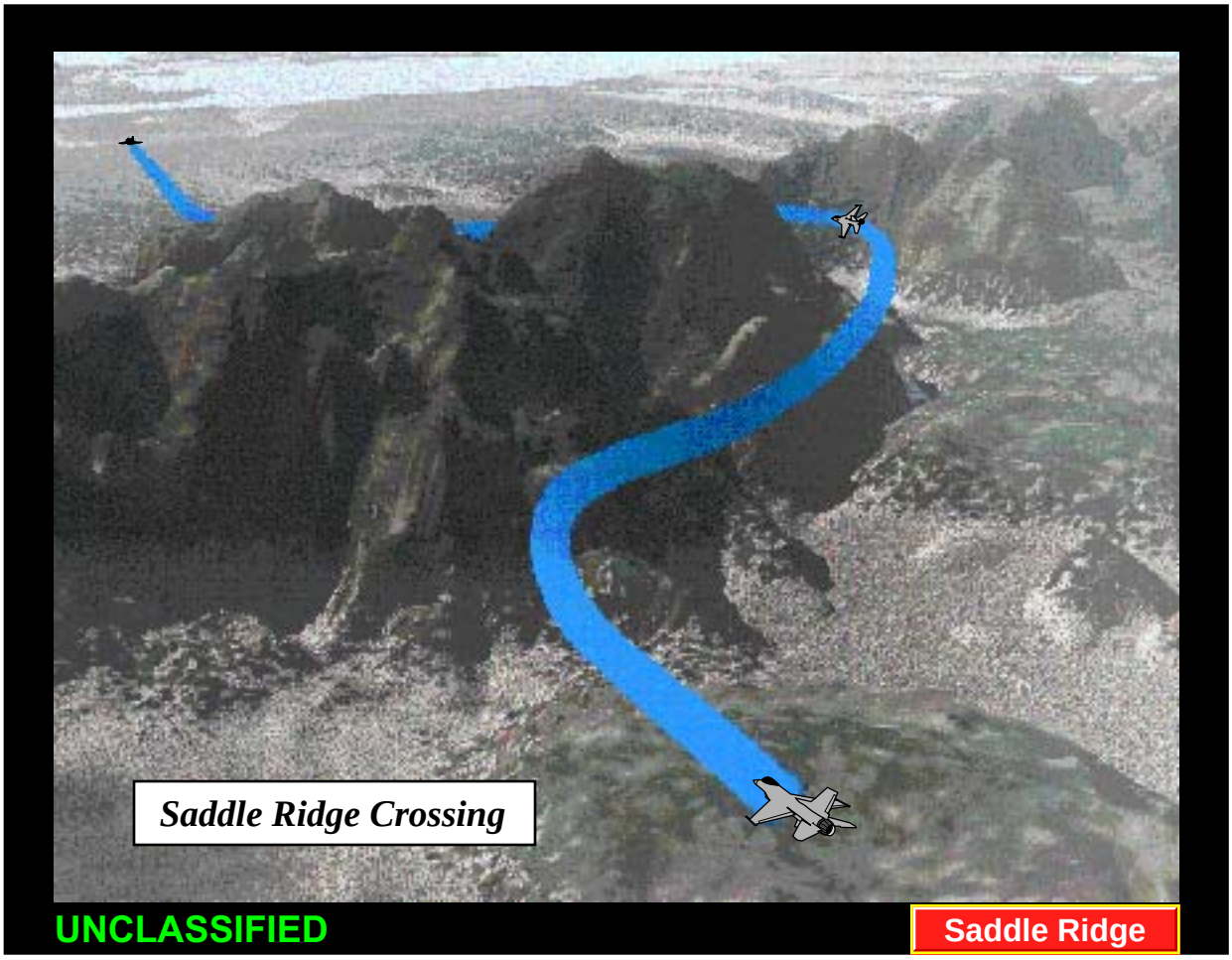


Figure 5.10 Saddle Ridge Crossing.



5.5.5.10 Emergencies/Abnormal Operations at Low Altitude. Emergencies may happen at 500 feet and below, but you do not "handle" them there. Items such as aircraft malfunctions, bird strikes, disorientation (loss of awareness), lost sight (wingman) and weather deterioration are critical at low altitude and need something such as an "initial move" prior to even looking at the problem. To generalize the handling of unusual occurrences, a response has been developed that covers all problems at low altitude: climb to cope. Climb any time you are not coping with your situation. Then, after initiating a climb, maintain aircraft control, analyze your situation, and turn toward the appropriate landing field or continue your mission as appropriate.

5.5.5.11 Route Abort Procedures. The best route abort plan is one executed well before the flight encounters instrument meteorological conditions (IMC). Constantly monitor down-track weather either visually or with snowplow on the radar. If possible, alter the route to maintain visual meteorological conditions (VMC). If unable, clear the wingmen to fighting wing and execute a 180 degrees turn to maintain VMC, allowing the trailing element to follow. Another option is to execute a hook left/right and allow the previously trailing element to lead out. As a last resort, if IMC is encountered, lead should transmit "VIPER 1, ROUTE ABORT." At this time, flight members should slightly turn away from the element mate's last position while selecting AB and establishing a 30-degree nose-high

attitude. Transition to flight instruments is critical. Deselect AB and level off at or above the RAA/MSA IAW the briefed game plan or VMC as appropriate. Trailing elements should avoid IMC by using the desired avoidance procedures, if able. Stay VMC-squawk EMERGENCY if required or still IMC. Large packages require a detailed flight briefing for the desired route abort procedure.

5.5.6 Medium-Altitude Considerations. Flying at medium altitude is another viable option for target area ingress and egress in certain circumstances. The same planning process must occur when selecting the altitude flown. Threat avoidance, early warning detection, and aircraft performance are but a few considerations.

5.5.6.1 Navigation. The same techniques for DR and map reading at low altitude apply at medium altitude with these exceptions:

- Easier to see the "big picture" in front of the aircraft.
- Turnpoints must be selected on the basis of distinct identification from higher altitudes. For example, choose the major highway interchange versus the dirt road/railroad intersection or the mountain peak versus the small ridge.
- Weather must be considered as well (e.g., low fog).

5.5.6.2 Cockpit Tasking. Medium-altitude ingress allows the pilot, based on task load, to fixate inside the cockpit for longer periods of time. More radar work can be accomplished; more time is available to monitor the cockpit displays. Medium altitude may be the correct option when the major threat is AAA.

5.5.6.3 Medium-Altitude Advantages:

- Better range and endurance potential.
- Threat avoidance from certain systems; especially AAA and man-portable air defense systems (MANPADS).
- Easier navigation when weather is not a factor.
- Higher potential energy.
- More time available to work aircraft systems and to interpret and recognize details from target study.
- Simpler attack geometry is possible.
- Your air-to-air missiles have longer ranges

5.5.6.4 Medium-Altitude Disadvantages:

- Vulnerable to certain threat systems.
- Easier detection by threat due to radar LOS.
- Threat is not isolated above you; 3-dimensional threat attack axis exists.
- Less aircraft performance dependent on configuration.
- Enemy Air-to-air missiles have longer ranges.

5.6 Computed Visual Bombing. Although the computed weapons delivery capability of the F-16 can make up for imprecise pilots, the system can get bombs closer to the target by flying

smooth, accurate parameters. The planned parameters ensure frag clearance, desired impact angle, fuze arming, or burst/function altitude for weapons. Varying the dive angle changes fuze arm, safe escape, and minimum recovery altitudes. A running aim-off distance (AOD) due to improper G can produce an excessively fast pipper ground track and prevent a good bombing solution. A steady AOD slows the pipper ground track rate and provides a better bombing solution, improving accuracy.

5.6.1 Choosing a Delivery Option.

5.6.1.1 The F-16, with its sophisticated avionics package, gives the pilot several visual bomb delivery options. The method of delivery is dependent upon the aircraft systems available. Specifically, ordnance is typically released in the following ways:

- CCRP.
- CCIP.
- DTOS.
- Strafe.
- Manual Delivery.

5.6.1.2 A computed delivery is obviously preferred due to its accuracy and independence from pre-calculated dive angles, airspeeds, altitudes, and winds. Computed delivery is dependent; however, upon the following:

- An operable FCC.
- Accurate INS alignment (good INS velocities).
- An accurate ranging reference (radar, system altitude, targeting pod [TGP], DTS-derived passive ranging, and radar altitude [RALT]).

5.6.1.3 AGR inoperative. If CCIP, DTOS, or strafe is required and AGR is bad (or the FCR has failed), go to backup ranging (barometric PR/BARO/RALT) by turning the FCR to STBY, or selecting OVRD. BARO requires an accurate system altitude and the current steerpoint elevation must be the same as actual target elevation. RALT requires level terrain under the final attack path, PR requires an operable DTS system. Perform a RALT ACAL if so equipped.

5.6.2 Manual Delivery. If the FCC is inoperative, there is no choice other than to deliver manually. This can be done with the help of the HUD, which will still provide airspeed and altitude scales along with pitch lines.

5.6.3 Target Study. In order to identify the target, you have to know what it looks like. The type of delivery and weapon used tailors your target study. All pilots should be very familiar with their assigned desired mean point of impact (DMPI) and backup DMPIs through target photographs and map study.

5.6.4 Dive Recovery. Any ordnance delivery requires a proper recovery for three basic reasons: (1) to avoid the weapon frag envelope, (2) to avoid hitting the ground, and (3) for safe separation if the weapon detonates prematurely. Perform the correct planned recovery maneuver on every pass. Plan to release at or above the MRA or abort the delivery.

5.6.5 Continuously Computed Impact Point. Initiate the CCIP delivery mode by selecting air-to-ground. Verify the appropriate attack profile, correct weapon, single/pair option, number of release pulses, spacing, and fuzing selection prior to roll in (preferably at FENCE check and the IP). Place the master arm switch to MASTER ARM and check for a SMS RDY indication and ARM in the HUD. Select the target steerpoint to ensure correct target elevation if the system reverts to BARO (PR and RALT back-up modes are independent of selected steerpoint elevation). From CCRP, with roll-in parameters met and the target positively identified, select CCIP by depressing the missile step button. Use a smooth roll in and roll out, compensating for the wind. Do not let the FPM fall below the planned dive angle during the roll-in. Lead the roll out to put the bomb fall line (BFL) through the target with the appropriate target-to-FPM Initial Aimoff Angle relationship.

5.6.5.1 Initial Aimoff Angle (IAA) and Initial Aimoff Distance (AOD). **Figure 5.11**, Initial Aimoff Angle, shows the correct picture at the roll-out for a 20 degree LALD with a planned IAA of 3.6 degrees. Concentrate on maintaining the FPM on the planned dive angle during the initial portion of and at rollout, immediately assess initial aimoff angle (IAA). Adjust IAA if required and then “freeze” the resultant dive angle. This will establish and maintain the correct AOD for the resultant dive angle, even if no visual reference exists for the AOD. If a visual reference exists for the desired AOD point exists, and the aircraft is on the correct “wire”, another technique is to pull the FPM toward the visual aim-off point.

WARNING: If you are on a low wire, using the originally planned aimoff point for the correct wire (i.e. pulling the nose up just enough to set the FPM on the originally planned aimoff point) can place you dangerously low at pickle. Correcting a low wire requires a longer AOD than originally planned. The IAA techniques described here will automatically correct for a low wire and insure you release above MRA. As experience builds, you can begin to assess IAA as soon as the target enters the HUD, prior to and during the rollout. (See **Figure 5.12**, High Wire., and **Figure 5.13**, Low Wire). As mentioned before, do not allow the nose to drop below planned dive angle during the roll-in. With the planned dive angle captured as the target enters the HUD, assess IAA as you begin the roll-out.

Figure 5.11 Initial Aimoff Angle.

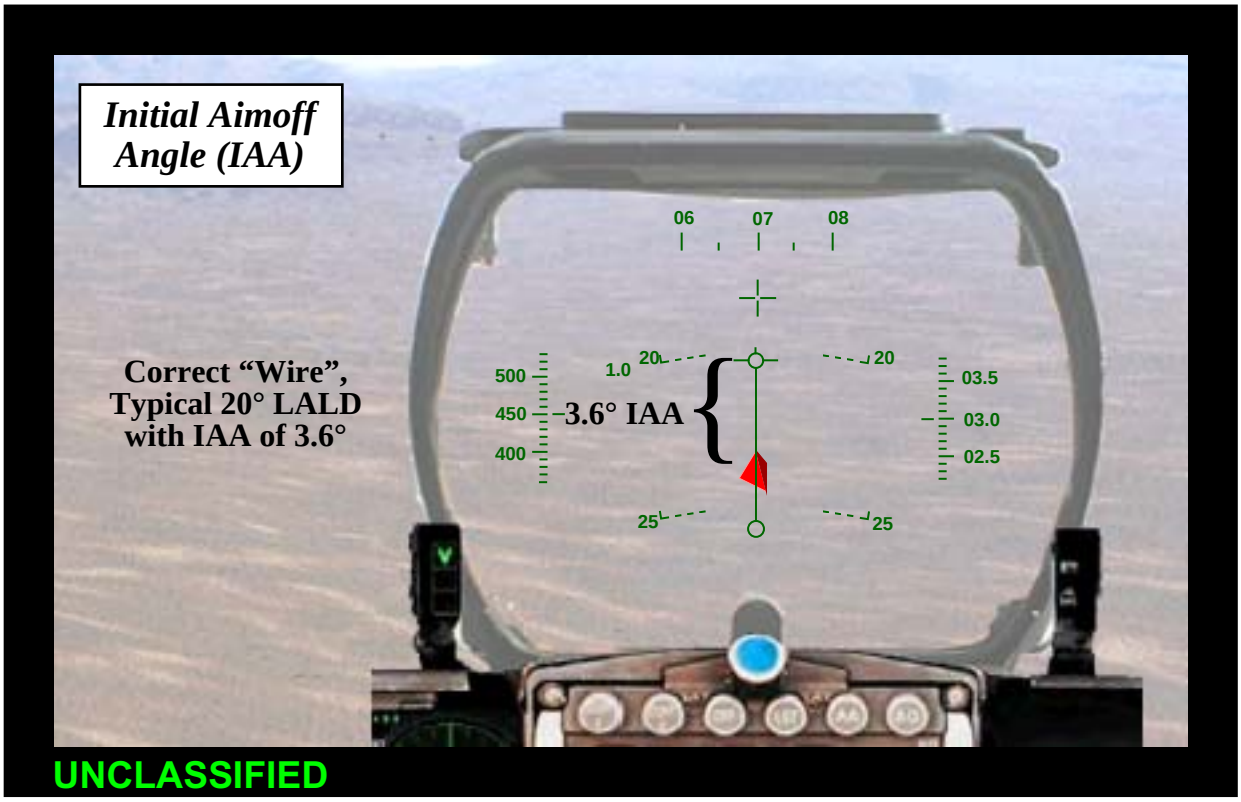


Figure 5.12 High Wire.

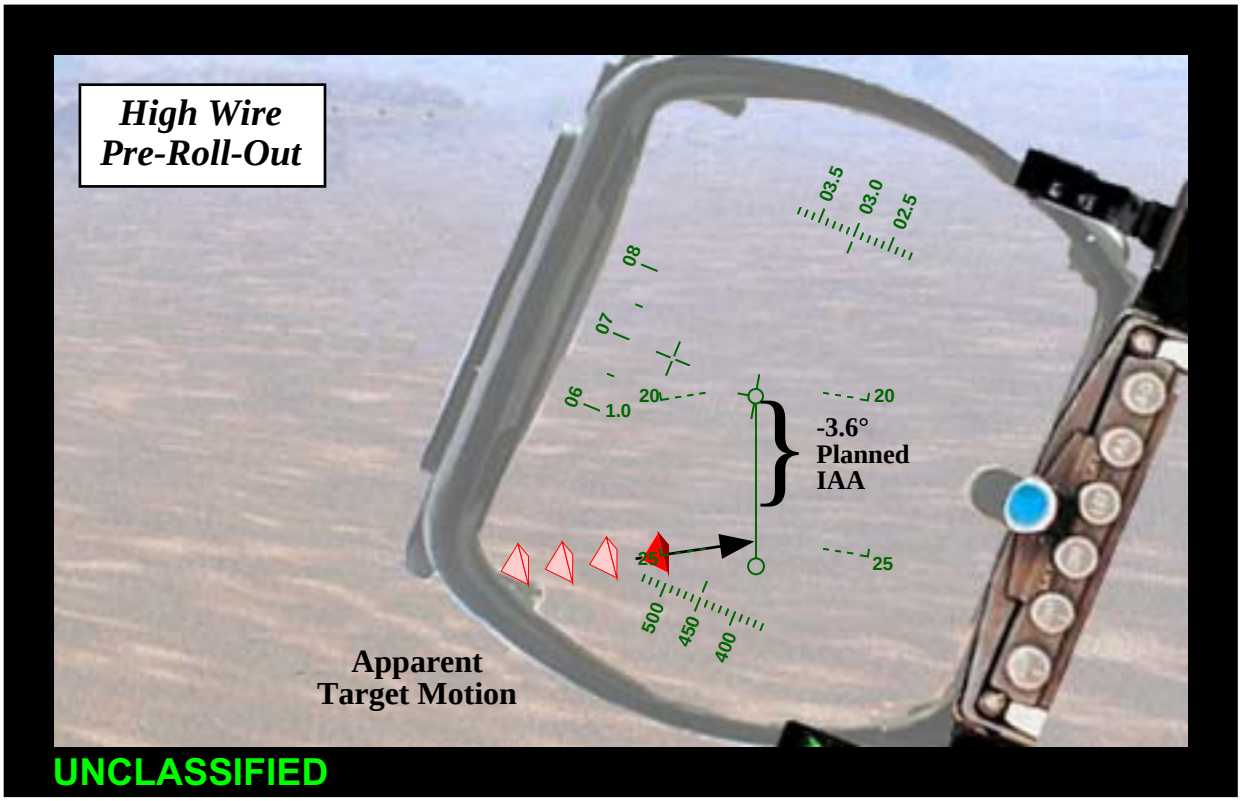
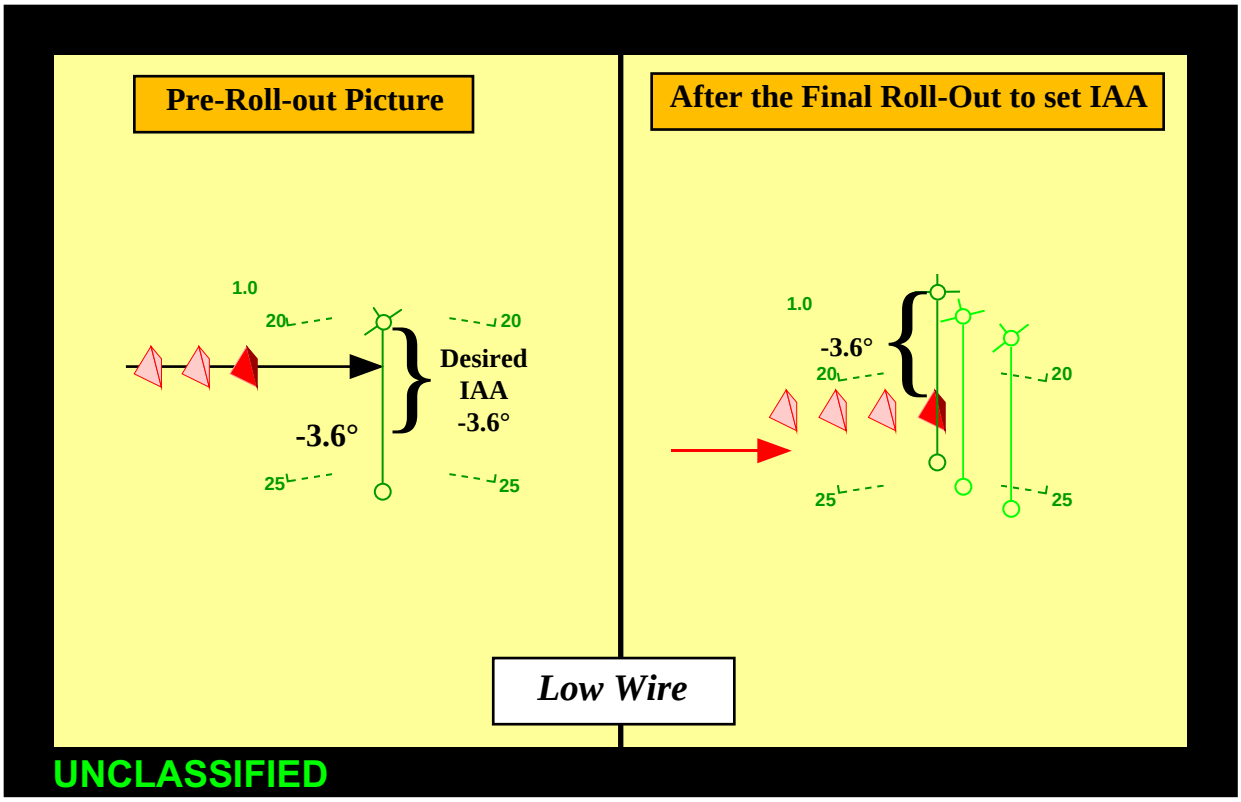


Figure 5.13 Low Wire.



5.6.5.1.1 High Wire. If IAA is greater than planned, you are on a high wire. If you assess that adequate track time will exist after roll-out to get the pipper on the target, just hold the resultant dive angle and accept the resulting short time on final and high pickle altitude. If you need an extra second or two on final, you can bunt (steepen your dive angle) up to the point your FPM is at the planned IAA (or on the visual AOD), or you reach the training rule limit (5 or 10 degrees steep, as applicable). Since IAA is only a valid parameter at the roll-out point, make this correction immediately. With experience you will learn to slightly steepen the dive angle prior to roll-out (if required), as soon as the IAA high wire relationship becomes apparent as the target approaches and enters the HUD. Continually assess altitude above planned release altitude (PRA). Do not pickle below PRA if you are steep. (See **Figure 5.12**, High Wire.)

5.6.5.1.2 Low Wire. If IAA is less than planned, you are on a low wire. Immediately pull the FPM up until the correct IAA exists between the target and FPM. This should put the FPM longer than the originally planned visual AOD. With IAA set, freeze the FPM on the new point on the ground, and track the BFL through the target. Continually assess minimum release altitude (MRA) and do not pickle below MRA. (See **Figure 5.13**, Low Wire.)

5.6.5.2 CCIP final attack. Once IAA is set, hold the FPM steady on its current ground reference and allow the CCIP pipper to approach the target as you steer out any azimuth errors. Do not pull the FPM up in an effort to rush the pass unless you predict pickling below your planned minimum release criteria. This “banana pass” results in a higher than planned release, and degrades delivery accuracy. If you determine the pipper will not get to

the target before PRA/MRA, decrease the dive angle by increasing the AOD. Setting the planned IAA as soon as you roll out on final, then holding the resultant AOD, should correct for all potential final attack errors. Pickle with the CCIP pipper on the target and immediately accomplish the applicable safe escape maneuver. (See **Figure 5.14**, CCIP.)

Figure 5.14 CCIP.

5.6.5.3 Pickle Technique. Pickle when the CCIP pipper reaches the target. Pickle and hold your release G until all bombs are released. Avoid the tendency to “quick pickle” as this could inhibit release with a delay cue or result in a partial release. A technique to avoid this is to hold the pickle button down until established in the safe escape maneuver (SEM).

5.6.5.4 Winds. Since CCIP is a computed delivery mode, the effects of winds are automatically compensated for by the FCC wind model. The pilot's job is to get the pipper over the target; to do that you must consider the winds. A headwind/tailwind component is automatically corrected by the FCC moving the CCIP pipper up or down along the BFL. Adjust base position to compensate for winds to ensure the correct dive angle is achieved. If there is a headwind on your attack/roll-in axis, then move your base position closer to the target. If a tailwind is present, then move your base position farther away.

5.6.5.5 Crosswinds. Most of the crosswind correction is made by drift stabilization of the FPM and associated symbology. As long as the drift cutout switch is in the NORM position, the technique of placing the FPM upwind and the BFL through the target causes the nose of the aircraft to crab into the wind. This crabbing causes the aircraft to fly over the target, thus compensating for most of the crosswind. The BFL slopes to the downwind side. Under these conditions you may wish to place the BFL slightly upwind of the target

on the initial roll out. Do not use drift cutout while in the CCIP mode. If drift cutout is selected, the FPM and BFL are not displaced downwind; however, the pipper still shows the impact point. Thus, the line between the FPM and pipper is angled excessively, the aircraft is in a near-constant bank to keep the target under the BFL.

CAUTION: During deliveries from high altitude, bomb time-of-fall is long, and winds may be very high from jetstream effects. Crosswind component from high altitude roll-ins may be so great that the HUD field of view is too small to display the crosswind correction. In other words, the FPM and CCIP will be pegged against the side of the HUD with "Xs" in them. Drift Cut-out will not fix this problem. It will center the FPM, but the pipper will still be pegged against the side of the HUD. To avoid this, note the crosswinds, and plan roll-in to align with the wind direction (headwind or tailwind).

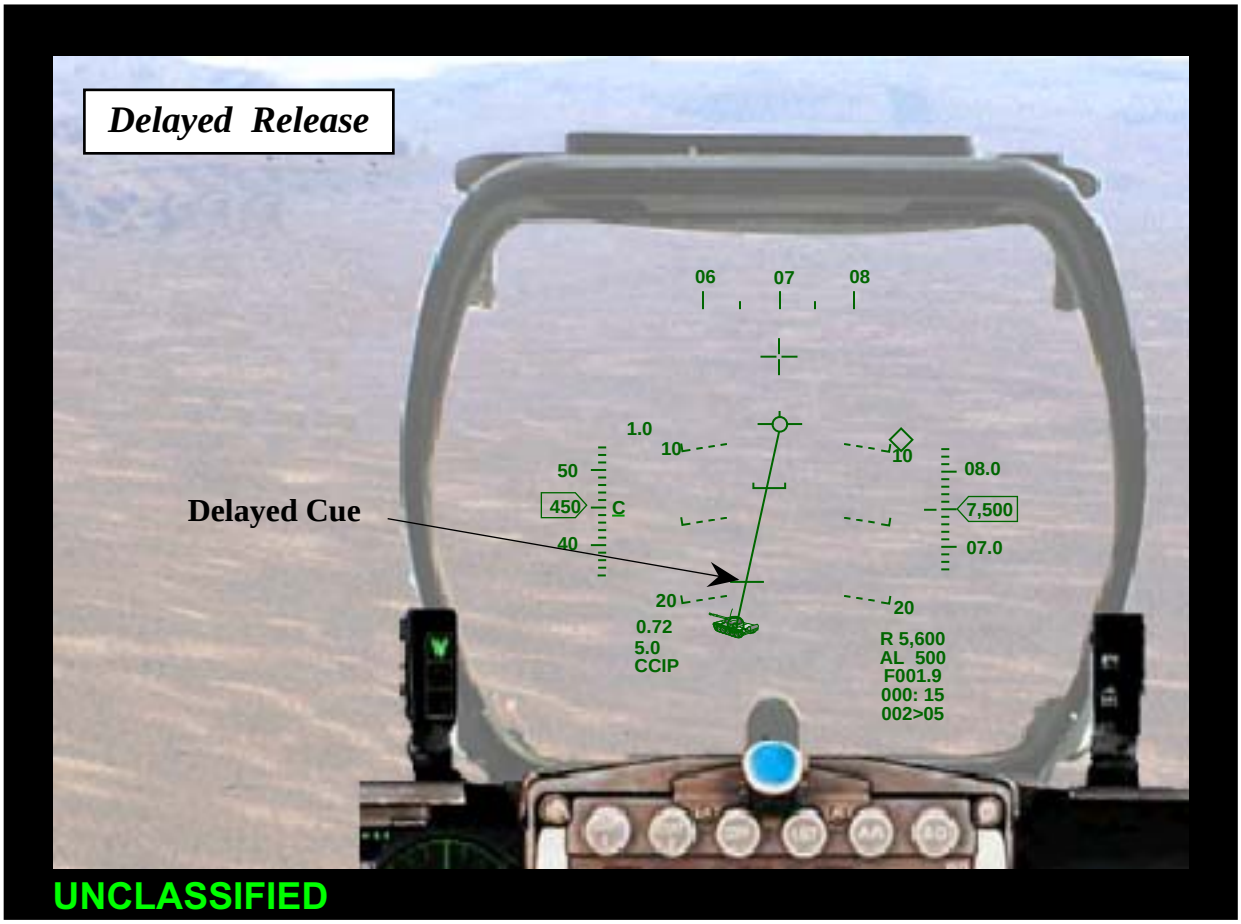
5.6.6 Continuously Computed Impact Point Delayed Release. For release conditions where the bomb impact point is below the HUD, the CCIP pipper cannot be positioned low enough at the instantaneous impact point. In this situation, the CCIP pipper is positioned approximately 14 degrees below the boresight cross and a time delay is computed, based on the difference between the pipper position and the actual impact point. The presence of the delay cue indicates that this situation exists. The delay cue is weapon and aircraft parameter dependent, but you can generally expect a delay cue if your planned attack calls for a manual mil setting greater than 230 mils. Strong headwinds, shallow dive angle, and slow airspeed on the attack are also parameters that commonly lead to delay cues. This delivery is the same as the normal release until the point of pickle. If the delay cue is present, hold the pickle button depressed. Steering symbology appears and the CCIP pipper remains over the target. Fly the FPM to the steering line to null any steering error while holding the pickle button. Release occurs when the solution cue reaches the FPM. In most situations the delay is very short (less than 1 second), and post-designate symbology may not be apparent prior to release. Ensure that maximum employment G is not exceeded prior to release while executing the dive recovery if minimum altitudes are approached. Release occurs when the FPM begins flashing coincident with the actual release of ordnance. It is a good habit to hold the pickle button down until well after release (technique: FPM through the horizon). This ensures that you get all bombs off when rippling a string of bombs.

WARNING: To minimize the possibility of an accidental live AAM firing, release the pickle button before switching to an air-to-air mode. (See **Figure 5.15**, Delayed Release.)

5.6.7 Dive Toss. The DTOS mode is used primarily to accomplish low altitude toss (LAT) deliveries. Initiate DTOS by selecting air-to-ground, the appropriate attack profile for the weapon, and the DTOS delivery mode. The missile step button is used to step to DTOS from CCIP or CCRP. Verify single/pairs release pulses, spacing, and fuzing. Recheck master arm switch to MASTER ARM, RDY on SMS, and DTOS and ARM in the HUD. If you want AGR, check that the FCR is not in OFF/STBY/OVRD. DTS passive ranging is also an excellent DTOS ranging mode. If you want PR, ensure switches are appropriately set. Plan a longer final than is used for CCIP or manual events. Also, check the steerpoint selected. If the radar works properly, the steerpoint is not important. But, if the radar breaks lock for 3 seconds, the FCC uses the elevation of the steerpoint as the target elevation when computing a BARO solution. PR or RALT back-up ranging computations work the same as in CCIP. Roll out on final with

the aircraft flight path directly in line with the target. Designate the target by pickle or by TMS forward to ground stabilize the TD box and then slew it to the target. When using pickle and hold to designate, avoid slewing to a release solution due to over controlling of the TD box (i.e., if you designate and then slew closer to you, you may get a release inside of minimum range). To increase accuracy, try to keep the aircraft steady at 1.0G while slewing the TD box. IE: don't make the final slew as you're pulling or rolling. Get on steering and ensure you hold the pickle button down when the solution cue approaches the FPM. If dropping multiple Triple Ejector Rack (TER)-mounted bombs in a ripple release, relax G prior to the solution cue reaching the FPM. If you keep too much G on the airplane you may string your bombs too far apart to achieve desired weapons effects. At 10 to15 degrees nose high, with 4 Gs on the jet, the 60 millisecond minimum FCC-generated release interval for TER-mounted bombs precludes bomb impacts any closer than 300 foot spacing. Execute a frag avoidance maneuver after bomb release occurs to adhere to recovery minimums plus vertical or horizontal separation of the bomb frag. Know minimum stand-off range (typically 0.5 NM for Frag Avoidance) and do not violate it!

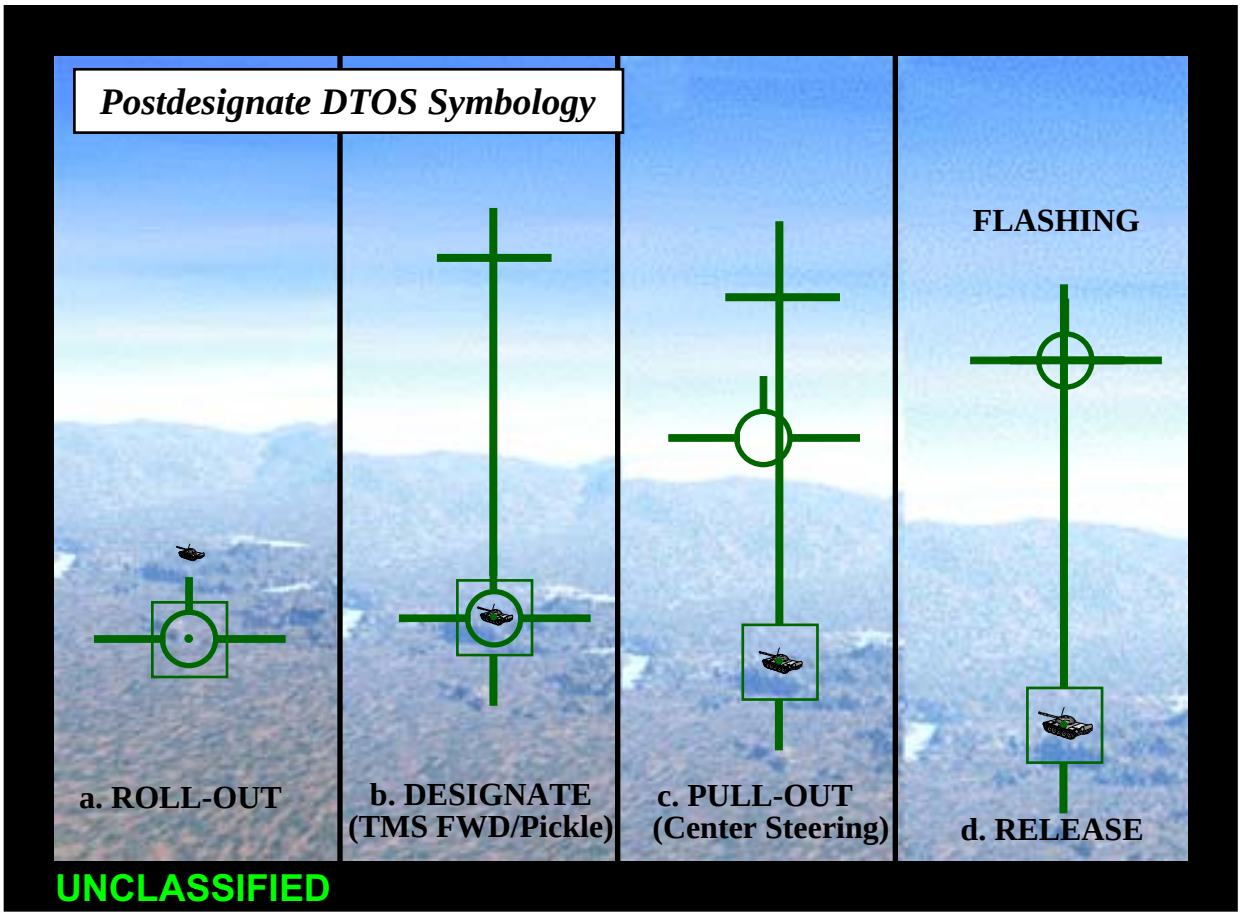
Figure 5.15 Delayed Release.



5.6.7.1 DTOS Symbology. After the TD box is ground stabilized over the target azimuth errors are controlled by steering the FPM to the steering line. When the target is at maximum toss range, a solution cue appears on the HUD along the steering line. The maximum

toss solution is based on the assumption that an instantaneous 5-G pull will be made to a 45-degree climb angle. Pulling greater than 5 Gs may result in short bombs or no release at all and, with some weapons, may exceed the stores limits. During a long range DTOS delivery, a maximum toss anticipation cue (100 milliradian circle) is displayed on the HUD 2 seconds prior to the solution cue display. When the solution cue is displayed, the anticipation cue flashes for 2 seconds, then disappears. Time-to-go to release is displayed in the lower right corner of the HUD. Bearing (in tens of degrees) and range to target are also displayed. As time-to-go approaches zero, the solution cue moves downward toward the FPM. Automatic release occurs when the solution cue intersects the center of the FPM, provided the pickle button is depressed. The FPM flashes at release. (See **Figure 5.16**, Postdesignate DTOS Symbology.)

Figure 5.16 Postdesignate DTOS Symbology.

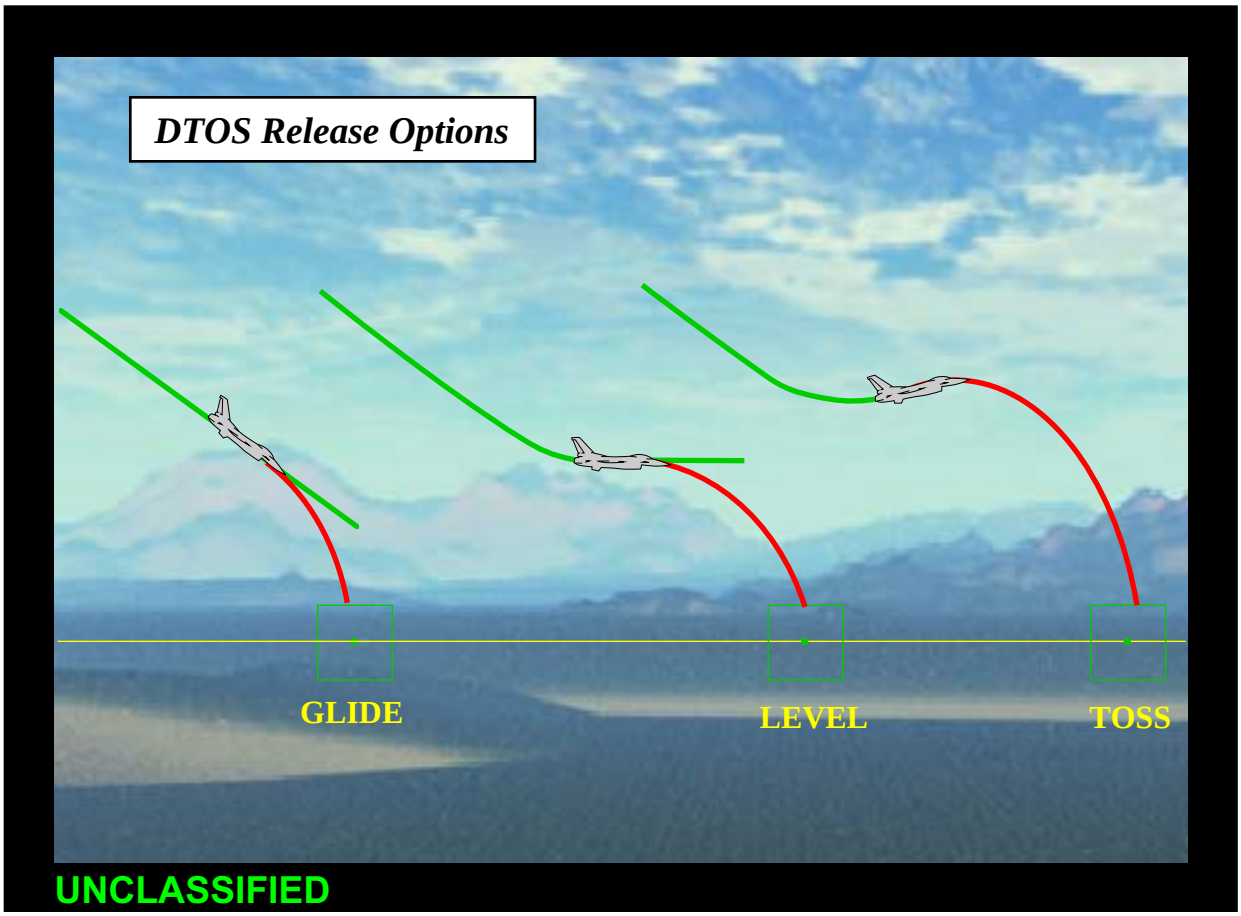


5.6.7.2 Point-Blank Aiming. Point-blank aiming (TD box on FPM) is the simplest DTOS method from a mechanical pilot skill standpoint. You can also “preslew” the TD box below the FPM. Some pilots find this helps them get the TD box on the target, but be aware of pendulum effect. When you designate, the TD box becomes ground stabilized and you can continue to slew to refine aiming. Designating with the pickle button and holding it until release is the easiest method. If designating with the TMS, depress the pickle button prior to the solution cue reaching the FPM. Hold the pickle button depressed until the solution

cue intersects the FPM and the FPM begins to flash to indicate release. The FPM continues to flash until the pickle button is released.

5.6.7.3 Climbing Release. Initiate a smooth pull keeping the FPM centered on the steering line. Continue to pull to remain outside the minimum release slant range. This can result in a toss, glide, or level release. After designation in point-blank aiming, watch the TD box for drift as you approach release. If toward 6 or 12 o'clock, an error is probable. If drift is small, refine aiming using the radar cursor/enable button to place the TD box back on the target. Note that movement toward 12 o'clock, followed by movement toward 6 o'clock is normal. If the TD box is off more than 5,000 feet laterally, the release is inhibited. Recage the TD box by either exiting the DTOS mode or selecting return to search (RTS). If you choose not to recage, the TD box remains ground stabilized. INS drift may cause the TD box to move. (See **Figure 5.17**, DTOS Release Options.)

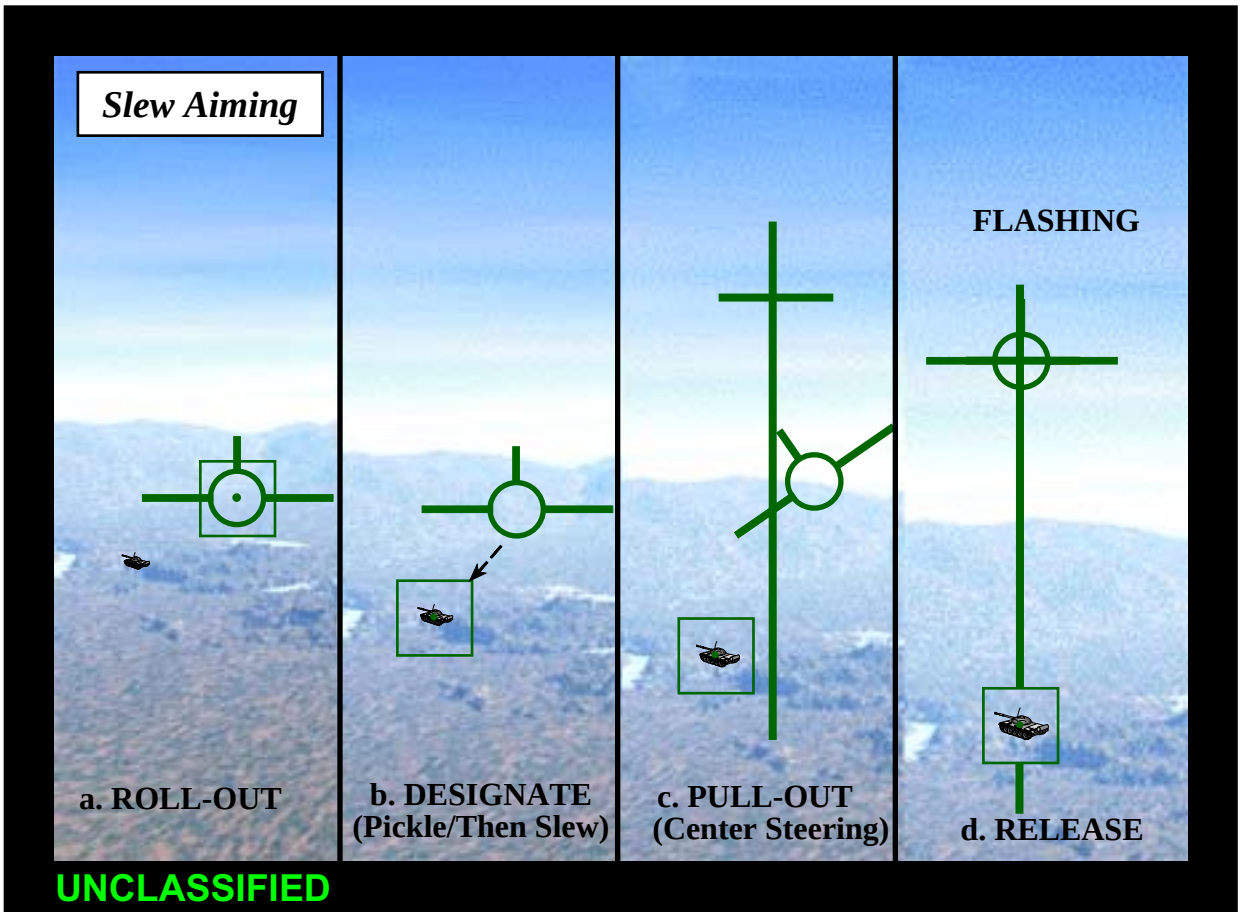
Figure 5.17 DTOS Release Options.



5.6.7.4 Slew Aiming. The method shown in **Figure 5.18**, Slew Aiming, provides maximum flexibility in tactical situations, but mastery is more difficult. It is possible to slew aim regardless of aircraft attitude as long as the aimpoint is within the HUD FOV. Remember that directional control of the TD box is always referenced to aircraft attitude. Develop slew aiming skill as follows:

- Roll out on final with the TD box on or near the target. One technique is to roll out with the TD box short of the target and smoothly pull it up to the target.
- Ground stabilize the TD box (designate or pickle). Another technique is to ground-stabilize the TD box as soon as the target is within the HUD FOV, prior to even rolling out. This allows immediate slewing as soon as you roll out.
- Adjust power, if necessary.
- Slew the TD box to the target. Use the cursor/enable button to slew the TD box (sensor of interest [SOI] in the HUD).
- "Fly" the FPM toward the steering line and select a release option based on range to the target.
- Continue to fly the FPM to the steering line until release.

Figure 5.18 Slew Aiming.



5.6.7.5 Azimuth Error. Observe the solution cue progress, keep the FPM on the steering line, and complete the delivery as described in point-blank aiming. If you have neglected to fly out the azimuth error while slew aiming and the solution cue is approaching the center of the FPM, you have three options:

- Abort the release (thumb off pickle button).
- Accept the error. If the error is more than 5,000 feet laterally, the release is inhibited.

- Fly out as much of the error as possible and accept the result. The closer the FPM is to the steering line, the better. Be careful not to violate current release limitations for the type bomb you are dropping.

5.6.7.6 Refining TD Box Position. Continue to slew after designation. In this case, the TD box is ground stabilized, move it over the ground rather than in relation to the FPM. In addition, each time you slew, the FCC takes a new range sample. Be extremely careful when slewing with the pickle button depressed; if slewing to 6 o'clock, the system may "see" a solution and release before you have a chance to correct. Refine TD box placement prior to initiating the pull up for a climbing release to minimize G-induced TD box lag in the HUD.

5.6.8 Computed Bombing Error Management. While the complexity of the system does not allow for easy error analysis, there is a way to organize computed error analysis which not only improves your bombs, but also results in better write-ups, and better systems lead to better bombs. GP bombs are far more accurate in delivery than BDU-33 practice munitions. Do not let the accuracy of BDU bombs in DTOS give you a false sense of inaccuracy with GP weapons. There are three main sources of error when the F-16 drops a bomb: you, the INS, or ranging.

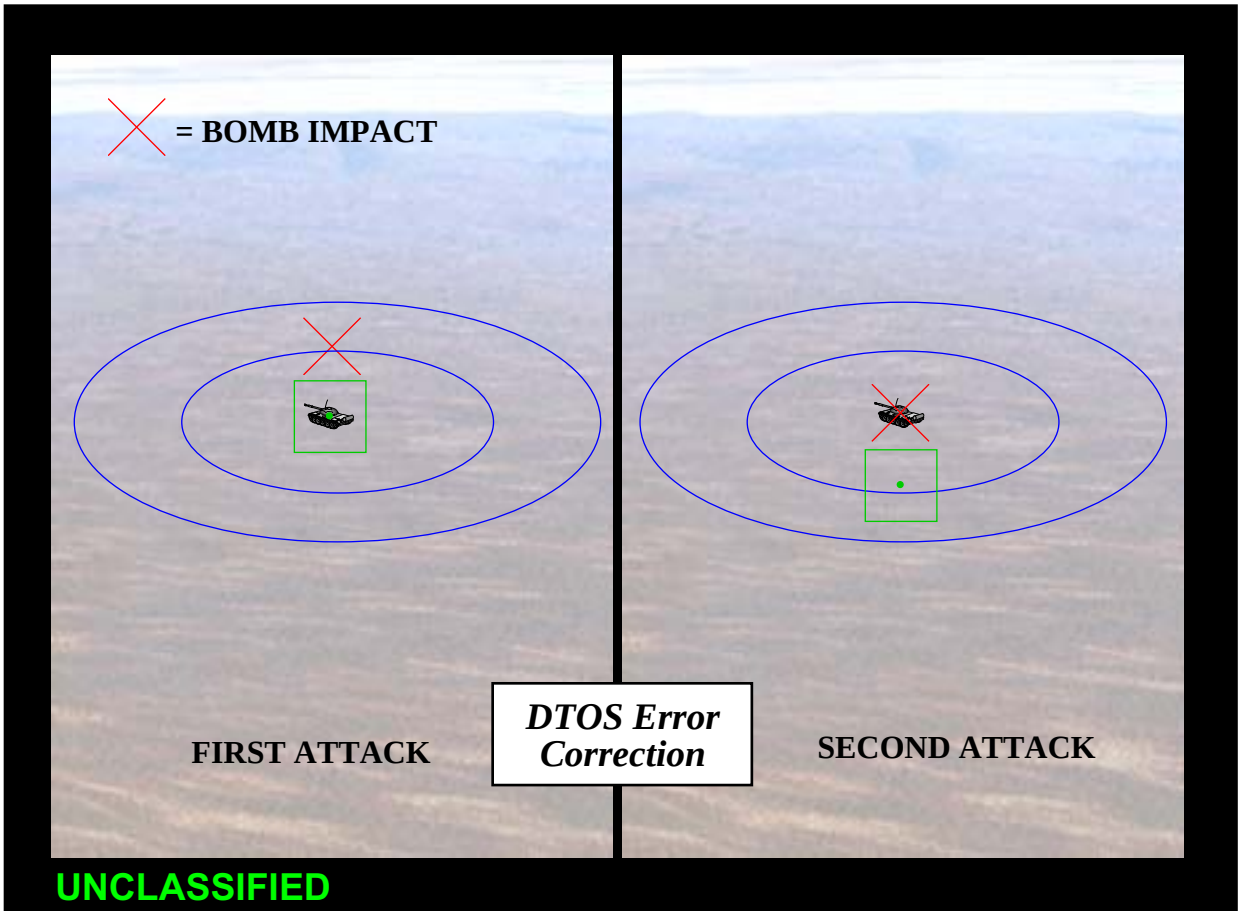
5.6.8.1 Pilot Error. Before you blame the INS or change the ranging mode, check yourself:

- Did you really designate/pickle with the TD box/CCIP pipper stabilized on the desired aimpoint?
- Were you pushing and pulling on the stick after designation?
- Accurate error analysis depends on having consistent parameters on each pass.

5.6.8.2 INS or Ranging Errors. Once satisfied that you are not the problem, there are some things you can do to determine whether the INS or the ranging mode is at fault. The first step is to understand these basic principles:

- Ranging errors cause 6/12 o'clock misses only.
- INS errors may be in any direction.
- The magnitude of an INS error depends on the time from designation to bomb impact (longer weapon range will equate to greater error).
- Correcting DTOS box placement on subsequent passes is fairly straight forward. (See **Figure 5.19**, DTOS Error Correction.)

Figure 5.19 DTOS Error Correction.



5.6.8.3 CCIP Analysis. The most common method for CCIP error analysis is the actual bomb impact versus the pipper placement at pickle. Large misses short or long are probably a ranging problem. Small misses short or long could be a ranging problem or boresight error. Rule of thumb: to correct a known error simply correct that same distance in the opposite direction. This can be accomplished by using offset aiming of the pipper or by using the DRNG mode for long/short and left/right corrections.

5.6.8.4 Canopy Coefficients/Boresight. Canopy coefficients are applied to the CCIP pipper and TD box, but not to the BFL. This sometimes results in what appears to be a misalignment of the symbology under certain conditions. For example, the CCIP pipper may not appear exactly on the end of the BFL. This is not unusual. Use the CCIP pipper for aiming even if it is slightly misaligned with the BFL. Bombing errors may be the result of inaccuracies in the three sets of coefficients that correct for canopy and camera errors. The first two, HUD and cockpit television sensor (CTVS), are listed on the canopy and/or in the aircraft forms. Squadrons should have a current listing of aircraft specific values used to verify coefficients. Verification is accomplished by accessing the list menu and miscellaneous page. If the camera numbers are different, insert the correct numbers into the FCC. Ask your squadron weapons shop where the most accurate coefficients are located.

5.6.8.5 Ranging Errors/Considerations. Selection of a ranging mode is critical when it comes to optimizing the hit probability. Several factors affect the choice of a ranging

mode. Is AGR working? Is DTS passive ranging available? Is system altitude significantly off? Are there radar jammers in the target area? A proper air-to-ground system check accomplished prior to the target is crucial for determining the optimum delivery mode.

5.6.8.6 Ranging Mode Selection. Assuming all modes are operating properly, radar or DTS passive ranging should be the primary ranging mode. AGR is probably a better choice for high angle deliveries. With a functioning DTS system, PR should give equal or greater accuracy to AGR at low radar graze angles. If you suspect AGR is in error or inconsistent, and DTS is not operable, and your system altitude is reasonable, BARO or RALT ranging may be preferable to radar ranging. Over relatively flat terrain, RALT ranging is the generally preferred backup mode if PR is unavailable. For BARO ranging, it is critical that the elevation of the selected steerpoint is equal to the elevation of the target and that system altitude is accurate. The effect of ranging and system altitude errors decreases with increased bomb impact angles.

5.7 Manual Weapons Delivery. In the event of complete system degradation, you may be forced to resort to manual bombing. Good manual bombing demands rigid compliance with delivery parameters. There are many conditions that might force you into a manual delivery. Some of these conditions might allow limited use of the HUD (such as FCC failure), but in general you only have the standby reticle and heads down instruments. If the HUD is operational, then the altitude, airspeed, and pitch scales (if available) may be useful in establishing parameters in certain circumstances.

5.7.1 Preparation and Planning. The following items should be accomplished even if manual bombing is not planned. The requirement to accomplish manual weapon deliveries is normally not predictable, so setting up your avionics for backup deliveries should become a normal habit pattern.

5.7.1.1 Before the Flight:

- Complete weapons employment data (AOD, mil setting, and initial pipper placement [IPP]) on the lineup card.
- Obtain current and forecast winds for each event.
- Compute an upwind aimpoint for the pipper at release.
- Determine the mil correction headwind/tailwind factors.

5.7.1.2 At the Aircraft:

- Turn on the standby reticle, confirm the aiming reticle is visible and set to the expected attack mil setting. ***NOTE:*** a maximum of 260 mils can be dialed in the standby reticle.
- Set up the SMS for a backup manual attack. One technique is to use “profile 2" in the SMS to have the capability to get to the manual delivery system with minimal switch changes. Make sure the correct intervalometer is set for the attack you intend to fly. The intervalometer sets the bomb spacing.

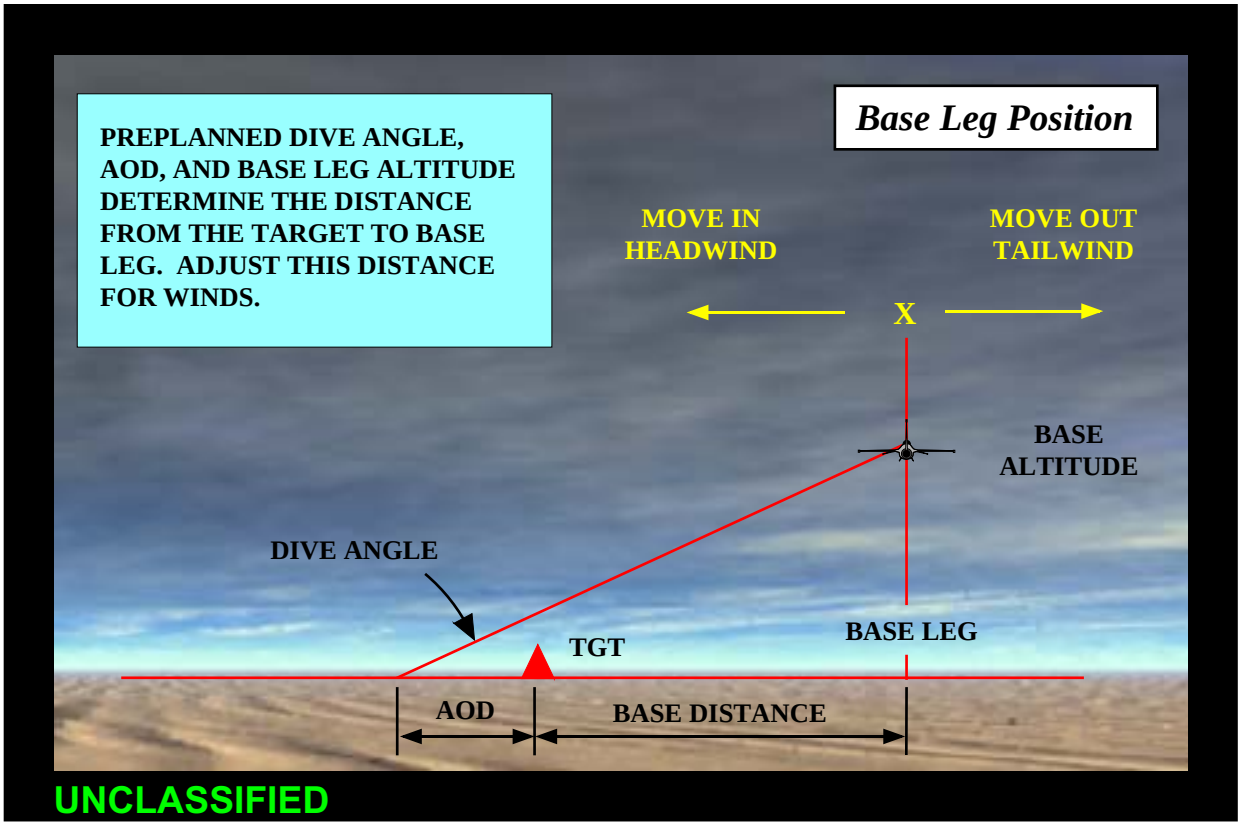
5.7.1.3 Target Area:

- If possible, reference INS (or wingman's) for winds at altitude.

- Obtain the latest surface winds if possible.
- As necessary, re-compute the upwind aimpoint for each event or the headwind/tailwind mil correction factors.
- Set SMS to the MAN mode, position the master arm switch to MASTER ARM, turn on the standby reticle, and set the mil depression for the event to be flown.
- Review parameters for the events to be flown.

5.7.2 Base Leg. The range wind (head/tail) determines the amount and direction of base leg position shift into the wind from the no-wind figures. The amount is dependent on the strength of the wind at both release and roll-in altitudes. Generally, adjust the base leg into the wind by about three times your computed upwind aimpoint. When you roll out on the adjusted base position, use crab to maintain that distance as you approach the roll in. Lead the turn to base to roll out at the right range. When you are tracking toward the correct roll-in point, start thinking about when to begin the roll in to roll out on final with the correct wind corrected flight path. (See **Figure 5.20**, Base Leg Position.)

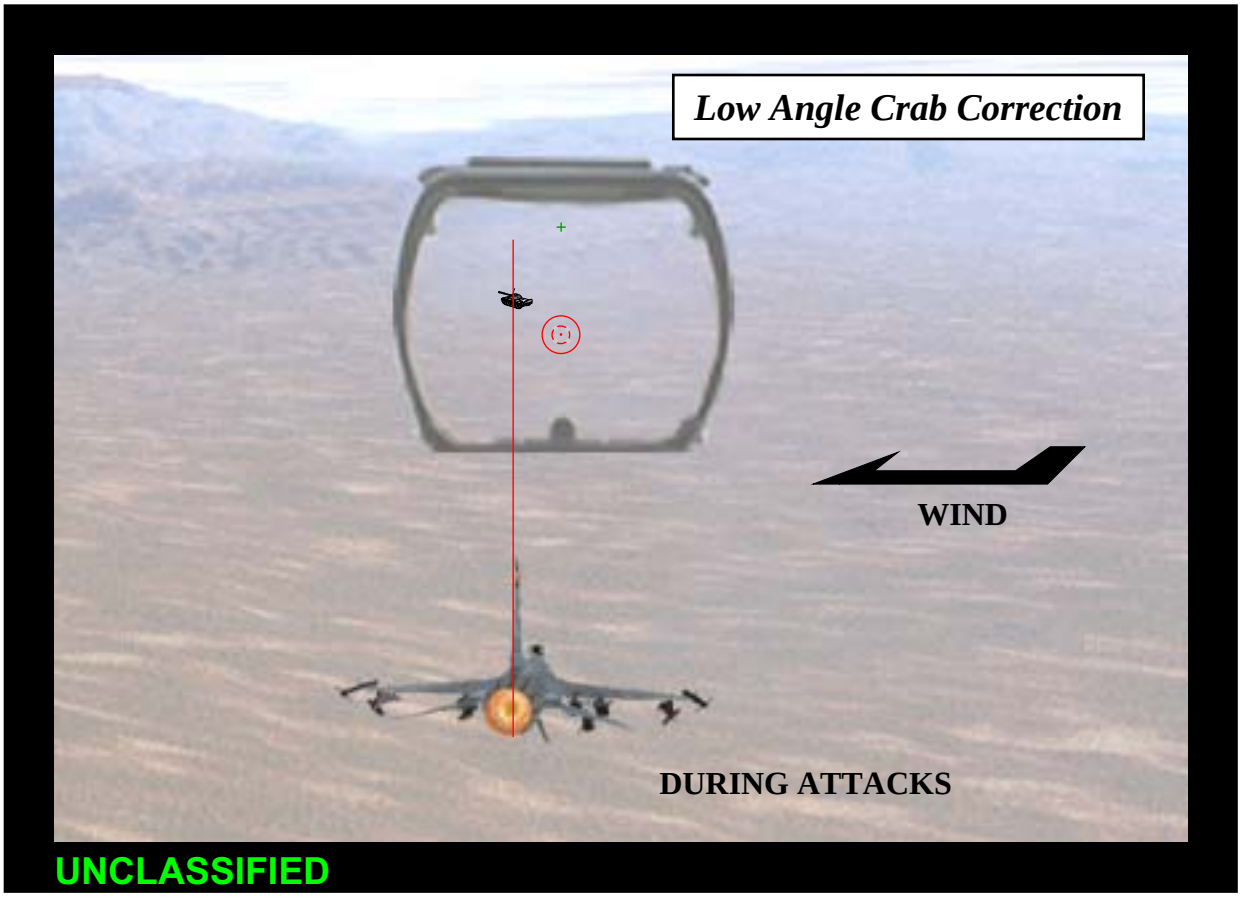
Figure 5.20 Base Leg Position.



5.7.3 Final. Crosswinds on final will force you to use a crab method or a drift method to establish a ground track that will allow for a successful release point.

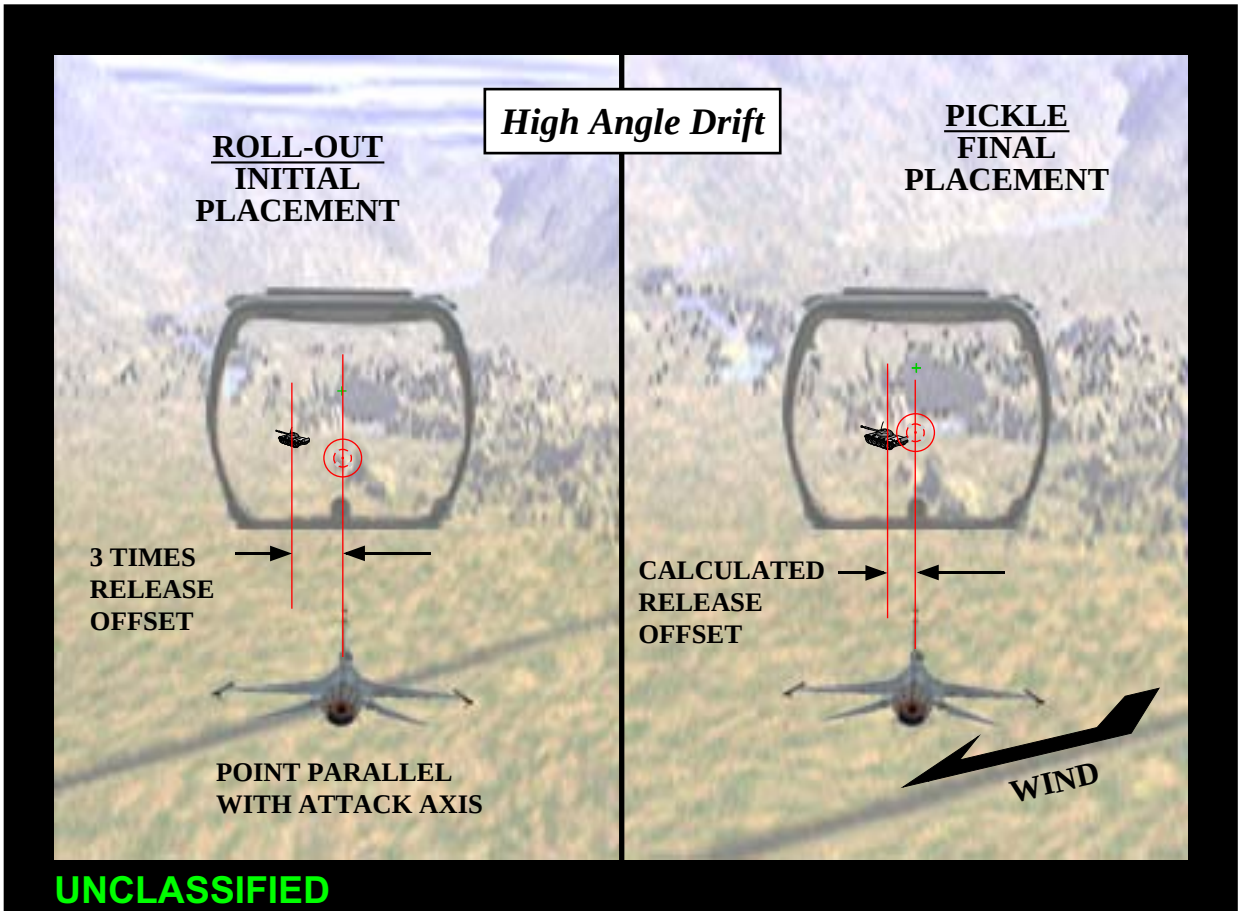
5.7.3.1 Crab. Crab is recommended for low-angle deliveries, roll out directly on an extension of the attack direction line. This is called the attack axis. (See **Figure 5.21**, Low-Angle Crab Correction.)

Figure 5.21 Low-Angle Crab Correction.



5.7.3.2 Drift. Drift is recommended for high-angle deliveries, use the "rule of three." This ROT positions the aircraft upwind so that the bomb track is pointed toward the target with the aircraft heading parallel to the attack direction. Look at the target and the release aimpoint. Imagine a line through the aimpoint parallel to the attack direction extending on back to base leg—you want to be over this line at release. The distance between this line and the target represents the lateral drift of the aircraft and bomb, during the time from release to impact. The time from roll out to release is about twice this, as is the distance drifted during that time. Therefore, you want to roll-out upwind from the target, about three times the release offset distance. Reference this distance to the release aimpoint and imagine another line parallel to the first, twice as far upwind. Roll out over this second line. (See **Figure 5.22**, High-Angle Drift.)

Figure 5.22 High-Angle Drift.



5.7.4 Manual Bombing (Dive). The roll-in is much easier at the proper base leg position, altitude, and speed. The importance of “base leg” cannot be overemphasized; it is the basic geometric factor affecting the dive angle. One technique is to use one-half the planned dive angle plus 90 degrees for roll-in bank (i.e., 105 degrees for a 30-degree dive). Keep your eyes on the target area and use back stick as necessary to make a hard turn in the delivery plane. Pull the nose directly to a point 12 o'clock to the target (the computed AOD). A common tendency is to “dish out” during the roll in, resulting in a shallow dive angle. This is caused by excessive bank during the roll in, allowing the nose to stabilize short rather than long of the target. If you must be off dive angle, it is better to be slightly steep than shallow.

5.7.4.1 Roll-Out. During the roll out, do not use the depressed pipper for azimuth control since even the slightest bank causes a pendulum effect and gives erroneous information. The FPM is a better reference for attaining the correct ground track through the target. If the FPM is not available, visualize your drift across the ground in relation to the reticle and adjust accordingly.

5.7.4.2 Initial Pipper Placement (IPP). As soon as you roll out on final, set the planned IPP at the appropriate IPP altitude and note the dive angle. This is the most important part of the final delivery pattern as this ensures that the pipper arrives on the target at release altitude.

5.7.4.3 Power Corrections. Adjust throttle to set planned airspeed. One technique is to pull the power at the planned delivery airspeed minus the planned dive angle (e.g., for a planned release airspeed of 450 KCAS during a planned 30-degree dive angle, pull the throttle back to 420 KCAS).

5.7.4.4 Wind Corrections. Make wind corrections by applying either the drifting or crab methods described earlier to arrive at a final solution with the pipper on the planned upwind release aimpoint for combat offset deliveries or on the 3/9 line for mil correction deliveries.

5.7.4.5 Final Corrections. Observe the rate of pipper track and altimeter decrease. If an accurate IPP has been set, the pipper would arrive at the upwind aimpoint at the preplanned altitude, airspeed, and dive angle. Since all these parameters are seldom met perfectly, adjust pickle altitude and/or sight picture to compensate. One technique of adjusting release for incorrect dive angle is to relate the change to a release altitude adjustment. With the correct AOD/IPP set, for every 1-degree steep, pickle 100 feet above the planned release altitude. This is a generalization that applies to all dive angles, with the intent of being easy to remember. Never release below the set MRA.

5.7.5 High-Altitude Manual Bombing. The high-altitude manual bombing picture is similar to the 30-degree pattern, but the release altitudes are higher to allow for a recovery above a given threat envelope. On base, set the appropriate canopy relationship sight picture for the dive event planned. Mentally prepare for the delivery by determining the AOP, IPP, and bomb release sight picture. Be aware of the fact that although the pattern is high, the dive angle is steeper and the aircraft accelerates more rapidly. The tendency to press is normal because of the higher pattern; do not press below the MRA.

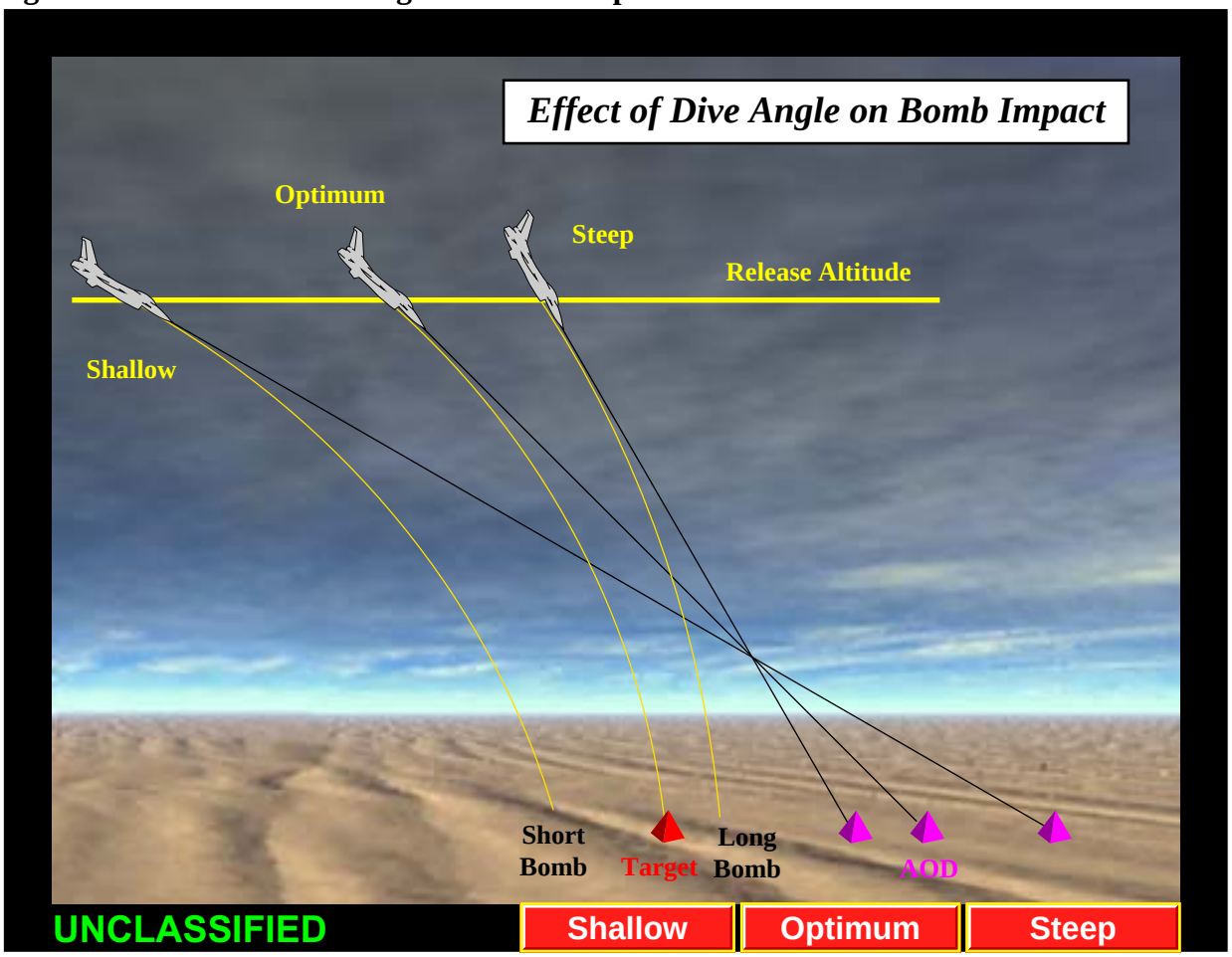
5.7.6 Manual Low-Angle Bombing Events. The major differences between low-angle, low-drag and low-angle, high-drag deliveries are the release altitude and AOD. Low-drag events have higher release altitude and a longer AOD. For level deliveries, a crabbing approach is recommended versus a drifting approach for all level deliveries—it requires less effort to fly over the target. While high drag ordnance is generally released closer to the target than low-drag ordnance, high drags have a longer bomb trail. The bottom line in crab versus drift approaches is to fly the aircraft over an upwind point so that the bomb hits the target.

5.7.7 Error Analysis. Since it is difficult to attain all the required release parameters simultaneously, you must understand the effect on bomb impact caused by not attaining one or more of the release parameters. Error analysis is essentially the same for all bomb deliveries; however, different dive angles produce errors of varying magnitude. Single dive bomb errors do not usually happen (i.e., a steep dive angle results in a lower release altitude and higher airspeed by the time you get the pipper on the target). The result is an unbelievably long hit. When discussing error analysis, assume the pipper is on the target with all but one of the other delivery parameters met. The following errors affect accuracy: dive angle, release altitude, airspeed, G-loading, bank angle, and skid.

5.7.7.1 Dive Angle. If correct AOD is not established and release is made with the sight on target at the preplanned release altitude, impact errors caused by dive angle deviations are the largest and therefore most critical. A steeper than planned dive angle places the aircraft further forward in space when the pipper arrives on the target. This is the release point (RP)

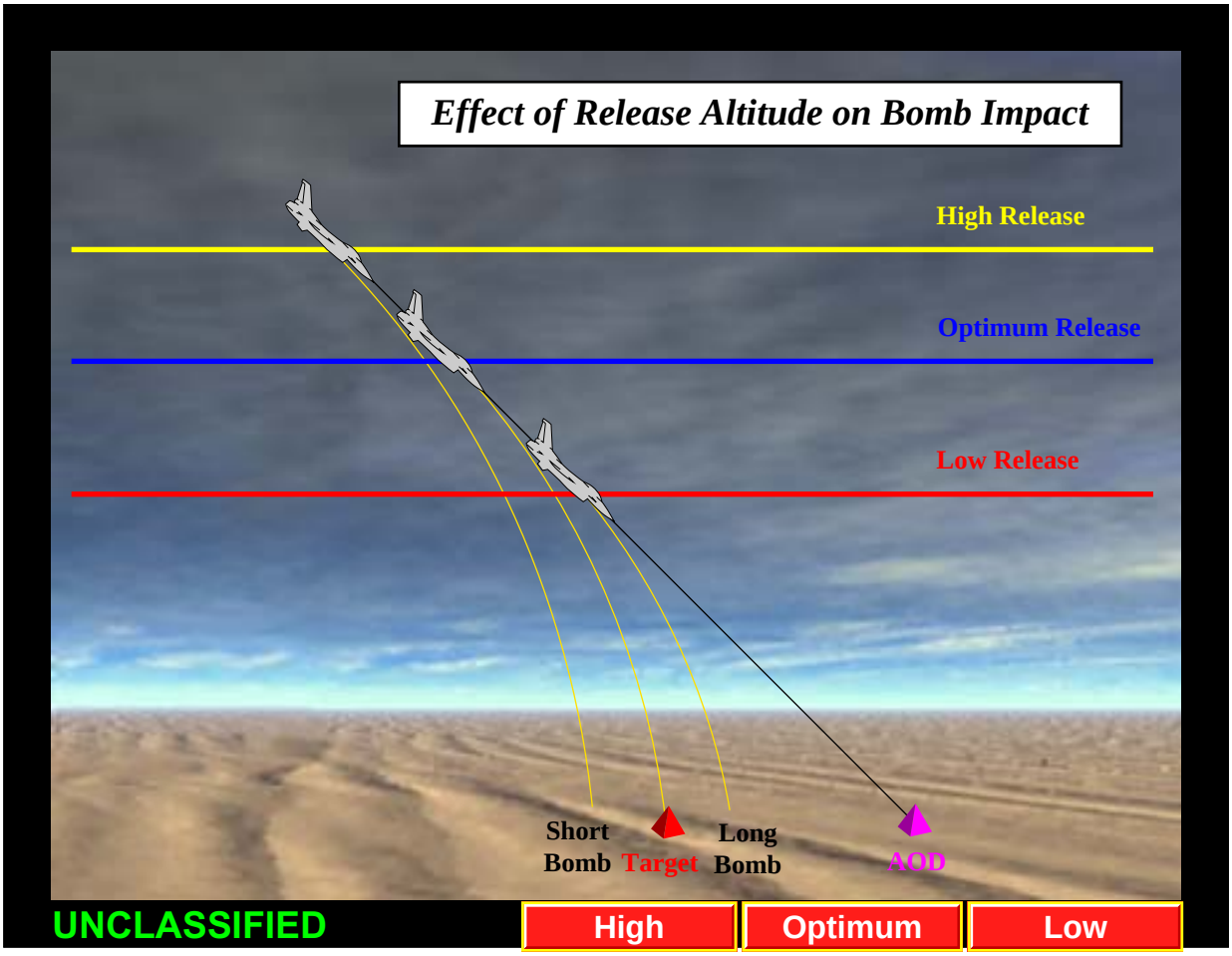
range error. In this situation, bomb trajectory is flattened, but not enough to compensate for the RP range error and a long hit results. The opposite effect is true for a shallower than planned dive angle, but the resultant short error is greater than a long error resulting from a steep dive angle. The most important fundamentals are to be at the correct roll-in point and set the correct AOD which equates to proper dive angle. These are the greatest errors, and once set, all other errors become correctable. (See **Figure 5.23**, Effect of Dive Angle on Bomb Impact.)

Figure 5.23 Effect of Dive Angle on Bomb Impact.



5.7.7.2 Release Altitude. This results in two partially canceling errors. The first is release-point range error in that the aircraft is farther forward in space if release altitude is low with the pipper on the target. This gives a long impact. The other error is a bomb trajectory error. If release altitude is low, bomb trajectory is reduced, but still the bomb will hit long as this is the lesser of the two errors. Again, it must be assumed that the pipper is on the aimpoint and the other parameters of the release are met. It is simply a result of not holding AOD. (See **Figure 5.24**, Effect of Release Altitude on Bomb Impact.)

Figure 5.24 Effect of Release Altitude on Bomb Impact.



5.7.7.3 Airspeed Error. Fast or slow release airspeed can result from such mistakes as the wrong power setting, incorrect airspeed on the base leg, improper roll in, and error in dive angle. The two factors that result from airspeed deviations are bomb trajectory change and AOA change. The resultant impact error is cumulative. Higher than planned airspeed results in a flatter bomb trajectory and a long hit. Increased airspeed decreases AOA which increases effective depression, giving a late sight picture and a long hit. (See **Figure 5.25**, Effect of Airspeed on Bomb Impact.)

5.7.7.4 Release G Error. Each delivery has a preplanned G-loading at release. This G is a function of the cosine of the dive angle. It is not a factor read on a gauge in the cockpit during release, but a “seat-of-the-pants” thing. To release a bomb with other than the preplanned G on the aircraft changes aircraft AOA, thus changing effective depression. In a normal approach, the pipper is moved to the target at a rate so it reaches the aimpoint as other release conditions are attained. If the sight picture is attained too early and the pipper is held on the aimpoint, you will begin to decrease release G, decrease AOA, increase effective depression, and get a long hit. Also, if you hold the bunt long enough, you may change your dive angle and this will add to the long impact. More G than planned (i.e., pulling the pipper up the aimpoint) results in a short hit. (See **Figure 5.26**, Effect of Improper G Force on Bomb Impact.)

Figure 5.25 Effect of Airspeed on Bomb Impact.

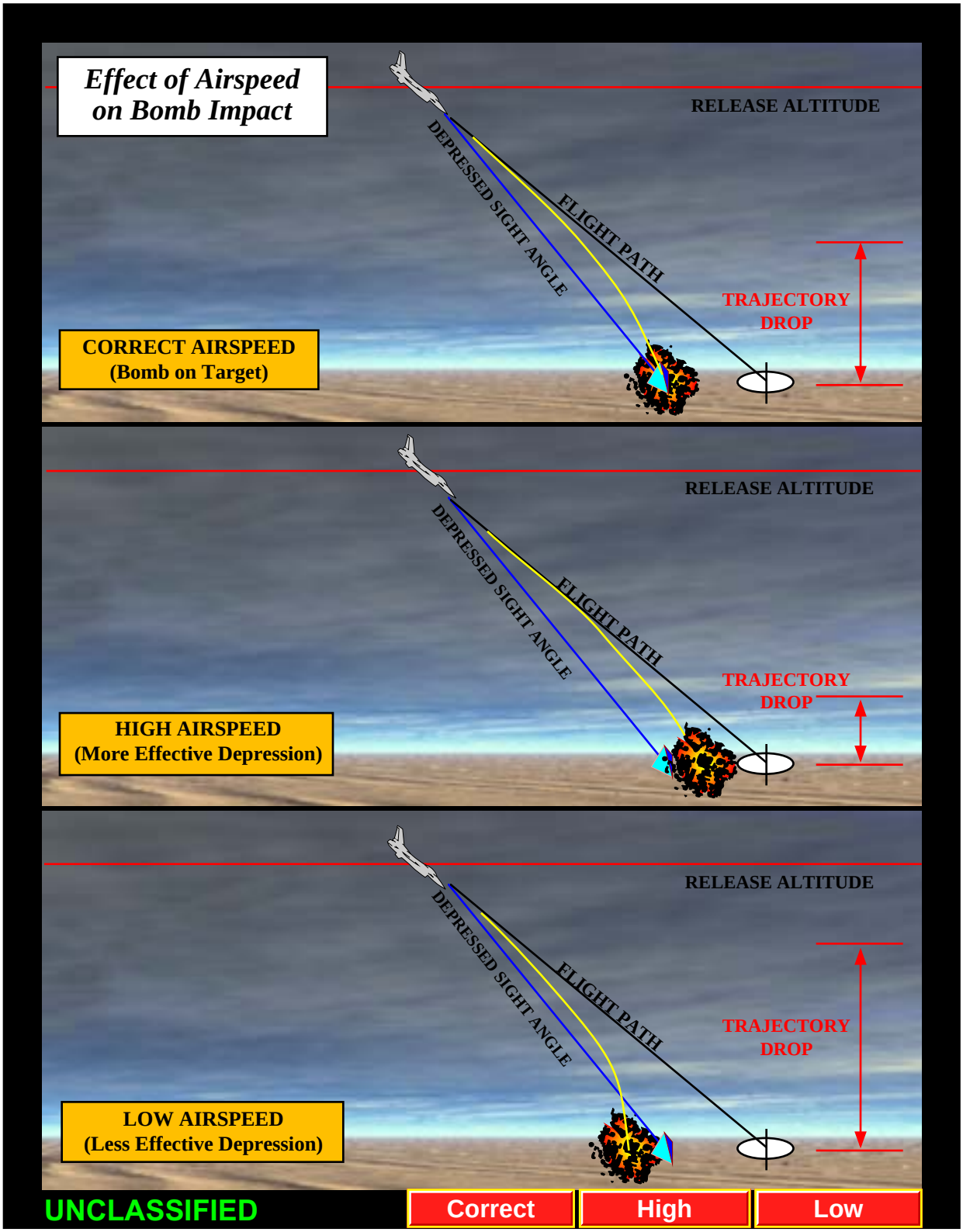
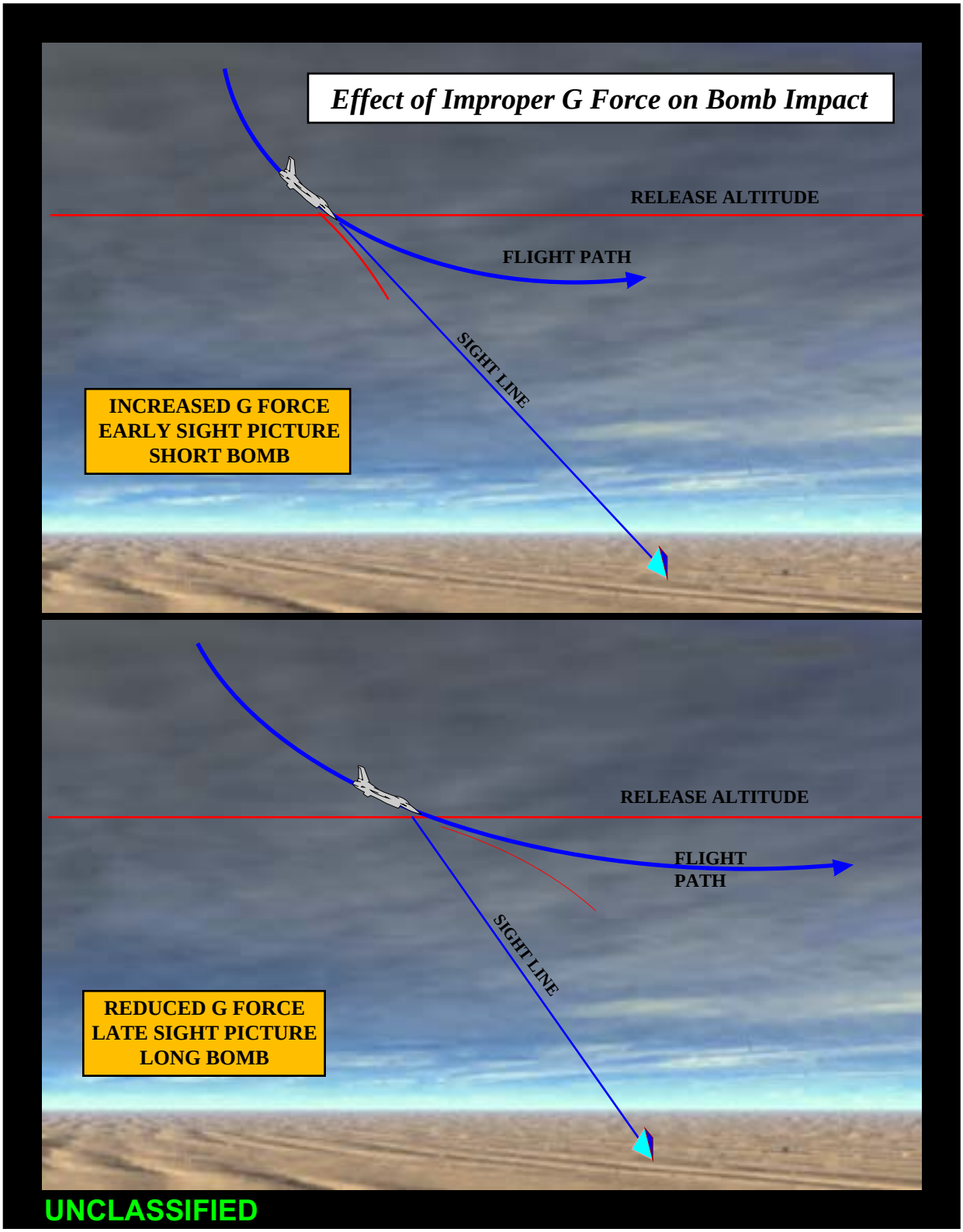
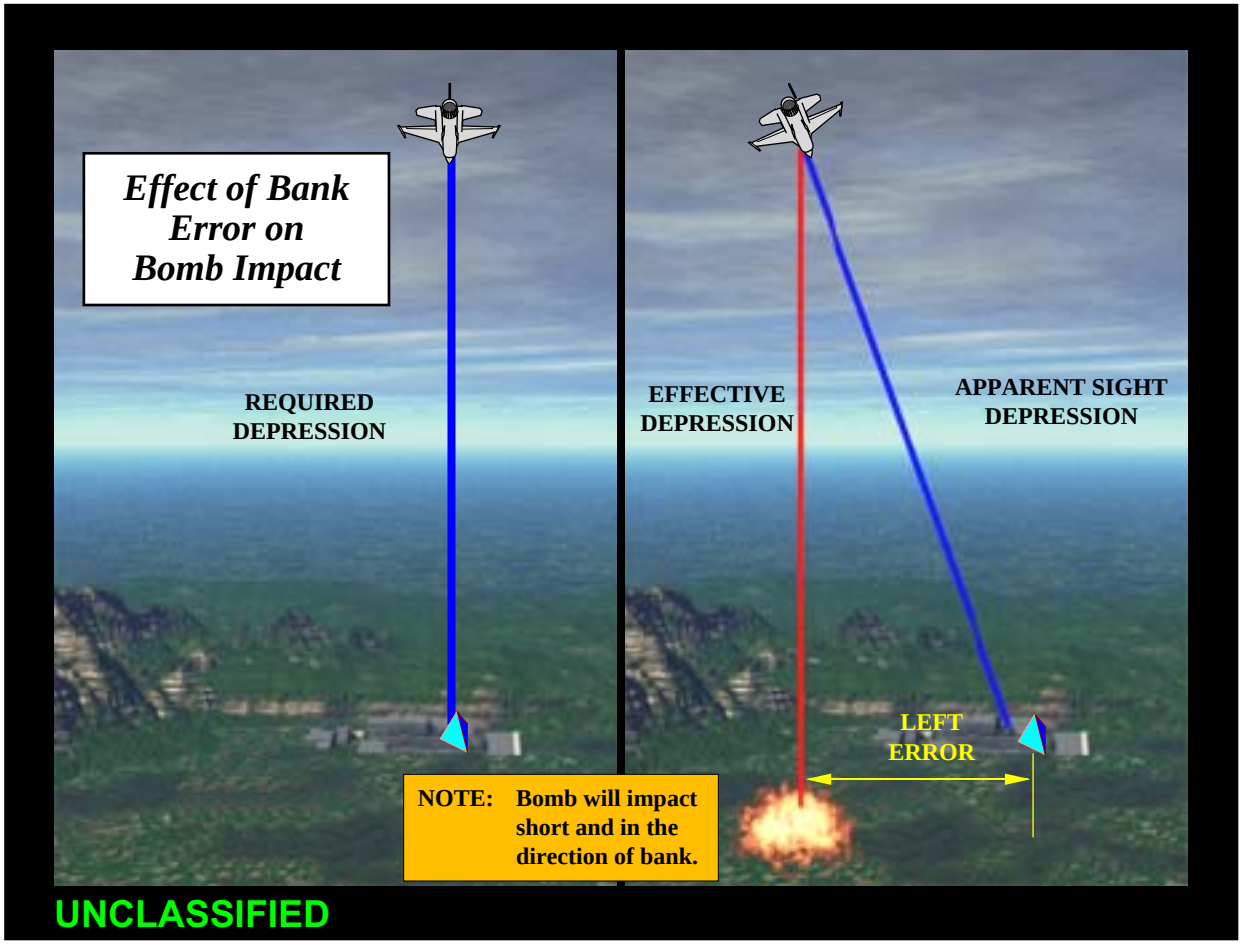


Figure 5.26 Effect of Improper G Force on Bomb Impact.



5.7.7.5 Bank Angle. A fairly common error in bombing deliveries is releasing with a wing low. A slight bank is difficult to recognize when the horizon is 30 degrees or more above the flight path. But, if the aircraft is banked at release, the sight picture is erroneous. This is due to the pendulum effect of the depressed sight. As the aircraft is banked, the sight swings in the opposite direction. With the pipper on the target under these conditions, the bomb will hit short and in the direction of the bank because the aircraft's flight path is not towards the target and the slant range to target is increased. (See **Figure 5.27**, Effect of Bank Error on Bomb Impact.)

Figure 5.27 Effect of Bank Error on Bomb Impact.

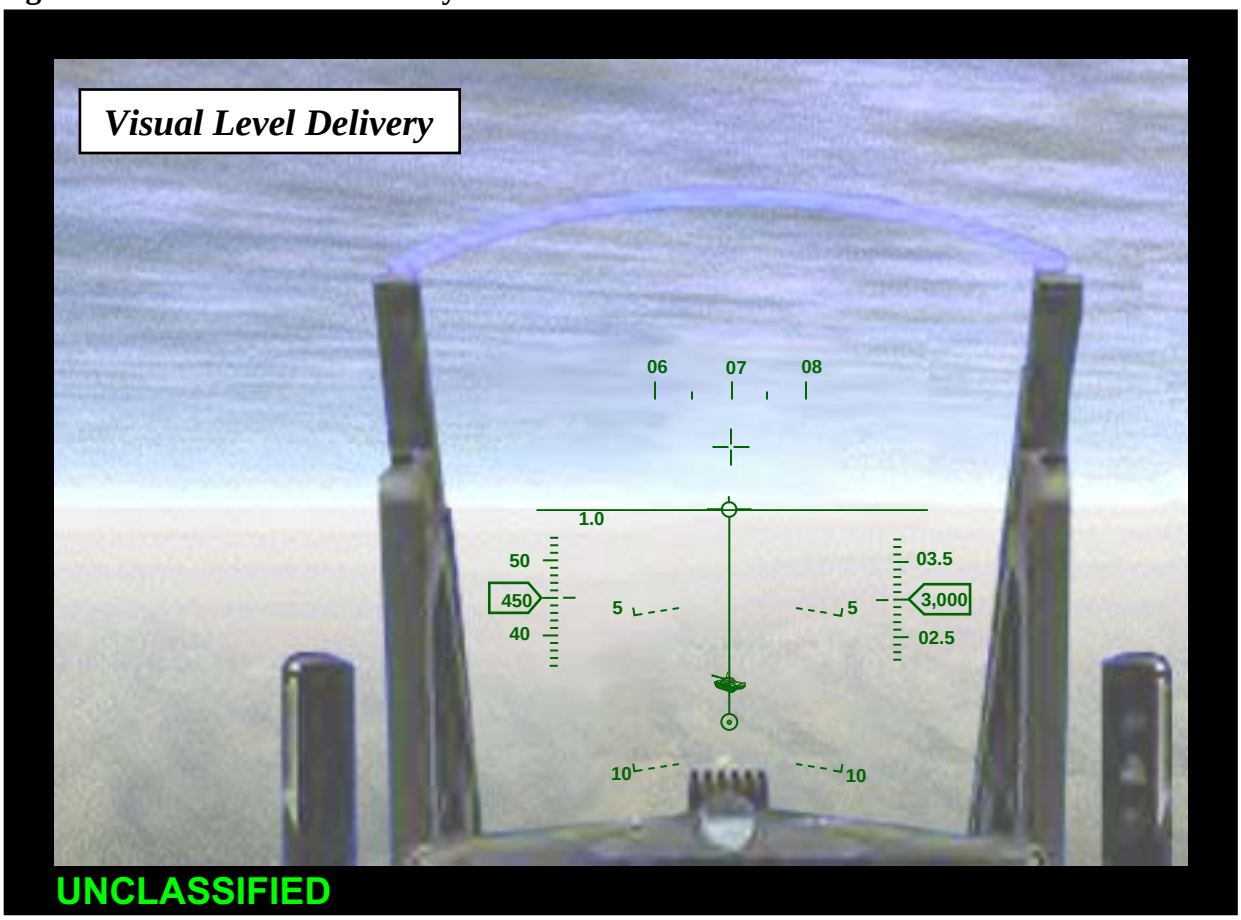


5.7.7.6 Skid. Release during uncoordinated flight causes an erroneous sight picture. In any bomb delivery, the bomb follows the flight path when released. If the ball is out to the right, the bomb will impact to the right. A last-ditch rudder correction to obtain the proper sight picture is not going to bring the bomb over to the target. The sight line and ground track must be parallel for the bomb to hit where the pipper is placed. The bomb will go long, in the direction of the skid.

5.8 Tactical Considerations. Attack selection is critical to mission success. A combination of variables drives attack selection: weather, weapon type, target, destruction level, and impact requirements, to name a few.

5.8.1 Visual Level Delivery. The visual level delivery (VLD) profile is essentially a level delivery or very shallow dive similar to that used for high-drag weapons. (See **Figure 5.28**, Visual Level Delivery.) However, parameters for adequate fuze arming and safe escape become much more critical due to the weapon TOF. F-16 ballistics tables and CWDS have minimum release parameters for various fuze settings. CCIP is the recommended delivery mode.

Figure 5.28 Visual Level Delivery.



5.8.1.1 Advantages:

- Exposure time is minimal.
- Navigation is direct to the target. No offset is required.
- Reduces acquisition time for threat systems.

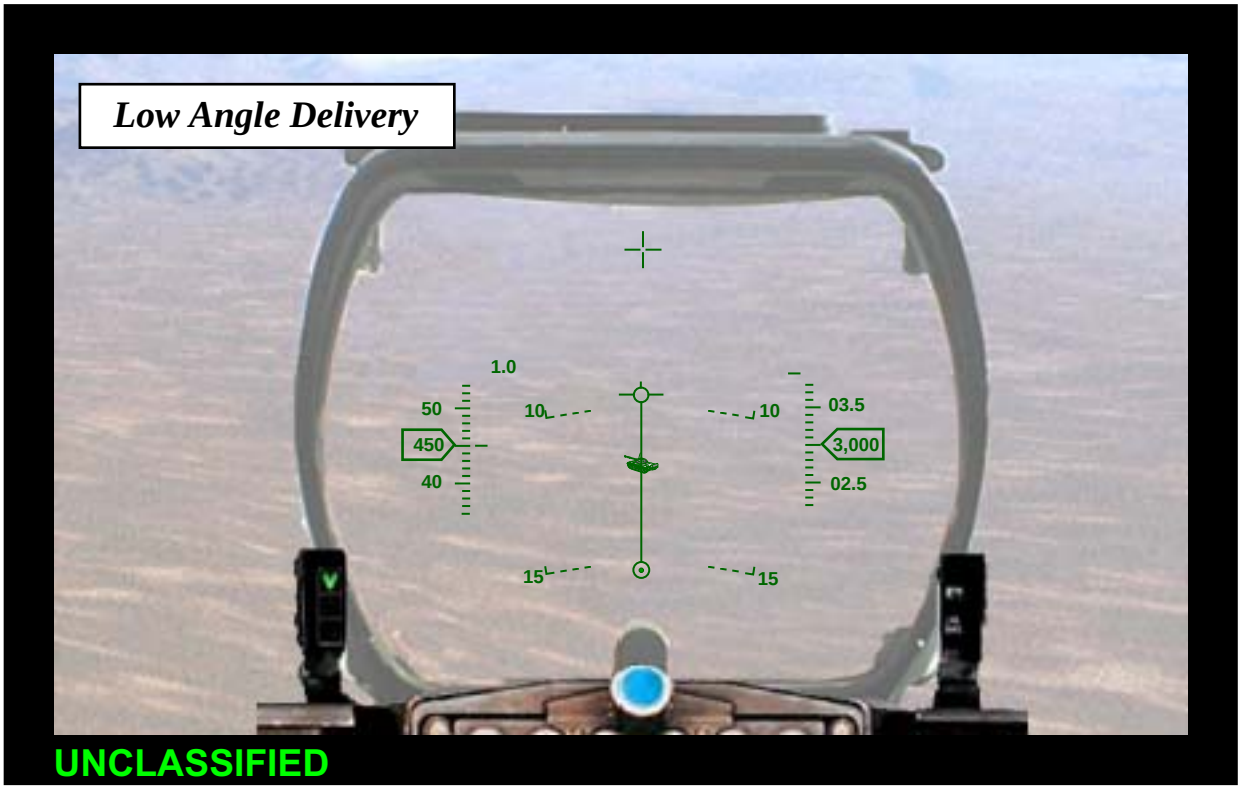
5.8.1.2 Disadvantages:

- Target acquisition is difficult.
- Low-impact angle may reduce weapons effectiveness.
- The minimum altitude for fuze arming and frag clearance is easy to violate.

5.8.2 Low-Angle Deliveries and Dive Bomb. Dive bomb (DB) is a delivery using 30 degrees or steeper dive. Low-angle low-drag (LALD) and low-angle high-drag (LAHD) deliveries are

for any dive angle less than 30 degrees. Roll-in altitude is achieved through a pop-up, fly-up, or medium-altitude ingress. (See **Figure 5.29**, Low-Angle Deliveries.)

Figure 5.29 Low-Angle Deliveries.



5.8.2.1 Advantages:

- Increased bomb impact angle with improved penetration effectiveness over low-angle deliveries for DB deliveries.
- Increased accuracy due to lower slant range and increased radar graze angle.
- Increased time for target acquisition.
- LAHD allows lower altitude operation while increasing bomb impact angle.
- Radar-fuzed CBU weapons may be delivered effectively with DB and 20 degrees LALD.

5.8.2.2 Disadvantages:

- Exposure to MANPADS and AAA increases significantly.
- Lower impact angles for low-angle deliveries.

5.8.3 High-Altitude Release Bomb and High-Altitude Dive Bomb. High-altitude release bomb (HARB) and high-altitude dive bomb (HADB) are deliveries from medium or high altitude, preferably using 30 degrees or steeper dive. Roll-in altitude is typically achieved from a medium-altitude ingress. Problems associated with HARB and HADB include high crosswinds, lateral miss bomb release inhibit (if using CCRP), delay cues, and high G releases due to delay cues. In addition, weapons effects may vary greatly from those expected at lower

release altitudes. Increased slant ranges, longer radar ranging, and high transonic release airspeeds all result in unpredictable bomb separation effects, cluster munition patterns, and unpredictable weapon impact points. (See **Figure 5.30**, High-Angle Deliveries.)

Figure 5.30 High-Angle Deliveries.

5.8.3.1 Advantages:

- Increased bomb impact angle and penetration.
- Increased time for target acquisition.
- Recoveries may be accomplished above small arms/light AAA threats.

5.8.3.2 Disadvantages:

- Increased exposure to certain surface-to-air missiles (SAM) and A/A threats.
- Unpredictable weapons effects.
- Decreased accuracy with free-fall munitions; especially CBU.

5.8.4 Low-Altitude Toss. The LAT profile allows accurate visual deliveries of low-drag munitions at standoff ranges.

5.8.4.1 Advantages:

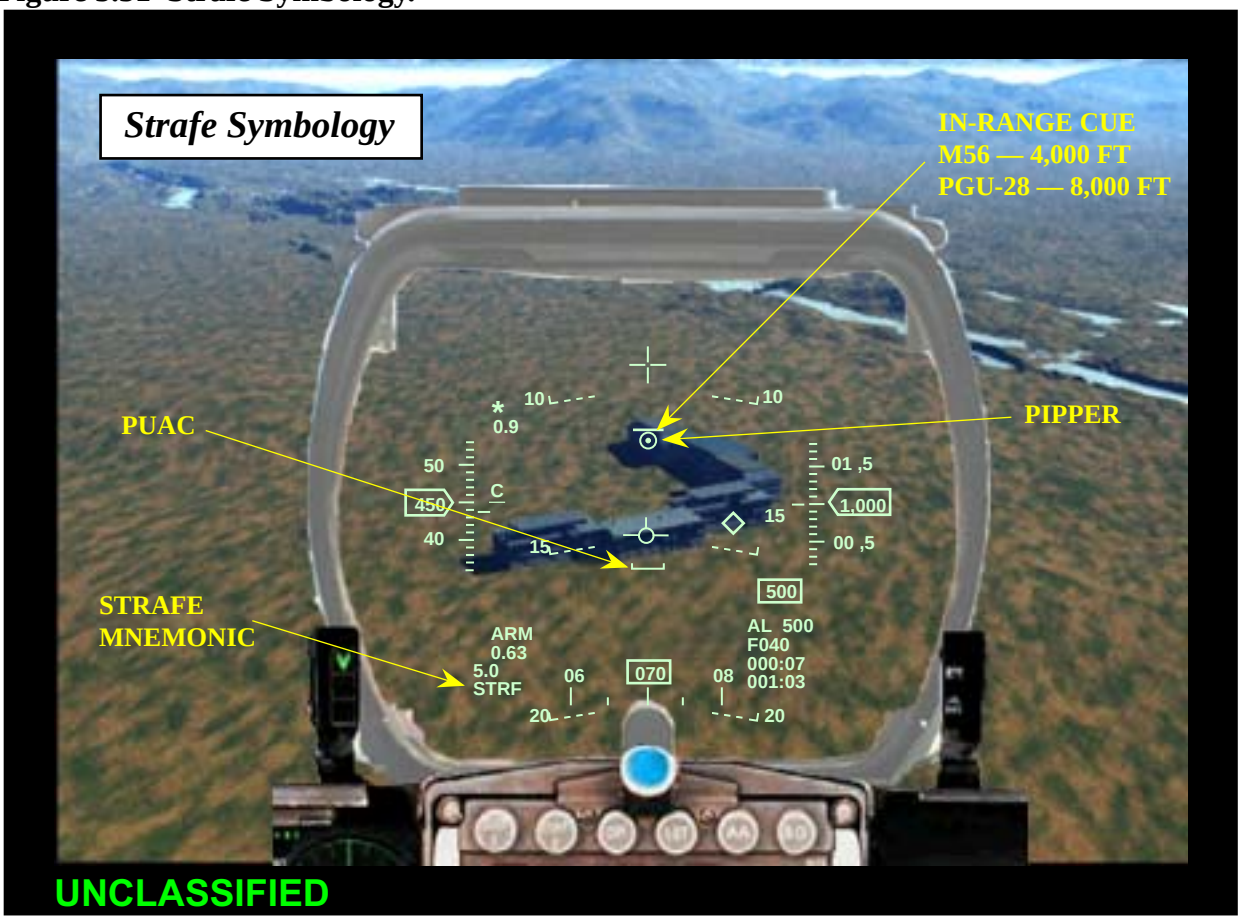
- Provides lateral spacing for frag deconfliction.
- Allows standoff from several lethal defensive systems.
- Increased defensive maneuvering time against SAMs in the target area.
- Allows considerable flexibility in meeting planned parameters.

5.8.4.2 Disadvantages:

- Accuracy is degraded over a CCIP delivery.
- Long slant ranges can cause difficulties with target acquisition.

5.9 Strafe. Since the FCC merely presents a continuous prediction of bullet impact in the HUD, the fundamental techniques of manual strafe must still be applied. The primary advantages of computed strafe over manual strafe are the automatic calculation of an upwind aimpoint and the freedom to fire at any range within the effective gun envelope. These features permit reliable impacts even in high or changing crosswinds. (See **Figure 5.31**, Strafe Symbology.)

Figure 5.31 Strafe Symbology.

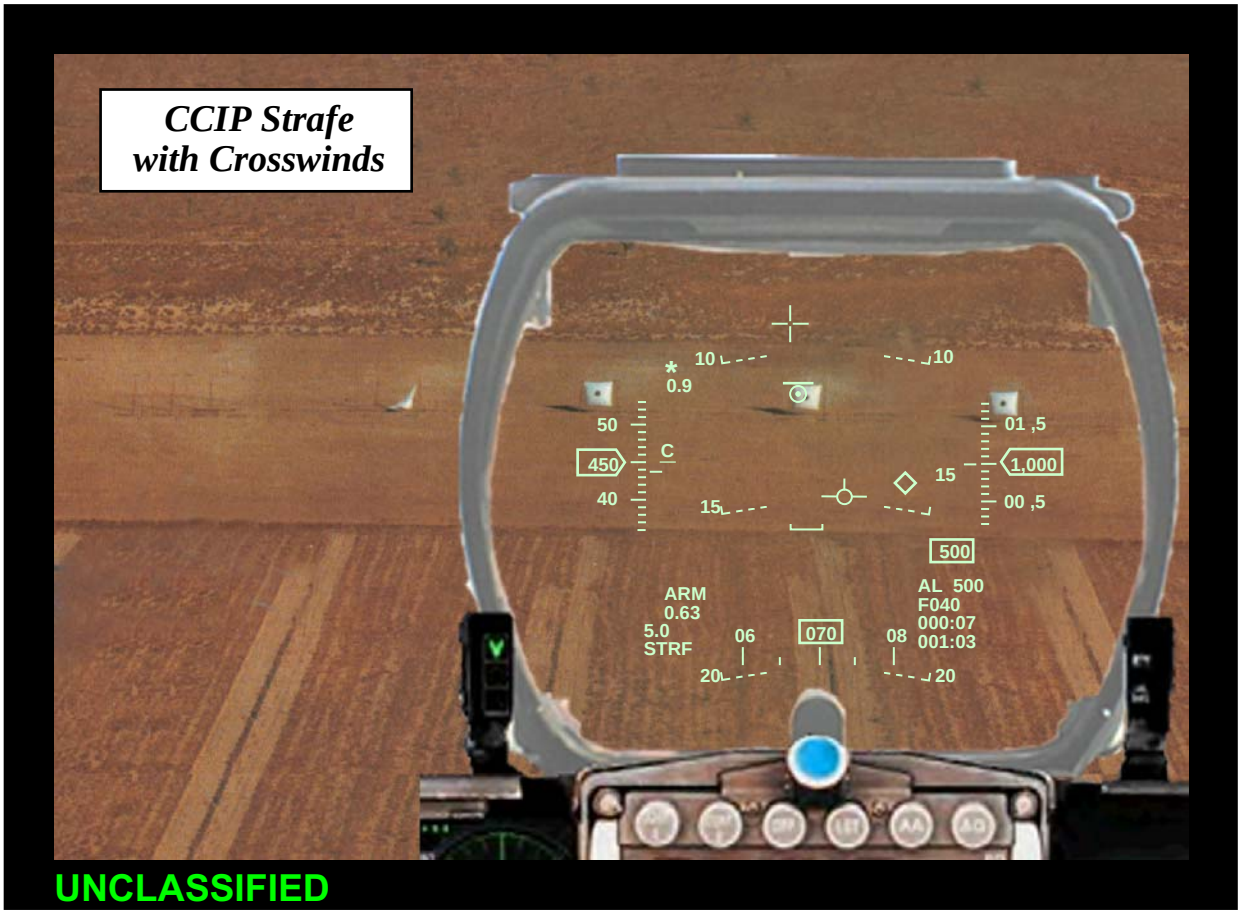


5.9.1 Effects of Wind. Winds are easily compensated for during CCIP Strafe.

5.9.1.1 Initial Aiming. When crosswinds are present, the FPM is shifted slightly downwind. The gun is still boresighted through the gun cross. Bullet impact is someplace between the two, proportional to drift angle and slant range. Consequently, the aiming symbol is upwind of the FPM. As the slant range decreases, the CCIP pipper moves laterally toward the gun cross. The combination of the two characteristics results in CCIP pipper motion, as range decreases from the original position, always toward the gun cross. Bank and/or yaw can distort this classic geometry slightly when maneuvering toward the

target, but should not be a factor when approaching open-fire ranges. (See **Figure 5.32**, CCIP Strafe with Crosswinds.)

Figure 5.32 CCIP Strafe with Crosswinds.



5.9.1.2 During Delivery. Crosswind effect during firing can best be controlled by using small amounts of bank to control lateral pipper drift during the approach. This should result in having the proper amount of bank on the aircraft at open-fire range. Maintain this bank while firing which should keep the pipper from moving off the target downwind. Effect on bullet impact due to firing in a bank is minimal. A ROT is that 1 knot of crosswind requires slightly less than 1 degree of bank to counteract. Compensating for a crosswind is subtly different in strafing. In bombing, the objective is to crab or drift so the bomb ground track passes through the target. Because of the self-possessed velocity of the bullets, the bullet track is not at all the same as the ground track of a crabbed or drifting aircraft. Consequently, in strafe we are primarily concerned with aiming the gun, not the aircraft velocity vector, toward the target.

5.9.2 Low-Angle Computed Strafe. On downwind, select gun mode and strafe option on the SMS. Check master arm switch to MASTER ARM and ARM in HUD (local restrictions permitting). Verify air-to-surface (A/S) gun symbology and declutter the HUD as necessary.

5.9.2.1 Base Leg. Fly the base leg and roll in as described for the lower angle bomb patterns. One technique is to roll out with the bottom of the gun cross on the target.

5.9.2.2 Line Up. Lead the roll in to final in order to line up on the run-in line (if applicable) of the target. Normally, on a controlled range, there are at least two active panels which are scored acoustically (Acoustic score). Due to the nature of Acoustic score, bullets that pass over the microphone high or are subsonic, do not register as hits.

5.9.2.3 Technique. A common technique is to strafe alternate panels (i.e., if Number One chooses panel one, then Number Two strafes panel two, and Number Three strafes panel one). This allows time for the dust to clear on that panel from a previous pass.

5.9.2.4 Symbology. The CCIP pipper is originally depressed for the slant range at which you roll out on final. For Block 40 and Block 50 avionics, when arriving at approximately 4,000 feet for the M56 bullets, an in-range cue (“the hat”) appears. As the slant range decreases, the CCIP gun pipper moves closer to the gun cross, reflecting a reduced gun elevation requirement. Although you have a valid pipper at maximum range, strafe effectiveness is greatly increased by getting closer to the target and holding open fire until inside, approximately 4,000 feet slant range. For Block 30 avionics, a 50-milliradian pipper is used. In-range cues can be set by the pilot in hundred's of feet via the SMS page. An in-range tic mark appears at the set range (much like dogfight TD circle) clock position.

5.9.2.5 Increasing Effectiveness. There are generally two techniques used by pilots to achieve maximum low angle strafe (LAS) hits.

5.9.2.5.1 Option One: Tracking the Gun Cross. Roll out with the gun cross slightly above the rag. Check dive angle at 10 to 15 degrees.

- Note the pipper relationship to the run-in line to determine crosswind.
- Offset the gun cross into the wind and note pipper tracking up the run-in line.
- Set the power to maintain 420 to 450 KCAS.
- At the point where the pipper track approaches the target, ease the pipper to the bottom of the rag.
- As the 2,000 feet foul line passes under the nose, track and hold CCIP pipper on the rag.
- Shoot.
- Track the rag momentarily (until either bullet impact or approaching the foul line).
- Recover.

5.9.2.5.2 Option Two: Tracking Pipper. The second technique is to simply roll out on final with the pipper on the rag, cross-check the dive angle at 10 to 15 degrees, and just keep the pipper on the rag until the 2,000 feet foul line passes under the nose. Track, shoot, track, and recover from that point.

NOTE: This technique is more sensitive to any change in pitch/Gs).

5.9.2.6 Sighter Burst. Regardless of the tracking method used, it is a good idea to fire a short (20- to 30-round) sighter burst on the first hot pass. Note the CCIP pipper position when firing. If the impacts were not through the CCIP pipper, use an adjusted aimpoint on

subsequent passes. On each pass, ammunition is wasted if firing when CCIP pipper is off the aimpoint. Remember, track, shoot, and track.

5.9.3 High-Angle Computed Strafe. This delivery is used much more frequently than low-angle strafe during tactical scenarios to avoid small arms fire and allow bullet penetration into revetted or entrenched positions. Open-fire slant range is typically more than twice that of low-angle strafe based on computed delivery. Consequently, computed impact prediction greatly improves results in an environment of unknown winds and extreme slant range.

5.9.3.1 Initial Picture. Perform the roll in from computed altitude as you would for a diving delivery with point-blank aiming. The FPM should initially be short of the target with the CCIP pipper some 50 plus mils below it. This roll-in is significantly more nose-low than it is for a diving delivery, because AOD is actually a negative value (short of the target). Using the gun cross as an initial aiming reference will help until the FPM and CCIP pipper become stabilized.

5.9.3.2 Final Attack. Note the altitude and set the power for release airspeed at open-fire range/altitude. Monitor your descent rate toward open-fire altitude. Control the rate of CCIP pipper movement toward the target with back stick and bank so as to have it at the target as you arrive at the desired open-fire altitude. Since the in-range cue does not appear until 4,000 feet slant range, it may not be above the CCIP pipper at open-fire range/altitude. Recovery can be based on slant range, altitude, or a combination of both.

5.9.4 Manual Low-Angle Strafe. Compared to bombing, strafe attacks are relatively simple. Point the aircraft at the target, correct for gravity drop, include a small amount of wind correction, and fire.

5.9.4.1 Downwind. On downwind, check sight depression mil setting (usually 6 to 10 mils) and adjust manual reticle intensity low enough to allow you to see and focus on the target.

5.9.4.2 Transition to Final. Fly base and roll in similar to low-angle bomb patterns. Before you roll in, look at the target and pinpoint the general location of the open-fire range. On controlled ranges, this is approximately 150 percent of the distance from the foul line to the target.

5.9.4.2.1 Roll-In. During roll-in, keep your eyes primarily on the target/aimpoint with an occasional cross-check of airspeed. As the target comes into the HUD field of view (FOV), play the roll out so that the pipper is initially short and slightly upwind of the target/aimpoint. In practice, it is advisable to plan the final turn to roll out with the pipper slightly upwind (laterally) of the target/aimpoint. A crosswind component requires the gun to be pointed upwind 1.5 feet per knot at 2,400 feet open-fire range, decreasing to 1 feet per knot at 2,000 feet.

5.9.4.2.2 Final Attack. After roll out and IPP, check airspeed and adjust power. Recheck and readjust as required. Airspeed has little effect on bullet impact, but it does affect aircraft control. As you close toward the target, focus your eyes on the chosen aimpoint and monitor pipper movement with your peripheral vision. The pipper should be moving smoothly towards the aimpoint.

- Continuously estimate your closure rate toward the open-fire range.

- Use bank to adjust lateral pipper movement.
- Longitudinal (6/12 o'clock) drift rates are critical and more difficult to correct.

5.9.4.3 Firing the Gun. You want to open fire with the pipper on the aimpoint when you are approximately 3,000 feet from the target. Open fire range is more critical in manual strafe, as bullet drop increases dramatically as firing range increases. During the firing of the gun, the pipper must be on the aimpoint. About 2 seconds of tracking is the maximum you are able to achieve. Therefore, do not concentrate tracking the pipper on the aimpoint before open-fire range. Fire the gun using just enough forward stick pressure so the pipper "pauses" on the target between open fire and cease fire. On the first strafe pass you may want to fire only a "sighter burst." The purpose is to verify gun/pipper boresight and validate your crosswind computation. Cease fire as you approach the foul line and initiate a recovery.

5.9.4.4 Manual High-Angle Strafe. This delivery is difficult in that release parameters are near the outer limits of effective 20mm gun range. In a 30-degree attack, a typical open fire slant range is 6,000 feet which requires considerable gun elevation to counter the increase in gravity drop. Since the path of the bullets is no longer flat, open-fire slant range becomes more critical. As you reach 1,000 feet above open-fire altitude, move the pipper up to the aimpoint. Track, fire, and track until the burst is completed. Execute the recovery immediately after the gun stops firing. Do not delay to watch bullet impact. Due to the increased range and corresponding increased bullet TOF, if you see the impact, you may never see anything else, other than your own impact.

5.10 Tape Assessment and Footprint Data. The squadron should have footprint data for all its aircraft. The validity of data is based on each pilot properly assessing their performance on each pass and comparing aimpoints to impacts. The program is only as good as the inputs, so VTR assessment and accurate bomb sheets are essential. Before you fly, look at the footprint data. Do not aim 50 feet short just because the last pilot wrote that your aircraft had dropped 50 feet long. See how recent the last flight was and look at the last pilot's experience level.

NOTE: An intelligent AF Form 781 write up goes a long way, but frequently, impact errors are caused by bad boresight, a problem that cannot be corrected overnight.

5.11 Non-Visual Bombing. This section covers delivery modes (CCRP, LADD, and beacon [BCN]), you can use to accurately attack targets without visually seeing them. The most obvious uses of non-visual capability is in weather or at night, or when attacking well camouflaged targets at a known location. Also, with accurate target coordinates, threat exposure may be reduced with a low-altitude loft option. Use non-visual techniques (rolling in on CCRP data) to help find the target and then convert to a pure visual attack (CCIP or DTOS). If navigating to a target and bombing it solely using the INS, accuracy is limited by planning errors and/or INS drift. Accuracy can be improved by updating the FCC with radar, HUD, and/or overfly-designate updates. A combination of GPS/DTS and accurate coordinates is the best solution. INS updates may also improve delivery accuracy. Even when the target area can be seen, using the TD box in conjunction with visual search lessens the possibility of DMPI confusion due to passive camouflage, concealment, and deception (CCD) techniques. For example, the TD box may designate a target that has been toned down with nets or paint, leaving an intentionally developed false target nearby to draw the atten-

tion of the attacker. An effective practice is to closely examine the TD box in CCRP or target diamond in CCIP before consenting weapons release.

5.11.1 Loft Tactical Considerations. The loft delivery is usable for area targets when using area weapons or when standoff is required against short-range defenses. Accurate coordinates and verified system accuracy (INS, FCC, and system altitude) are paramount to ensure desired weapon effects. Azimuth steering and the initial pull up are the most critical factors in this maneuver. The FCC still attempts to deliver the munition to the correct point over the target, but variations become important with radar-fuzed munitions and special weapons.

5.11.1.1 Disadvantages:

- The aircraft is exposed belly-up to the target area and the loft maneuver may place the aircraft in SAM engagement zones.
- Accuracy is decreased with INS navigation errors (especially non-GPS aircraft).
- Long weapon TOF combined with wind effects result in decreased accuracy.
- Accurate target and aiming offset coordinates must be available.

5.11.2 Critical Avionics. The APG-68 radar, FCC, GPS (if equipped), and other F-16C system integration areas combine the primary components to accurately employ ordnance on a non-visual target. The FCC uses INS information to position HUD and radar symbology on the selected reference. The cursor rotary is used to select the sighting option. The pilot can update symbology by inputting FCC slew commands or by designating the visual release point (VRP) to the FCC at overflight (VRP/computed release point [CRP] mode). The SOI identifies the MFD or the HUD as the primary sighting reference. To use the overfly VRP designate option, the SOI must be in the HUD. Overall system accuracy is a function of input data, INS drift, NAV status, and any updates made by the pilot.

5.11.2.1 APG-68 Radar. If GM is the selected FCR mode, the FCC places the radar cursors at the INS estimated position of the steerpoint, offset aimpoint (OAP), or IP/RP. Refinements can be made using the cursor on the throttle. For more detail, depress the FOV (pinky switch) to get to the EXPAND mode. This places the cursor in the center of the display and expands the detail by a factor of four. In 10, 20, and 40 NM scopes depressing the pinky switch again commands the Doppler beam sharpening (DBS)-1 mode, which increases azimuth resolution for returns more than 5 degrees off the nose. Depressing the pinky switch again commands DBS-2 mode which increases display resolution by 4:1 and is optimized for returns more than 15 degrees off the nose.

CAUTION: In expand, DBS-1 and DBS-2, the cursors stay centered on the display which can cause misorientation. Use the SA cue (+) and HUD to remain oriented in the delivery. The SA cue indicates the position of the cursors on expanded displays.

5.11.2.2 Receiver Gain. Each GM FOV has an individually adjustable gain, which the pilot sets during the air-to-ground (A/G) systems check. The manual range/uncage knob can control 35 percent of the gain selected on the radar. For an initial setting, select normal FOV and rotate the uncage knob full clockwise (maximum), then adjust the gain with the rocker switch to approximately 40 to 45 percent on this gain scale. Then select expand and adjust gain, with the hands-on control, a nearly black picture can be achieved with mini-

mum gain. DBS-1 and DBS-2 gain will automatically initiate at approximately 90 percent. Little adjustment is necessary.

5.11.2.3 Antenna Elevation. Antenna elevation, or tilt, is controlled by the FCC in GM to keep the radar pointed at the steerpoint or OAP. Moving the antenna elevation thumbwheel out of the detent overrides the FCC. The FCC still automatically adjusts tilt but it is biased by the elevation knob position.

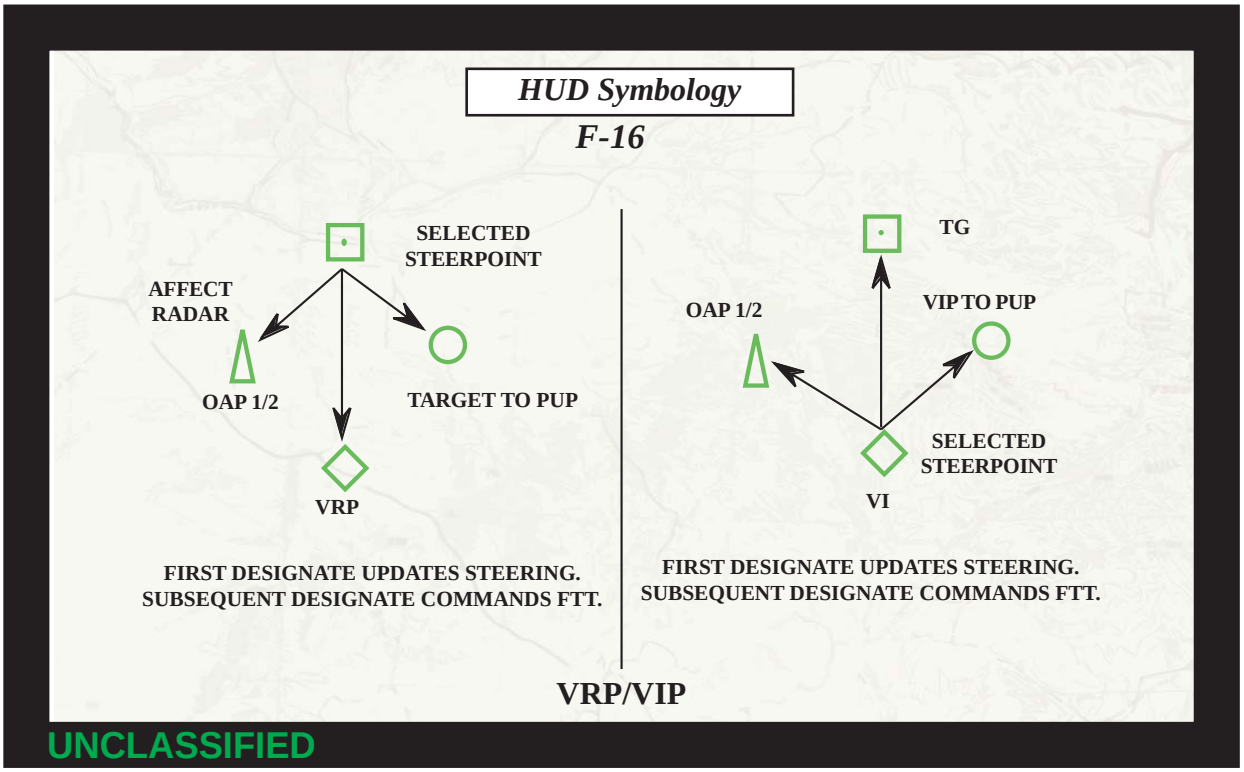
5.11.2.4 Range. To get the best resolution, use the smallest range scale that allows you to see the cursors. Selecting "Auto" range scale ensures the cursor intersection stays in the top half of the display for easiest radar interpretation. Auto, however, does not give you a 10-NM scope (best resolution) until well inside of where the last updates are typically accomplished. You can override the auto feature by selecting a 10-NM scope, when the aimpoint is less than 10 NM.

5.11.3 Fire Control Computer Data. Accurate steering is obviously driven by the accuracy of the data entered. The VRP data must identify the correct steerpoint as target data and VRP bearing and range data must be correct, and both points must have accurate elevations entered. Elevations are important since this data is used for positioning radar and HUD symbology. Additionally, anytime you bomb with the FCR in a non-AGR mode, the FCC uses steerpoint elevations for BARO bomb computations. TMSing forward to command Fixed Target Track (FTT) on a radar significant target/OPA will allow ranging, allowing the FCC to compute height above target.

5.11.4 System Integration. There are several options to choose from for non-visual attacks. CCRP allows the most flexibility, providing adequate references to drop from medium or low altitude, from a level, dive, or climbing delivery. It allows target identification or other reference points from several SOIs. LADD is designed for preplanned loft deliveries, but in reality, gives no better loft mechanization than CCRP. VIP/VRPCRP is specifically designed to allow for a visual system update prior to the target, usually from low altitude. VIP/VRPLADD allows for a visual update for a loft attack.

5.11.4.1 Symbology. When you select CCRP or LADD delivery mode on the SMS, the IP or target steerpoint must be selected on the DED and VRP/VIP must have been previously mode selected for the VRP/VIP sighting options to function. Only one mode, VRP or VIP, can be selected at a time. With these requirements met, the radar cursors automatically go to the target, OAP, or IP/RP (depending on what rotary/sighting option selected). The HUD symbology, TD box, OAP triangle, and the IP/RP diamond appear if these points are in the HUD FOV. (See **Figure 5.33**, HUD Symbology.) If the TD box is not in the HUD, the pilot will see the target locator line (TLL).

Figure 5.33 HUD Symbology.



5.11.4.2 Slew Inputs. If an aiming error is discovered, slew the cursors or HUD symbology over the point of interest. Slew rates are optimized for whichever point selected on the MFD (target, OAP1, OAP2, and IP/RP). All cursor slews carry over for other steerpoints and deliveries. Cursor zero (CZ) can be used to clear all slews and place the cursor at the INS estimated point. The SOI automatically initializes to HUD when the VRP/VIP aiming option is mode-selected. The bearing pointer and DME on the HSI usually points to the INS estimate of the steerpoint. The exception being post-designate VIP, then it points to the designated IP.

5.11.5 Continuously Computed Release Point and Visual Initial Point/Visual Release Point Computed Release Point Specifics.

5.11.5.1 Radar Slewing. The use of the OAP helps develop a pointing system to make target identification easier. Selecting an OAP as a sighting reference will cause the radar cursors to move from the steerpoint to the selected offset point. Check the location of the OAP prior to going to expand to ensure that the cursors move to the correct position. In expand, the cursors are centered in the display, and slews move the map underneath the cursors, while OAP selection shifts the map display rather than the cursors. Ensure the radar return chosen to slew on corresponds to the selected aiming reference (i.e., OAP 1 or OAP 2). Whether target, OAP 1, or OAP 2 is selected, HUD steering is always to the selected steerpoint, and adjusted for FCC inputs. Anytime a significant error is made with an FCC slew input or if the scope relationships do not appear to be correct, you can return to raw INS data by depressing the CZ option select button (OSB).

5.11.5.2 Visual Reference Point. The VRP option is available anytime the VRP option is mode selected with valid data entered from the target to the visual point. While OAP provides a method of updating radar sighting to a target, VRP provides a visual means of doing the same thing. The two visual update points are the VRP and the PUP. Once VRP/PUP data has been entered, the HUD displays a small diamond at the programmed bearing and range for the VRP and a small circle for the PUP. The HUD symbology can be slewed over either point using cursor inputs and/or the pilot can overfly the point and designate with the TMS switch to update the FCC steering.

5.11.5.3 Visual Initial Point (VIP). The VIP option is similar to the VRP option except that the update point is referenced from the IP steerpoint instead of the target steerpoint. Switches are set as follows:

- VIP/VRP mode—mode select on DED/set proper steerpoint as IP/target, if desired.
- Master mode—A/G.
- Steerpoint selected—target (IP for VIP mode).
- FCR mode—Any.
- SMS—weapon, profile, RP, pair/SGL, CCRP, and release angle (if appropriate).
- Master arm switch—MASTER ARM or SIMULATE.
- Sight point option—select target/OA1/OA2/IP/RP.

5.11.5.4 Employment Considerations.

5.11.5.4.1 Ranging is DTS PR, BARO or RALT since AGR is unavailable. Check system altitude and do an ACAL if required.

5.11.5.4.2 Ensure AUTO range scale is selected, or select the scope range which shows the steerpoint in NORM FOV.

5.11.5.4.3 Check the antenna elevation knob in the detent. The FCC will automatically control tilt.

5.11.5.4.4 Work big to small. Select the best radar return—target/OA1/OA2/IP/RP. Adjust the radar gain to eliminate background clutter, if required, using hands-on control.

5.11.5.4.5 Once the proper return has been positively identified, Expand, DBS-1, and DBS-2 may be used to refine cursor placement.

5.11.5.4.6 If a visual overfly update is desired, with the SOI in the HUD, depressing designate will update the weapons aiming solution and the SOI will return to the radar. Further refinements can be made on the radar if required.

5.11.5.4.7 Fixed target track (FTT) can be used to track a return. Pressing designate with the SOI in the radar and the radar in any GM FOV commands FTT if the radar can track the FTT point.

5.11.5.4.8 Fly the FPM to the steering line or center the steering symbol on the radar or SMS. Time to release is available in the HUD.

5.11.5.4.9 A 100-milliradian circle appears in the HUD to warn of the maximum solution, 2 seconds prior to maximum range for weapon delivery. At maximum solution range, the circle flashes for 2 seconds, then disappears and the solution cue appears on the BFL.

5.11.5.4.10 CCRP allows you a choice of delivery G and pitch. You can pull up and loft the ordnance, continue in level flight, or dive at the target if required.

5.11.5.4.11 When the solution cue reaches the FPM, the bombs release and the FPM flashes.

5.11.5.4.12 The SMS weapons quantity will not countdown until the pickle button is released. If the weapon quantity decreases to zero, the HUD A/G symbology will disappear.

5.11.6 Low-Altitude Drogue Delivery and Visual Initial Point/Visual Reference Point Low-Altitude Drogue Delivery. The LADD mode was originally designed for delivery of retarded weapons with an airburst fuzing requirement.

5.11.6.1 System Use. Currently the LADD is most often used to loft free-fall airburst type weapons. Actual weapons release computations in the FCC are very similar to CCRP with a few notable exceptions. The LADD mode replaces the maximum range CCRP solution with a programmed 4-G pull to a 45-degree climb angle. This Pull-Up maneuver occurs as a pilot entered pull-up range. The LADD mode allows the pilot to enter a LADD TOF, which enables the FCC to compute and compensate for average wind effect on the bomb after release. With a value other than zero entered in LADD TOF, the FCC will adjust the programmed pull-up range for variations in GS. Switches are as follows:

- VIP/VRP sighting option—mode select on DED, set proper steerpoint as IP/target.
- Master mode—A/G.
- Steerpoint selected—TGT (IP for VIP mode).
- FCR mode—GM, SEA, BCN, and GMT.
- SMS—weapon, profile, RP, pair/SGL, and LADD.
- SMS control page—pull-up range, verify.
- Master arm switch—ARM/SIMULATE.
- Sighting point—TGT/OA1/OA2/IP/RP.

5.11.6.2 Employment Considerations.

5.11.6.2.1 Radar operation, consideration, and procedures are the same as those for VIP/VRPCRP.

5.11.6.2.2 Vertical steering cue appears and moves toward the FPM, 10 seconds prior to pull-up.

5.11.6.2.3 When the cue hits the FPM the solution cue resets to the top of the HUD and this vertical steering cue commands a pull to 45 degrees.

5.12 System Altitude Errors. Unknown or uncorrected system altitude errors have a negative impact on the accuracy of the F-16's computed weapons deliveries (non-AGR). A comprehensive understanding of factors effecting TD box placement, the impact a system altitude error has on delivery accuracy, and methods to correct system altitude errors is required to effectively employ the F-16.

5.12.1 Factors Affecting Target Designator Box Placement. There are many factors that affect TD box placement. A primary influence on TD Box accuracy is the accuracy of the coordinates. Mensurated Coordinates provide the most accurate target location. Target coordinates and elevation data extracted from reference charts must be as precise as possible. The finer scale reference map used, the more accurate the coordinate will be, i.e. a coordinate extracted from a 1:50,000 chart should be more accurate than from a 1:500,000. A second factor affecting TD box placement is the accuracy of the INS. Obtain the best INS alignment that time and mission will allow. A quality GPS track will greatly increase system accuracy. If the digital terrain database is available for the planned area of operations, DTS will further enhance system accuracy. Finally, keeping the system accurate with FCC slews on significant turnpoints and ACAL's if required will provide the most accurate TD Box placement. Check the TD box placement on multiple turnpoints and ensure a trend before inputting a slew. Assess how accurate the turnpoint coordinates are before making a correction, random errors are most likely coordinate inaccuracies, while consistent errors are most likely system errors. Realize a 6/12 error with a TD Box/diamond moving across the ground is likely a system altitude or turnpoint elevation error. If the estimates of present position and system altitude are incorrect, the display of target symbology will also be incorrect.

5.12.2 Target Designator Box Placement with Errors. The placement of the TD box/diamond is on a three-axis graph as shown in **Figure 5.34**, TD Box Three-Axis Graph. The X-axis (3/9) of the graph represents side to side or latitude (N-S), the Y axis represents aircraft heading or longitude (E-W), and the Z axis represents elevation of the target. The TD box will not be on the target, if any one of these values is erroneous. If the position of the TD box/diamond relative to the ground does not change as the aircraft approaches the target/steerpoint likely the coordinate or X/Y component of the navigation solution is inaccurate. If the position of the TD box/diamond appears to drift toward the target/steerpoint as the aircraft approaches the target/steerpoint, system altitude is erroneous. As shown in **Figure 5.35**, TD Box Error, an incorrect elevation value and/or system altitude error effects TD box placement along the Z-axis. The TD box appears long of the target if the elevation entered is higher than actual or the system altitude is low. The TD box appears to be short of the target if the elevation entered is lower than actual or the system altitude is high. In both cases, the TD box/diamond will appear to move towards the target/steerpoint as the aircraft gets closer to the point and the line-of-sight to the target steepens.

Figure 5.34 TD Box Three-Axis Graph.

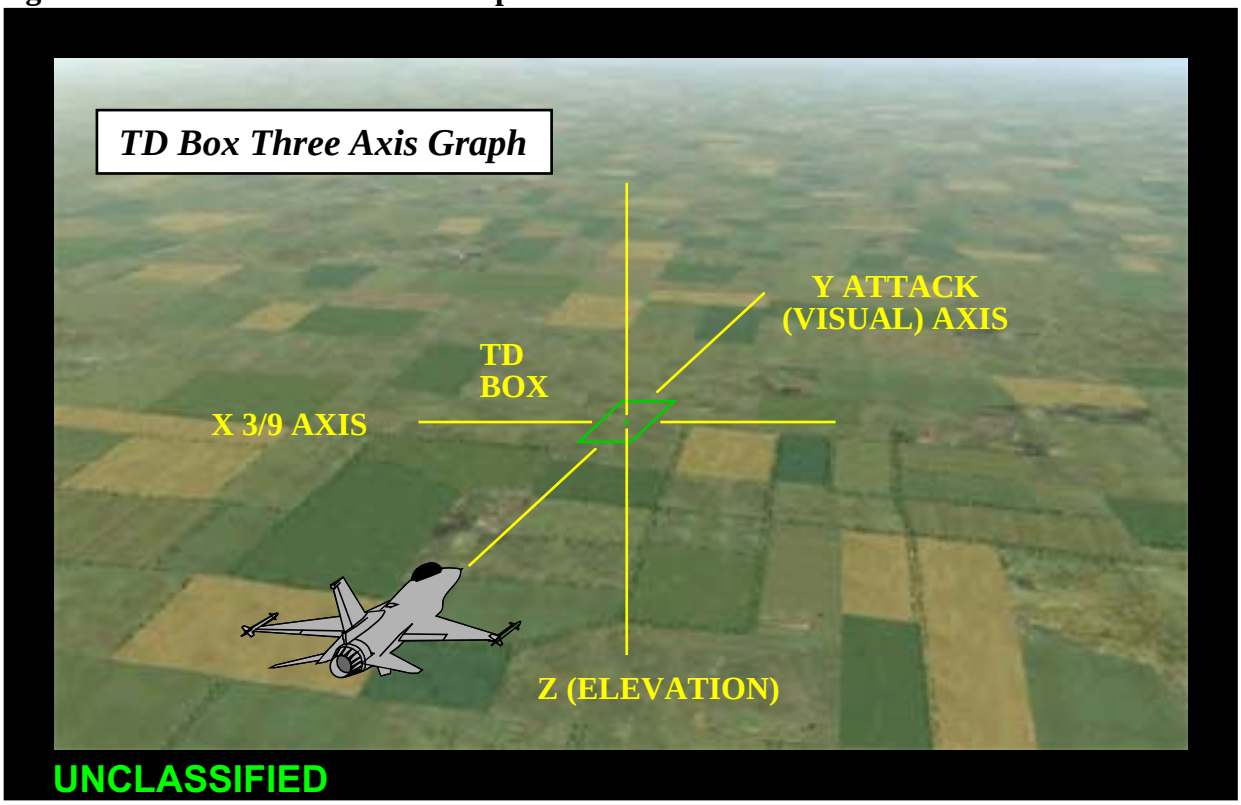
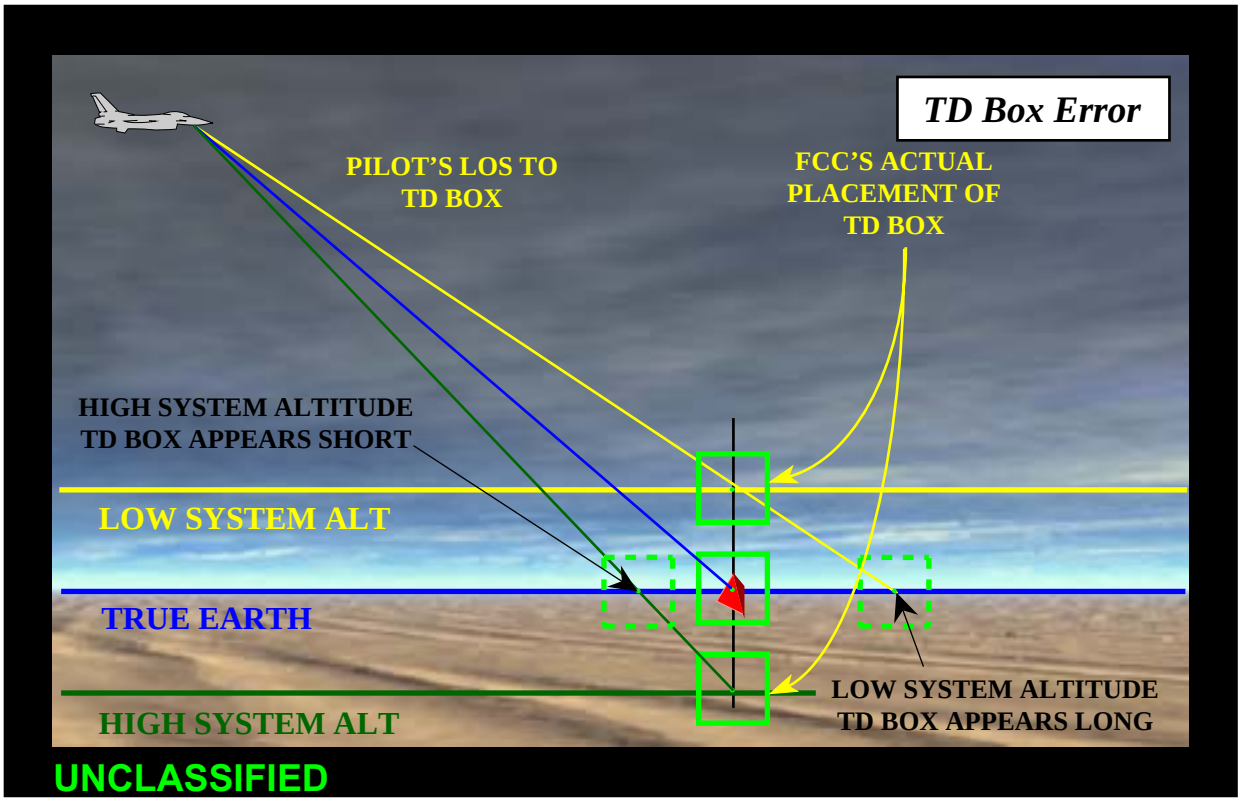
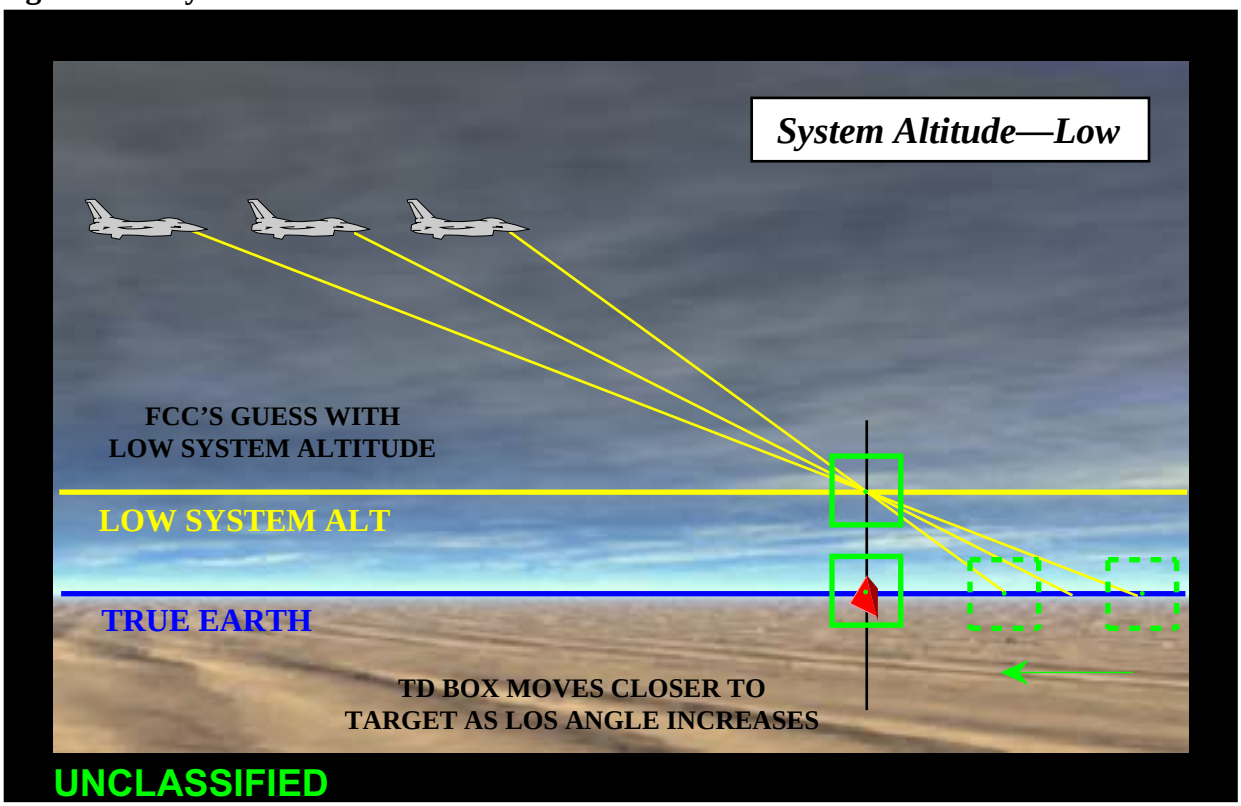


Figure 5.35 TD Box Error.



5.12.2.1 System Altitude—Low. Remember that with a low system altitude, the jet thinks the ground is closer to the jet than it actually is. System altitude is low when the TD box appears to be positioned long (memory jogger: Low = Long) of the target. Its actual position on the three-axis graph is high of the target because the airplane is erroneously positioning the TD box where it thinks the ground really is (above the real ground). An example is shown in **Figure 5.36**, System Altitude—Low. The position of the TD box appears to track toward the target in a time-sequenced profile view.

Figure 5.36 System Altitude—Low.



5.12.2.2 System Altitude—High. The opposite is true when system altitude is high. The aircraft thinks the ground is further below the aircraft than it actually is. An example is shown in **Figure 5.37**, System Altitude—High.

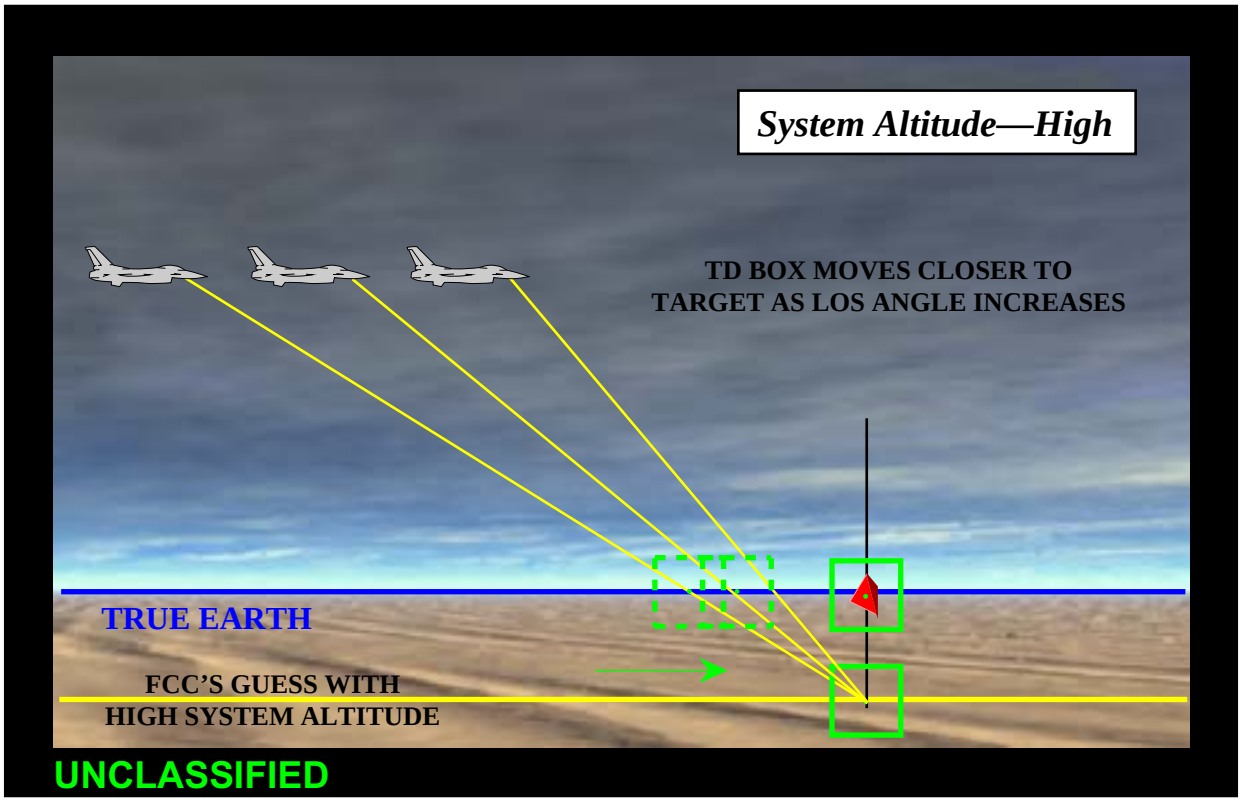
5.12.2.3 System Altitude—Accuracy (Blind Deliveries). System altitude errors significantly affect weapon delivery accuracy. A review of blind delivery events and visual delivery events is required to understand weapon delivery errors due to incorrect system altitude. In a blind delivery event, assume the radar cursors are correctly positioned on the aimpoint, and the TD box location is ignored.

5.12.2.3.1 If system altitude is high, a short impact occurs because the FCC thinks the target is below the actual elevation and computes an early release. The weapon is released with a trajectory to hit the erroneous point below the actual target, and impacts the earth short of the actual target while on its path to the erroneous position. The TD box appears short of the target and the system tries to drop the weapon through the TD

box. However, because the weapon follows a curved trajectory, bomb impact error is less than TD box positioning error. (See **Figure 5.37**, System Altitude—High.)

5.12.2.3.2 A low-system altitude results in a long impact because the FCC thinks the target is above the actual elevation and computes a late release (**L**ow-system altitude equals a **L**ong bomb). (See **Figure 5.36**, System Altitude—Low.)

Figure 5.37 System Altitude—High.



5.12.2.4 System Altitude—Accuracy (Visual). Impact errors due to system altitude inaccuracy in visual deliveries are opposite those experienced in blind deliveries. Visual events such as DTOS employ sighting through the HUD. TD box location is set via the HUD LOS and ignores radar cursor placement. The same errors occur in CCRP if 6 to 12 o'clock TD box or VRP symbol errors are corrected using the HUD as a reference.

5.12.2.4.1 Even with the TD box on the target, if system altitude is high, the FCC thinks the target elevation is below actual and computes a later release point resulting in a long impact. (See **Figure 5.38**, Visual Delivery—High-System Altitude.)

5.12.2.4.2 If system altitude is low, the FCC thinks the target elevation is above the actual elevation and computes an early release point resulting in a short impact. (See **Figure 5.39**, Visual Delivery—Low-System Altitude.)

Figure 5.38 Visual Delivery—High-System Altitude.

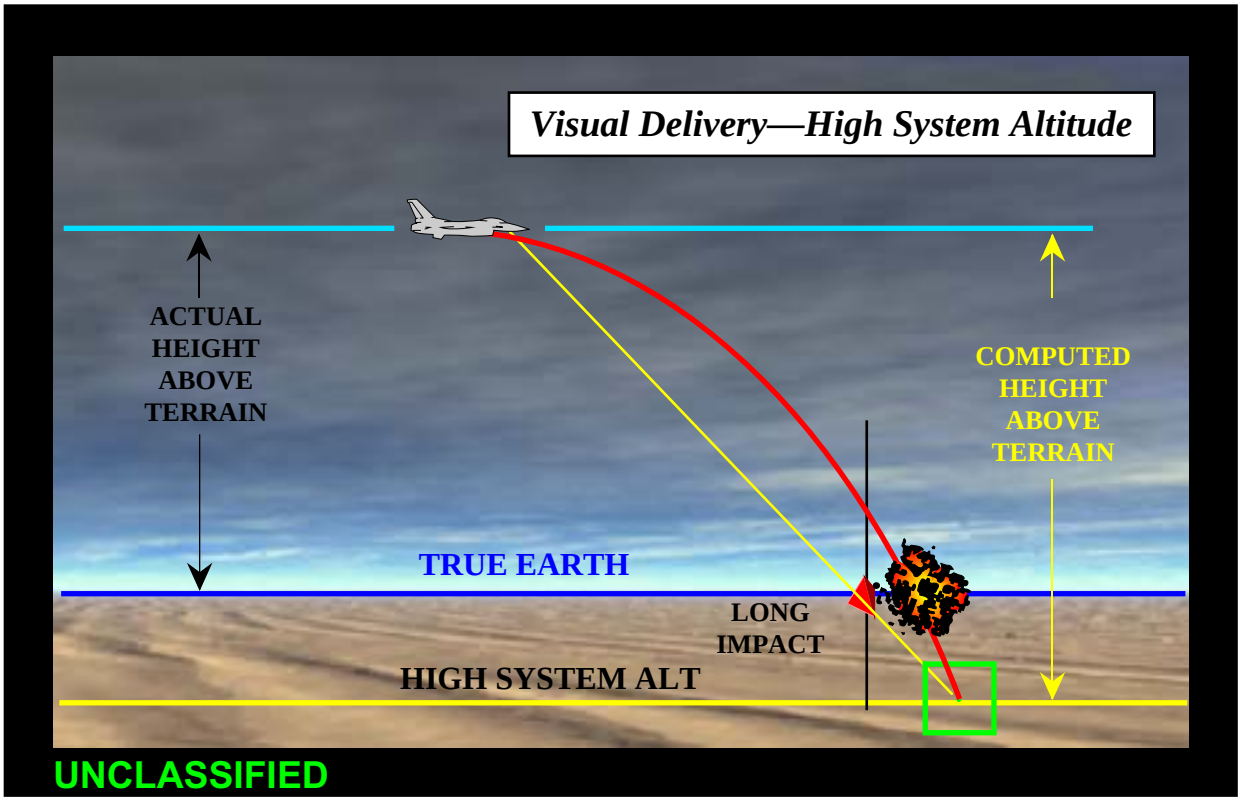
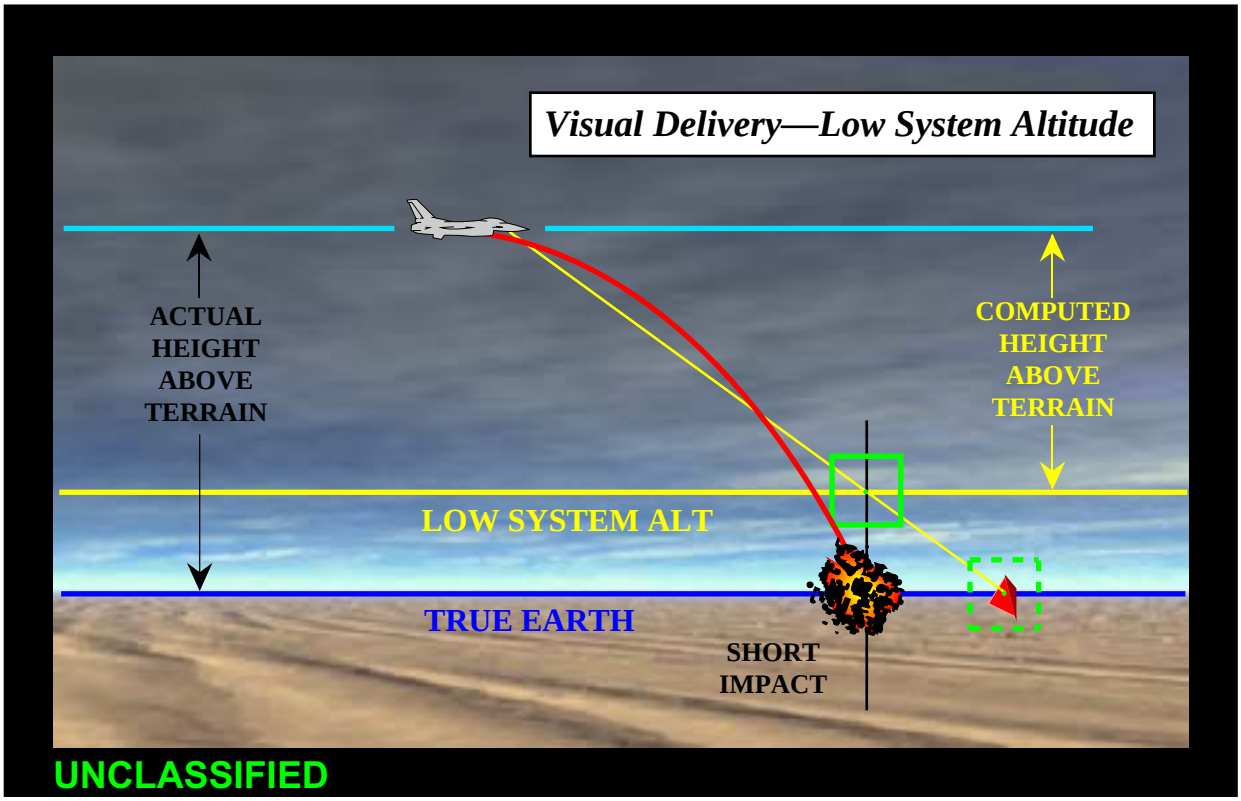


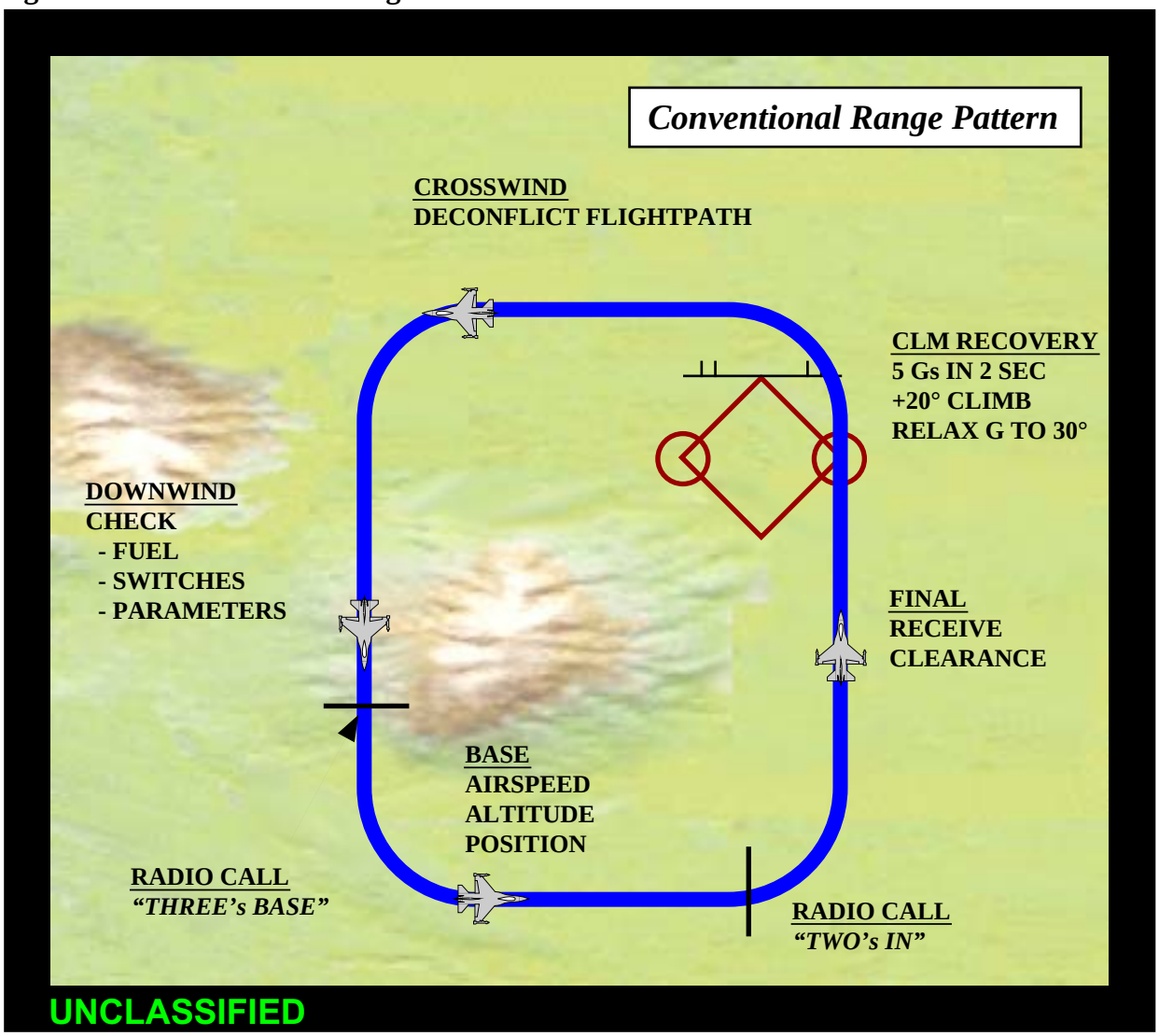
Figure 5.39 Visual Delivery—Low-System Altitude.



5.12.3 Correcting System Altitude Error. The best method to correct for a known system altitude error is to do an ACAL. There are a variety of methods which include radar altimeter (RALT), FCR, HUD, GPS, DTS or TGP to update system altitude. Refer to the aircraft TOs for the various ACAL update procedures.

5.13 Controlled Range Patterns. Basic or initial qualification will normally be accomplished on a conventional manned range. (See **Figure 5.40**, Conventional Range Pattern.) There are usually four patterns available to accomplish the various events: box, curvilinear, pop-up, and radar (or nuke). Curvilinear and pop-up patterns are considered tactical deliveries.

Figure 5.40 Conventional Range Pattern.



5.13.1 The Box Pattern. The pattern activities described here will span approximately 80 to 90 seconds.

5.13.1.1 Crosswind. When turning crosswind (or any other place in the pattern), realize that you may be turning inside the preceding aircraft (the "coffin corner"). Roll out or ease

off momentarily and look outside as well as inside your turn until you are sure your turn is clear. If you are still not sure who is where, ask! For example, “VIPER 1, SAY POSITION.” All other flight members should stay off the radio except to resolve the situation: “VIPER 1 IS TURNING BASE.” Once the visual is regained, or SA confirms there is no conflict, the affected fighter should transmit “VIPER 2, CONTINUE.” If the situation cannot be immediately resolved, a “KNOCK-IT-OFF” will be called. Maintain altitude separation until the confusion is resolved to avoid passing or colliding with the preceding aircraft. This will also aid in keeping the pattern from becoming uncomfortably tight.

5.13.1.2 Downwind. The flight leader will establish the downwind leg ground track. This is not a fixed position and may be varied by individual pilots to adjust spacing. Downwind should be wide enough to allow for wings-level stabilization on the base leg.

5.13.1.2.1 In low-angle patterns (20 degrees or less), adhere closely to the pattern airspeeds and altitudes. In higher altitude delivery patterns, climb at an airspeed no slower than the planned base leg airspeed. Plan to arrive at base leg altitude prior to actually turning base. On hot days or with higher gross weights, afterburner may be required.

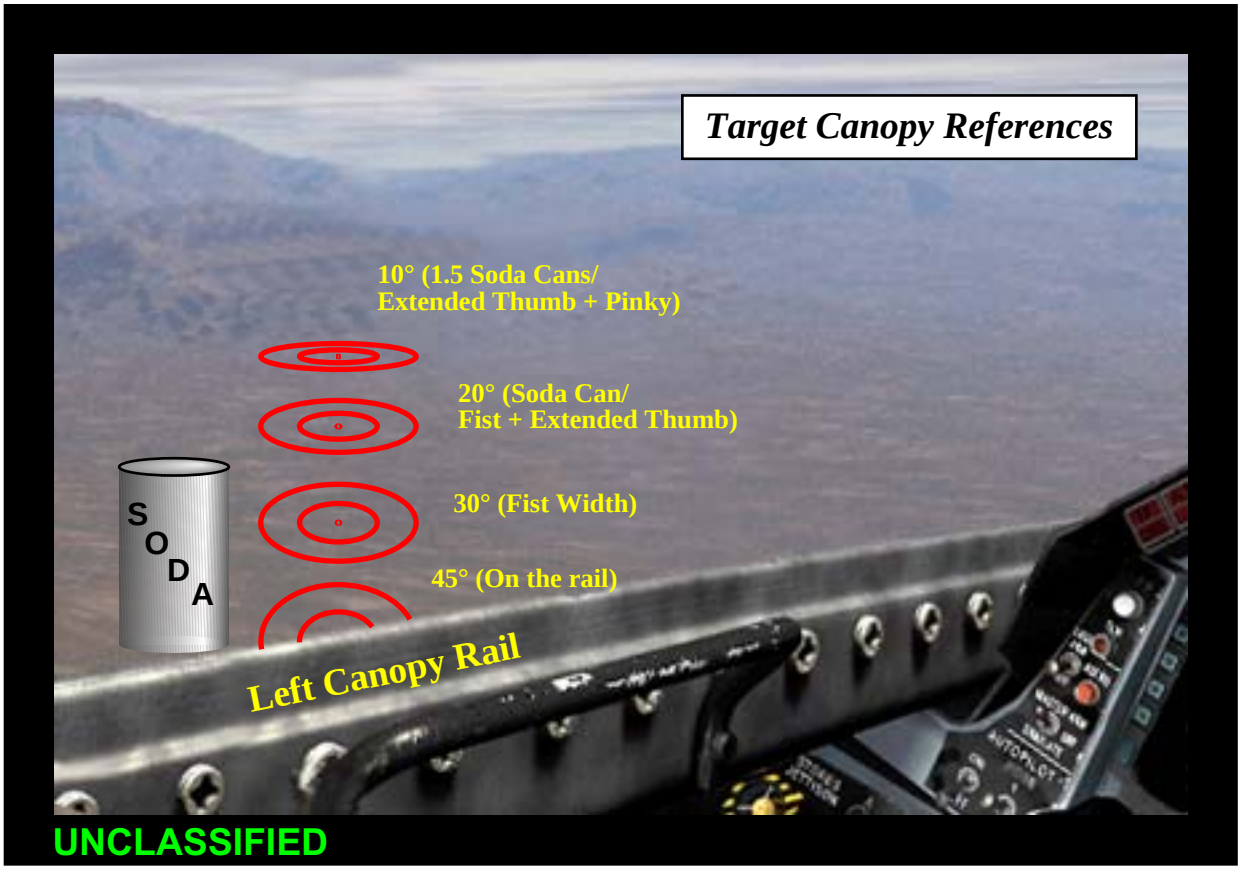
5.13.1.2.2 While on downwind prepare armament systems as necessary. Evaluate pattern spacing and analyze previous delivery errors. Note winds and adjust pattern as necessary to fly the correct ground track.

5.13.1.2.3 A four-ship is properly spaced when an aircraft is at each of the four corners of the pattern. Alter the distance abeam the target on downwind as necessary to adjust pattern spacing.

5.13.1.3 Base. Base position is one of the most critical positions in the pattern. It determines proper dive parameters and is normally the largest cause of poor parameters when improperly flown. There are three major conditions required to begin a successful roll in: airspeed, altitude, and base distance. Determine these parameters through attack calculations done during preflight planning or a taken from locally approved weapons attack guides. The proper base distance can be achieved via two sources: eyeballs (visual point on the ground or visual assessment of the wire) or the HUD. The easiest way is to set the correct target-to-canopy reference or “sight picture” for the event being flown while on base. (See **Figure 5.41**, Target Canopy References.)

5.13.1.3.1 Using HUD Data. With an accurate INS/FCC, the base position can also be flown by using the range calculations in the HUD (CCRP mode). This can be an accurate base distance used for not only a box/curve pattern, but also a pop-up and roll-in point for low- and high-altitude attacks. A practice of using CCRP with a preplanned roll-in range could enhance the attack parameters.

Figure 5.41 Target Canopy References.



5.13.1.3.2 Procedures. The following procedures should be used when flying the conventional range pattern:

5.13.1.3.2.1 Do not vary base leg position to adjust pattern spacing. If you are too close behind the aircraft ahead, turn base at the normal point and plan to go through dry on final. Adjust your pattern on downwind.

5.13.1.3.2.2 Call turning base (e.g., “VIPER TWO, BASE”).

5.13.1.3.2.3 Delay your base call (not the turn), if necessary, until the aircraft ahead has received clearance from the range control officer (RCO).

5.13.1.3.2.4 When established on base, check the “sight picture” and make last-minute adjustments in heading to compensate for errors, winds, or actual ground track—adjust airspeed.

5.13.1.4 Roll In. Consider the winds at pattern altitude and adjust the final roll-in point as necessary. As you begin the final turn, determine if you are too close or too wide on base, you may still achieve a proper dive angle by adjusting nose attitude during roll in. Compensate for being too close by over banking and lowering the nose sooner. Avoid an extreme nose-low attitude. Abort the pass if dive angle is over 5 degrees steeper than planned at the roll out (10 degrees if the planned recovery altitude is above 10,000 feet AGL). Compensate for being too wide by reducing bank and maintaining the nose level

longer in the final turn. Realize that airspeed on final approach depends largely on power setting. Use Mil power throughout the turn, retarding the throttle to the proper setting on final. Mil power should preclude an inadvertent slow speed/high AOA situation. Lead roll in by one turn radius (usually about 3,300 to 4,500 feet depending on TAS) to prevent angling. The amount of allowable angling varies for different ranges, and depends on RCO judgment. However, up to 10 degrees is normally allowable. Never overfly manned range towers. If it looks or feels bad, go through dry.

5.13.1.5 Final. When rolling out on final during any attack, make certain you know exactly which is your target and release ordnance only when you are positive of its identification.

5.13.1.6 Recovery. Recover the aircraft above the minimum recovery altitude regardless of whether ordnance is away or not. Recoveries should be flown in order to meet safe escape parameters.

5.13.1.6.1 Climbing Safe Escape Maneuver. Normally, a climbing (CLM) SEM is used for dive angles greater than 20 degrees. After release, obtain 5 Gs in 2 seconds. As the nose approaches the horizon, apply Mil power. G is maintained to a 20-degree climbing flight path angle and then relaxed until 30 degrees.

5.13.1.6.2 Turning Maneuver. For dive angles 20 degrees or less, a climbing or turning maneuver may be used depending on local guidance.

CAUTION: There are two types of turning maneuvers: Level Turn and Descending Turn—ensure you refer to the appropriate one.

5.13.1.6.3 Level Straight Through Maneuver. For level deliveries at low altitude, another SEM option is the level straight through (LST) maneuver. To fly this maneuver, release at or above the calculated MRA and fly straight and level for bomb TOF plus 3 seconds.

5.13.1.7 Turn to Crosswind. Begin the turn to crosswind as soon as the proper SEM is completed and power has been advanced for the climb back to base altitude. Any delay will extend the pattern and present the risk of the following aircraft turning inside your aircraft.

5.13.1.8 Pattern Spacing. Adjust downwind as necessary and place base leg in the proper position every time.

5.13.1.9 Radio Procedures.

5.13.1.9.1 If turning base and the pilot in front of you calls in, allow the RCO to clear him before making your base call.

5.13.1.9.2 Acknowledge all radio calls directed at you except when “cleared” by the RCO.

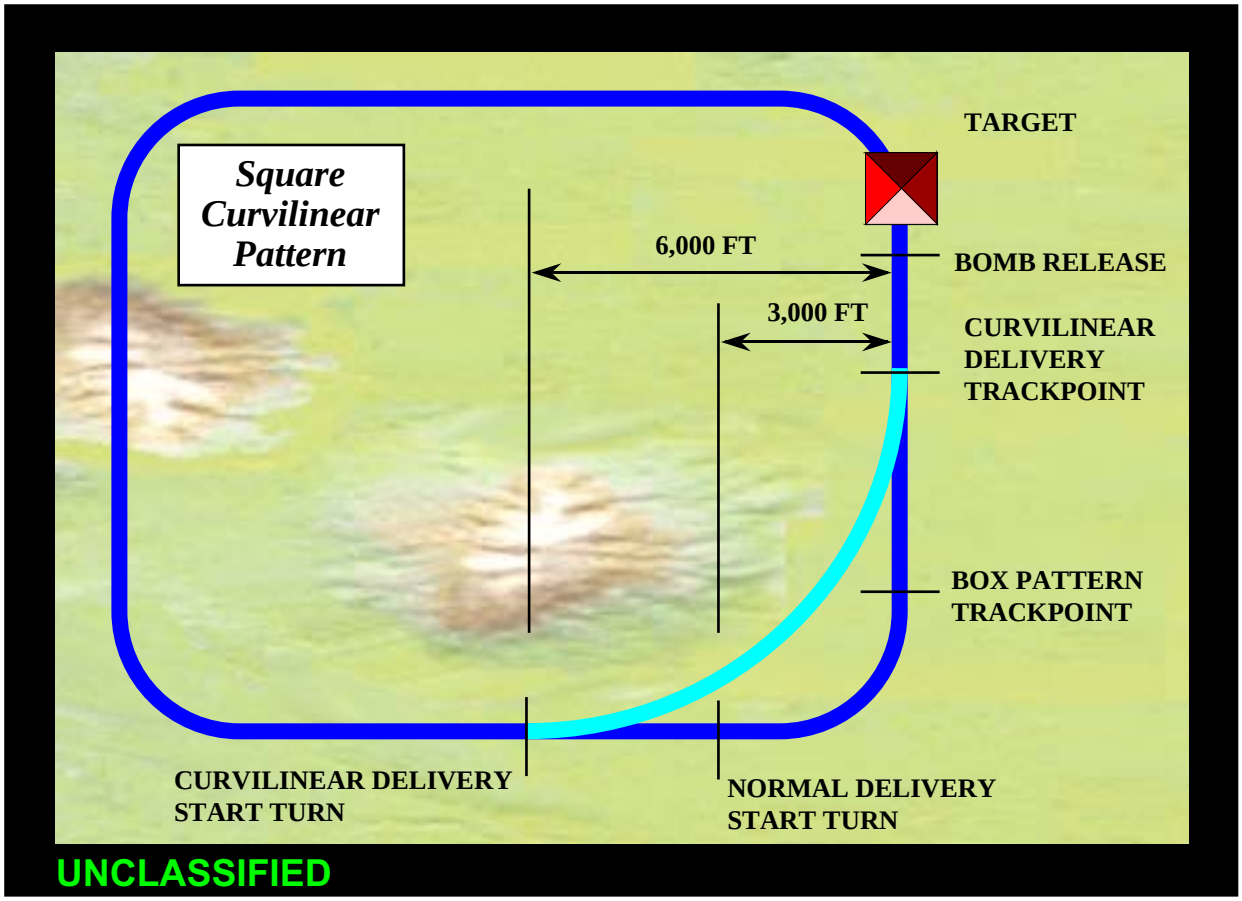
5.13.1.9.3 Do not hesitate to request clearance if the RCO has not cleared you to drop. Do not drop without clearance.

5.13.1.9.4 If you go through dry, call, “OFF DRY.”

5.13.2 Curvilinear Deliveries. Curvilinear deliveries are used primarily for delivering ordnance from shallow dive angles at relatively low-release altitudes. The use of shallower dive angles and lower release altitudes may be required due to the type of ordnance being delivered, weather in the target area, or other tactical considerations.

5.13.2.1 Curvilinear Options. A curvilinear approach consists of constantly changing heading, altitude, airspeed, and G-loading to arrive on final for a short tracking solution, thus decreasing AAA hit probability. (See **Figure 5.42**, Square Curvilinear Pattern.) It may consist of almost any flight path, which will allow the pilot to get from roll-in altitude to wings-level on final at the planned track point. The most common technique is a descending turn in 30 to 60 degrees of bank using Mil power initially. Approaching desired release airspeed, retard the throttle as required to hold airspeed. Play the last half of the turn to arrive on final with the BFL through the target for CCIP deliveries. For DTOS deliveries fly the TD box to, or just short of, the target. Cross-check the parameters and make any adjustments necessary to meet the planned release minimums. Designate/pickle and initiate the recovery. This technique is good for LAS, LAHD, LALD, and LLLD deliveries. Curvilinear deliveries may be flown as follows.

Figure 5.42 Square Curvilinear Pattern.



5.13.2.1.1 The crosswind, downwind, and base leg are similar to the basic box pattern.

5.13.2.1.2 Begin the curvilinear approach to final at approximately twice the distance of the basic delivery turn to final—6,000 feet prior to an imaginary extended centerline through the target—by lowering the nose slightly, increasing power, and simultaneously establishing a 30- to 60-degree bank.

5.13.2.1.3 Adjust dive angle, power, and bank angle throughout the final turn to arrive wings-level on final with the target approximately two-thirds of the way down the BFL between the FPM and the CCIP pipper for CCIP. Wings-level tracking time on final should not exceed 5 seconds with 3 to 4 seconds desired.

5.13.2.2 Curvilinear Downwind. Curvilinear deliveries may also be flown by initiating the turn to final from a modified downwind position. The key to starting the pattern from other than the base leg position is to adjust the downwind altitude and position so that a turn can be made to put you at or near the curvilinear base leg position. (See **Figure 5.43**, Curvilinear Pattern [Continuous Turn].) Fly a higher downwind altitude and make your turn to final a continuous 180-degree turn. However you get there, whether a descending turn or a level turn, the desired objective is to arrive at the planned track point with the proper parameters.

5.13.3 Pop-Up Deliveries. Standard range patterns should be established to enable pilots to fly pop-up deliveries to arrive at similar attack parameters as the previously discussed box pattern finals. (See **Figure 5.44**, Typical Pop Pattern.) Use caution for descending turns at low altitude. Pop-up deliveries may be flown as follows:

5.13.3.1 The base position should be based on a DME range from the target that will allow a descending Mil power turn to point at the target NLT 1 to 2 NM prior to the action point.

5.13.3.2 Accelerate to 480 to 540 KCAS or as required for the delivery action at the specified range. Pop attack planning and execution is discussed in **paragraph 5.14**, Pop-Up Deliveries, and **paragraph 5.17**, Pop-Up Formulas.

Figure 5.43 Curvilinear Pattern (Continuous Turn).

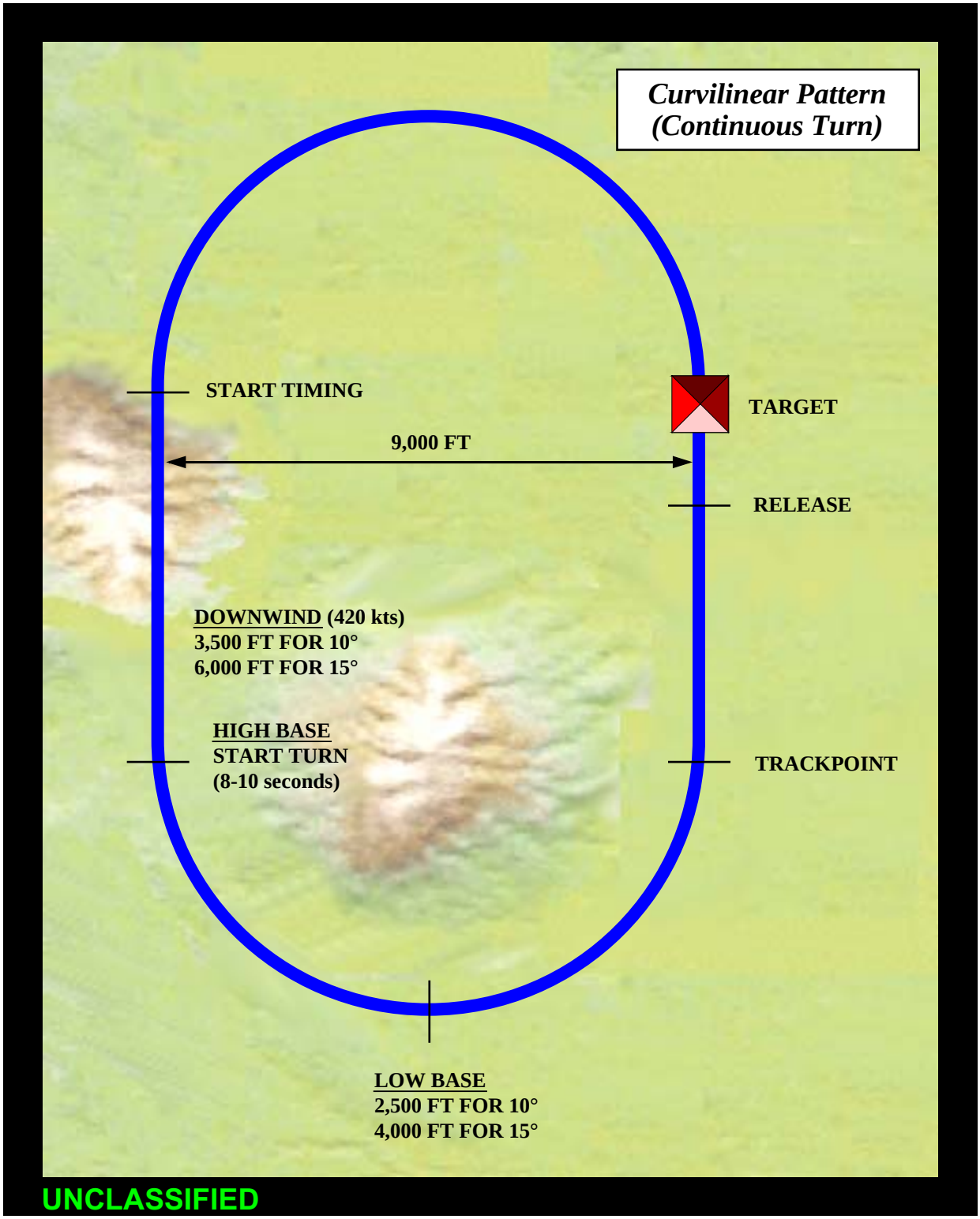
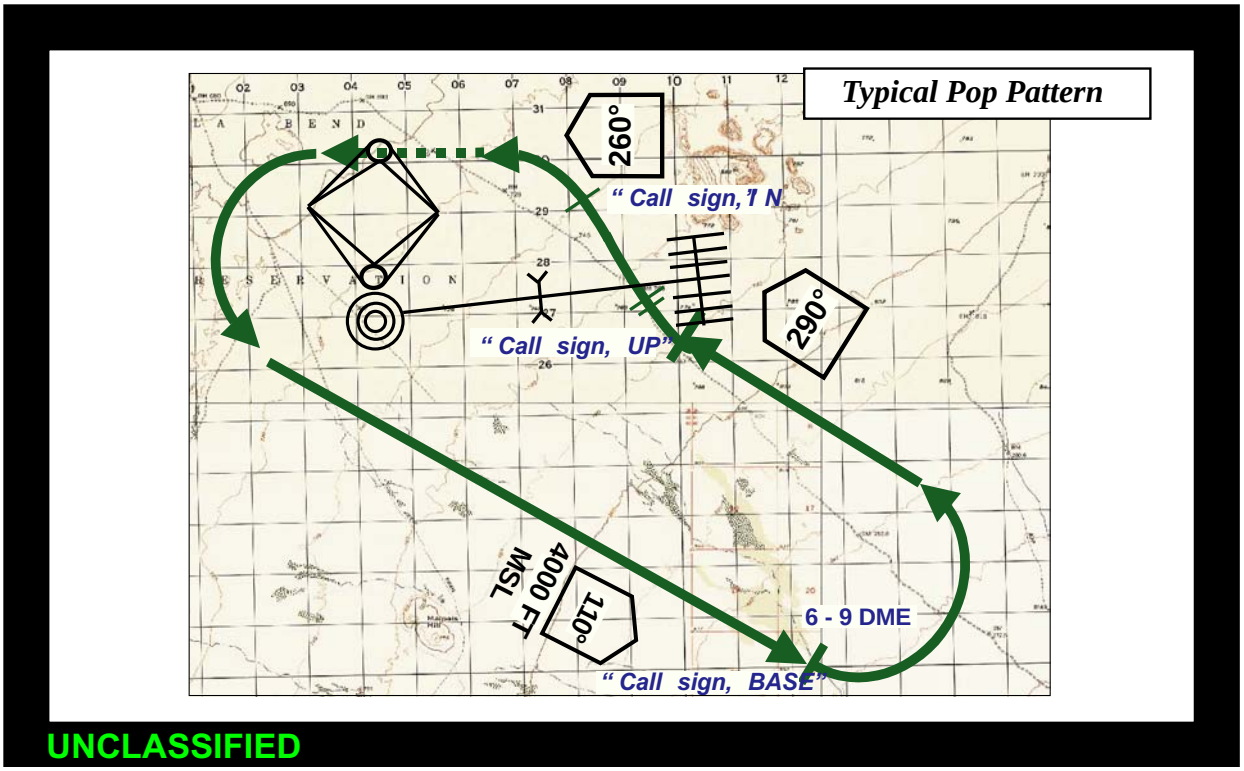


Figure 5.44 Typical Pop Pattern.



5.13.4 Radar Deliveries. The radar delivery pattern is used primarily for nonvisual events culminating in system level deliveries or loft deliveries. As shown in **Figure 5.45**, Radar Pattern, a typical radar-bombing pattern is depicted. Use caution when descending to final at low altitude; fly the aircraft first, work the radar second.

5.13.4.1 Fly downwind at the appropriate airspeed and altitude.

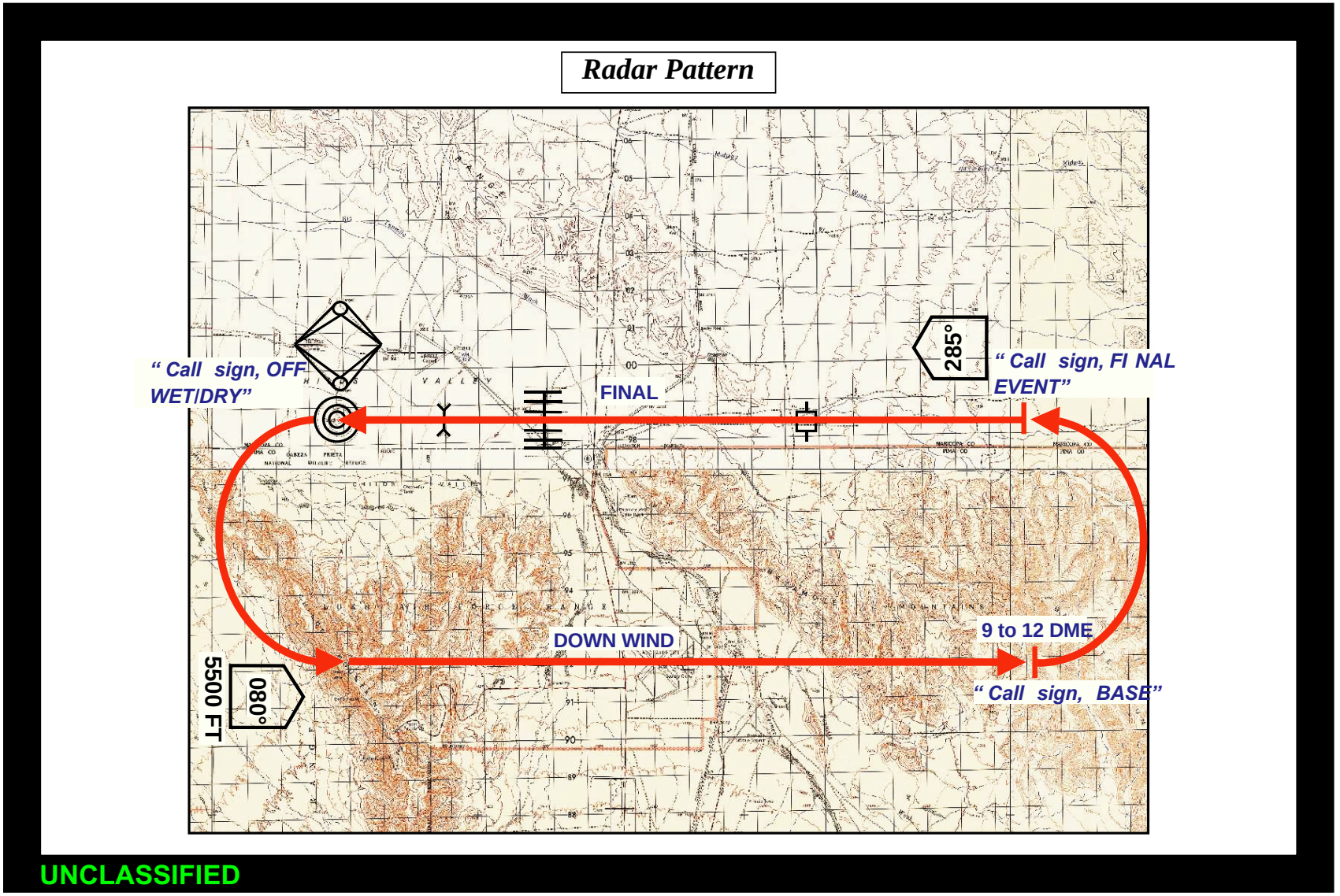
5.13.4.2 While on downwind, prepare armament systems as necessary. Evaluate pattern spacing and analyze previous delivery errors. Analyze winds and adjust pattern as necessary to fly the correct ground track.

5.13.4.3 Turn base at the briefed position.

5.13.4.4 Execute the attack and proper escape maneuver.

5.13.5 Range Departure. When recovering from the last pass, the flight lead climbs while slowing to the planned rejoin airspeed. Prior to rolling in on final for your last pass, attempt to acquire the preceding aircraft. This makes later acquisition easier. Execute a normal pass and recovery.

Figure 5.45 Radar Pattern.



5.13.5.1 Radio Calls. Report all aircraft you have in sight. For examples,

- "VIPER TWO, OFF, ONE AIRCRAFT IN SIGHT."
- "VIPER THREE, OFF, TWO AIRCRAFT IN SIGHT."
- "VIPER FOUR, OFF, THREE AIRCRAFT IN SIGHT."

- or, if Viper Four does not see all preceding aircraft...

- "VIPER FOUR OFF, ONE AIRCRAFT IN SIGHT. VIPER THREE ROCK YOUR WINGS"...(Viper three rocks wings, and Viper four confirms the single aircraft Viper four sees is Viper three)..."VIPER FOUR VISUAL ON VIPER THREE". (Viper Three then directs Viper four as required to insure a safe rejoin.)

5.13.5.2 Blind Off Range. If you do not have visual contact with all preceding aircraft, say so immediately. Do not begin a turn until you have visual contact or until positive altitude separation is assured. Realize that angle-off can be rather high during off-range rejoins. When coupled with high airspeeds, this situation often requires more judgment and skill than do normal rejoins. Avoid dropping low during rejoin. Remember aircraft control takes precedence over a channel change if a frequency change is necessary prior to the rejoin.

5.13.5.3 Safety Checks. At the earliest convenience, safe all armament switches. The flight lead calls for an armament safety check and all wingmen confirm their switches are safe and acknowledge. Complete an ordnance check when directed.

5.13.6 Foul Avoidance. Minimum recovery altitudes are established based upon blast and fragmentation envelopes of live ordnance, fuze arming requirements, or the engagement envelopes of particular classes of threats. These altitudes are generous in that they allow release at the closest possible slant range and still effect a safe and proper recovery. Violation of established minimums places life and aircraft in jeopardy; accuracy seldom improves with such action. The RCO, whose decision is final, issues fouls and/or suspends your operation on the range for any of the following reasons:

- Recovering below minimum altitude.
- Abrupt or dangerous recoveries.
- Firing past the strafe foul line.
- Delivery of ordnance on a wrong or unauthorized target.
- Double bursting strafe.
- Releasing ordnance without clearance.
- Lazy pull-offs.
- Any act deemed unsafe.

5.13.6.1 Multiple Fouls. For the first foul, you receive a gross error bomb or zero strafe hits for that pass. If the pass was dangerous, you are ordered off the range. If you are issued two fouls on any mission, the RCO must order you off the range. Climb to pre-briefed altitude and safe all switches. Adherence to the following guidelines aids in avoiding fouls:

- Know the minimum recovery altitude for each event and do not "press" past the planned release altitude.

- Begin each delivery pattern within proper parameters.
- Avoid any last minute tracking corrections that carry you past release altitude.
- Do not attempt to observe the ordnance impact. Your most critical task is to safely recover the aircraft above the foul altitude/ground.
- Recover smoothly, using a guideline of 5 positive Gs in 2 seconds. Do not bank in an attempt to air score your own bombs.

5.13.6.2 Strafe Fouls. Most fouls come during low-angle strafe, and firing past the foul line is the most common way to get one. Reference to the foul line as well as the entire range environment with your peripheral vision will aid in avoiding this type of foul. Adherence to foul avoidance techniques also aids in avoiding ricochets. If you are aware of a large number of rounds remaining on the last pass in strafe, consider opening fire a bit further out.

5.13.6.3 Target Identification. Being absolutely sure of your target is not confined to training on controlled ranges; it continues to be a very important factor anytime ordnance is used, even in combat. If you are not certain, ***go through dry!***

5.13.7 Malfunctions. Malfunctions discovered during preflight or any time prior to flight will be isolated or corrected, or abort the aircraft. Circumstances surrounding airborne malfunctions may vary considerably; all require adherence to proper procedures and good judgment. These malfunctions fall into two basic categories: inadvertent releases and failure to release. Inadvertent releases are rare but serious.

5.13.7.1 Inadvertent Release. An inadvertent release is the jettisoning, firing, or releasing of any ordnance, suspension equipment, or aircraft part which was not commanded by the pilot. If an inadvertent release occurs:

- The incident aircraft will abort, check armament switches safe, and be escorted home following the hung bomb procedures.
- Any remaining ordnance that presents a carriage or landing hazard should be expended in a suitable area (single pass, if practical).
- The pilot should note switch positions at the time of release to clarify subsequent write-ups. Initiate aircraft impoundment procedures as outlined in the appropriate directives.

5.13.7.2 No Release. A no release is commonly caused by incorrectly set switches, releasing the pickle button early (quick pickle), malfunctioning SUU/TER, or an SMS problem. Your first indication of no release will likely be the RCO's declaration of a "no-spot." If switches are correct, suspect hung ordnance. On downwind, recheck the SMS for a RDY indication and note the quantity remaining. If the quantity did not step down, then the SMS never delivered a fire signal. A "quick pickle" (releasing the pickle button too soon) can cause this indication and will result in a no release. Continue in the appropriate delivery pattern, executing dry passes if necessary while analyzing the problem. Re-attempts to expend may be accomplished as long as there are no other apparent malfunctions.

CAUTION: Do not become so engrossed in manipulating switches that you exceed pattern parameters. Certain avionics malfunctions will prevent releases:

- FCC or INS failure: no computed releases, manual deliveries only.
- If the SMS fails completely, you are not able to release or jettison anything. Other SMS MFLs may indicate partial system or station failures.

5.13.8 Jettison Procedures. Refer to Dash-1 for jettison of external fuel tanks or any unsecure heavyweight/live ordnance. Local procedures describe what to do when jettison is required. Wingmen should notify their flight leader as soon as they think a jettison may be required because it takes time and fuel to set up for jettison. Bingo fuel is not the time to start jettison procedures. Know the Dash-1 jettison limits for the ordnance/suspension equipment you are carrying. Refer to the checklist when forced to land with asymmetrical stores.

5.13.9 Return to Base and Landing With Hung Ordnance.

5.13.9.1 Strange Field Recovery With Hung Ordnance. In many cases, the strange fields you encounter in your local area may not be familiar with hung ordnance. The primary item to remember is to ensure the tower is informed as soon as possible, preferably before landing.

5.13.9.2 It is also important to notify the tower if the weapons are live or training ordnance.

5.13.10 Radio Failure. During complete radio failure, exercise good judgment when confronted with a situation not covered in this volume, or the flight briefing. Should the situation so dictate, do not be reluctant to use emergency actions which pertain to local flying operations. The following procedures provide guidelines for actions during complete radio failure.

5.13.10.1 Return to base (RTB) with radio failure:

- If there is no standard local procedure to recover with radio failure, be certain that you understand what has been briefed.
- Proceed IAW the briefed procedures if ordnance is hung. Watch for tower signals (flares or lights) or any other conditions which would require a go-around. The idea behind hung ordnance patterns is to safely recover the aircraft on the first attempt.

5.14 Pop-Up Deliveries. A highly sophisticated and integrated SAM/AAA/air-to-air threat environment or weather may force a low-level ingress and pop-up attack. While such tactics place us within the AAA and small arms environment, a properly planned and executed pop-up attack should give us our best possible odds against SAM or A/A threats and, in addition, can provide surprise and deception to enhance survivability against AAA. There are many variations of pop-up attacks. It is important to understand the basics of the maneuver; namely how to plan and execute each type of attack. Establish habit patterns and use ROT which will ensure successful and safe attacks.

5.14.1 Pop-Up Safety. Target acquisition and alignment with the proper target attack heading are critical on all deliveries. There is little time to decide if you have achieved your desired delivery parameters. If you are faced with parameters that you do not recognize or if you have any doubts about whether or not you should continue the pass, then either abort the pass or reposition. Immediately abort a pop-up attack if any of the following conditions arise:

- Actual dive angle exceeds planned by more than 5 degrees.

- Airspeed below 350 KCAS (300 KCAS above 10,000 feet AGL).

5.14.2 Pop-Up Definitions. (See **Figure 5.46**, Pop-Up Definitions.)

- Approach Heading—The heading flown during wings-level pull-up and climb.
- Attack Heading—The heading flown during wings-level attack. Also called attack axis.
- Angle-Off—The difference between approach and attack heading.
- Direct Pop-up—Angle-off less than 15 degrees.
- Offset Pop-up—Angle-off greater than 15 degrees.
- Indirect Pop-up—Angle-off greater than 90 degrees

5.14.3 Offset Pop-Up Definitions. An example is shown in **Figure 5.47**, Offset Pop-Up Definitions.

- Initial Point (IP)—The steerpoint where the last leg to the target begins. Normally, the IP is prominent, unique, and 10 to 20 NM out from the target.
- Action Point/Range—The point/range from the target where you take offset for an offset or indirect pop-up attack.
- Pop Point—A position at which the pop-up attack is initiated. The point where climb is initiated.
- Climb Angle—The angle of climb to be achieved following the initiation of the pop-up.
- Pop-to-Pull-Down Distance—Distance from the pop point to the pull-down point. This distance is predictable for a specific set of delivery parameters.
- Pull-Down Point (PDP)—A maneuver point where you transition from the climbing to the diving portion of a pop-up delivery.
- Dive Angle—The selected dive angle for weapons delivery.
- Apex—The highest altitude in the pop-up delivery profile.
- Minimum Attack Perimeter (MAP)—An imaginary circle centered on the target equal to the distance from the target at which roll out and tracking begins. The radius of this circle varies with planned delivery parameters.

Figure 5.46 Pop-Up Definitions.

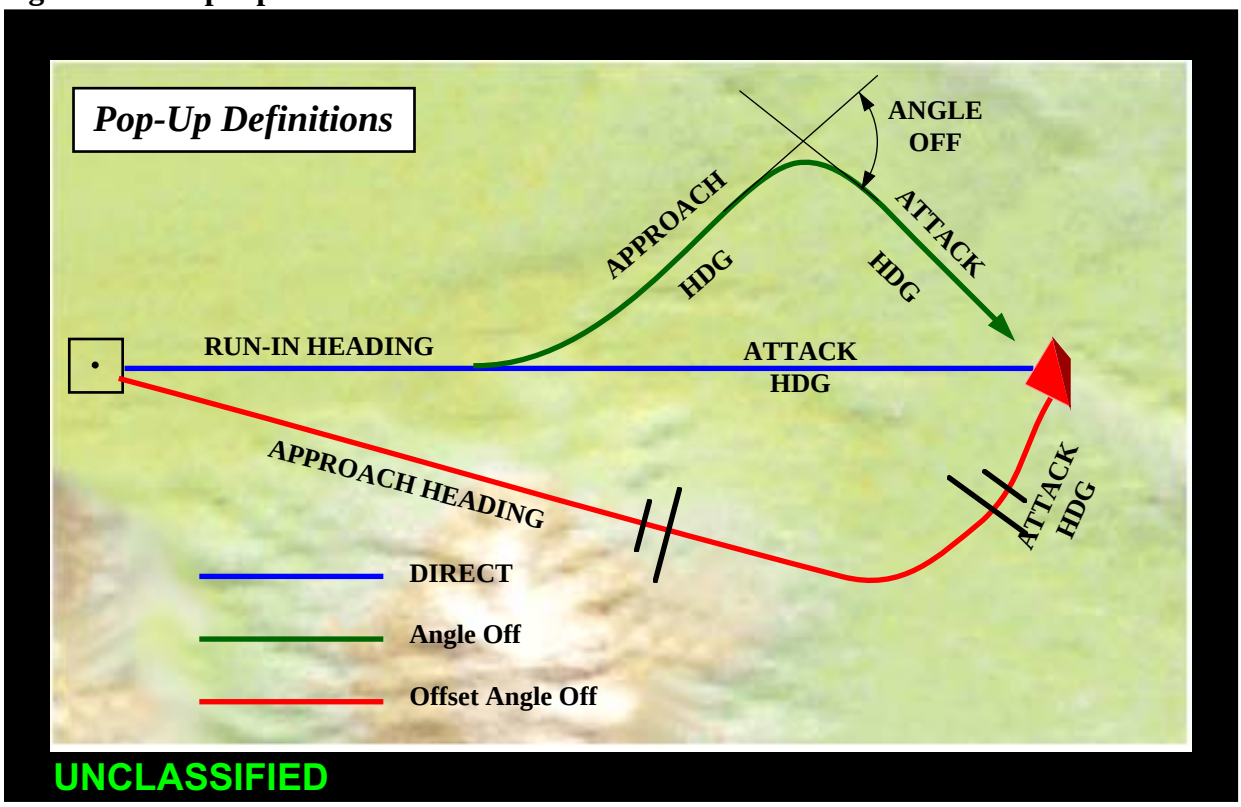
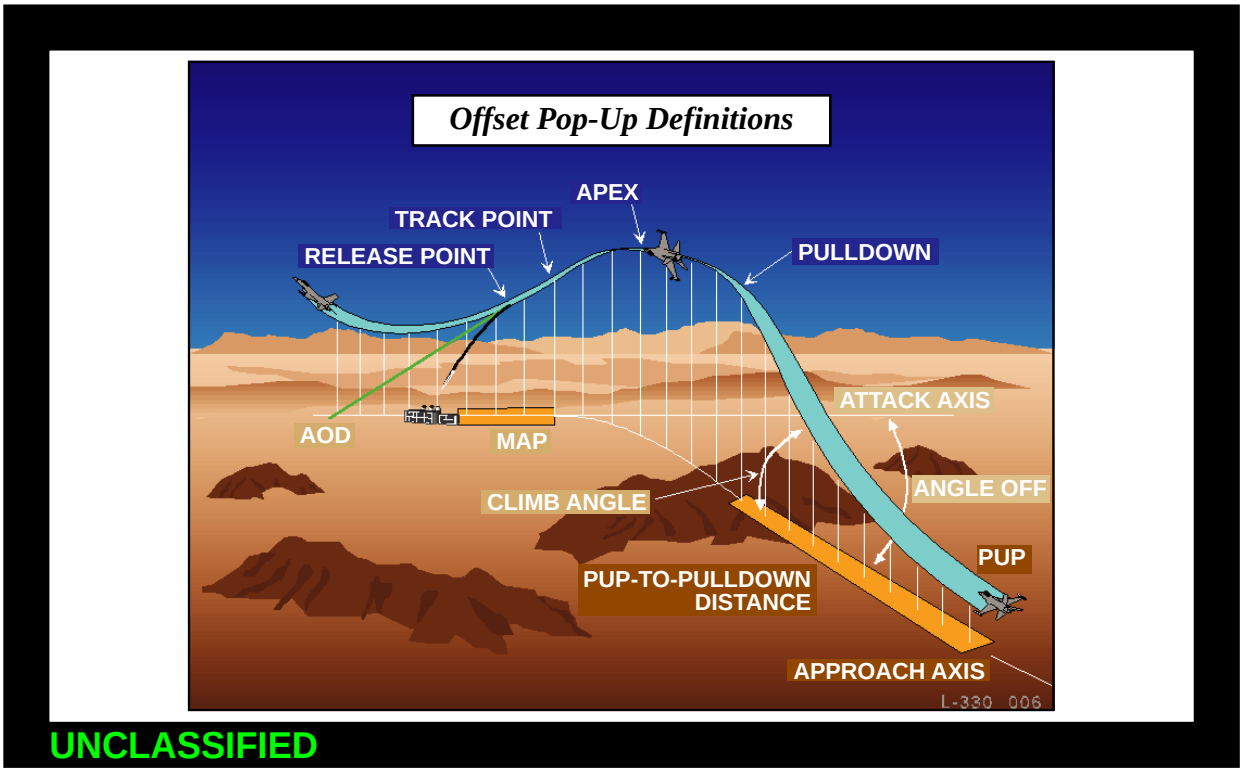


Figure 5.47 Offset Pop-Up Definitions.



- MAP Distance—Distance from the MAP to the target. Composed of bomb range and horizontal distance covered while tracking.
- Tracking—That portion of the weapons delivery devoted to the final alignment of the aircraft sighting systems with the target.
- Tracking Time—Wings-level time from roll out to weapons release.
- Horizontal Tracking Distance—The distance traveled across the ground during the tracking time.
- Vertical Tracking Distance—The vertical distance from the track altitude to the release altitude.
- Aim-Off Distance (AOD)—The ground distance at 12 o'clock from the target where the nose is pointed during tracking.
- Release Altitude—The altitude above the ground at which weapons delivery is accomplished.

5.14.4 Typical Offset Pop-Up. In this maneuver, the pop-up approach course is at an angle from 15 to 90 degrees from the final attack heading. The approach course angle-off varies with the planned climb angle to permit the pilot to acquire the target as soon as possible and maintain visual contact until completion of weapons delivery.

5.14.4.1 Approaching the Pop-Up. The pop-up is initiated over a preplanned pop point (normally with airspeed greater than 450 KCAS). System avionics can aid in finding the planned pop-up point. In CCRP, the A/S TLL helps to confirm desired angle-off. The pop point may be coincidental with this ground reference, or adjacent to it.

5.14.4.2 Initiating the Pop. At the pop point, select desired power (afterburner or Mil) make a 3- to 4-G wings-level pull to the desired climb angle and initiate the desired chaff/flare program. The target should become visible in the front quarter of the canopy slightly off to the side of the planned roll-in direction. Start a visual search for the target just above the canopy rail and over the forward end of the towel rack. After popping, maintain planned climb angle and monitor altitude gained.

5.14.4.3 Pull-Down. Approaching the preplanned pull-down altitude, make an unloaded roll in the direction of the target. Perform a 3- to 5-G pull-down to intercept the planned dive angle. Make corrections during the maneuver to compensate for minor errors in the pop point or unexpected winds in the climb to apex at the desired altitude. You normally achieve planned apex altitude about halfway through the pull-down maneuver.

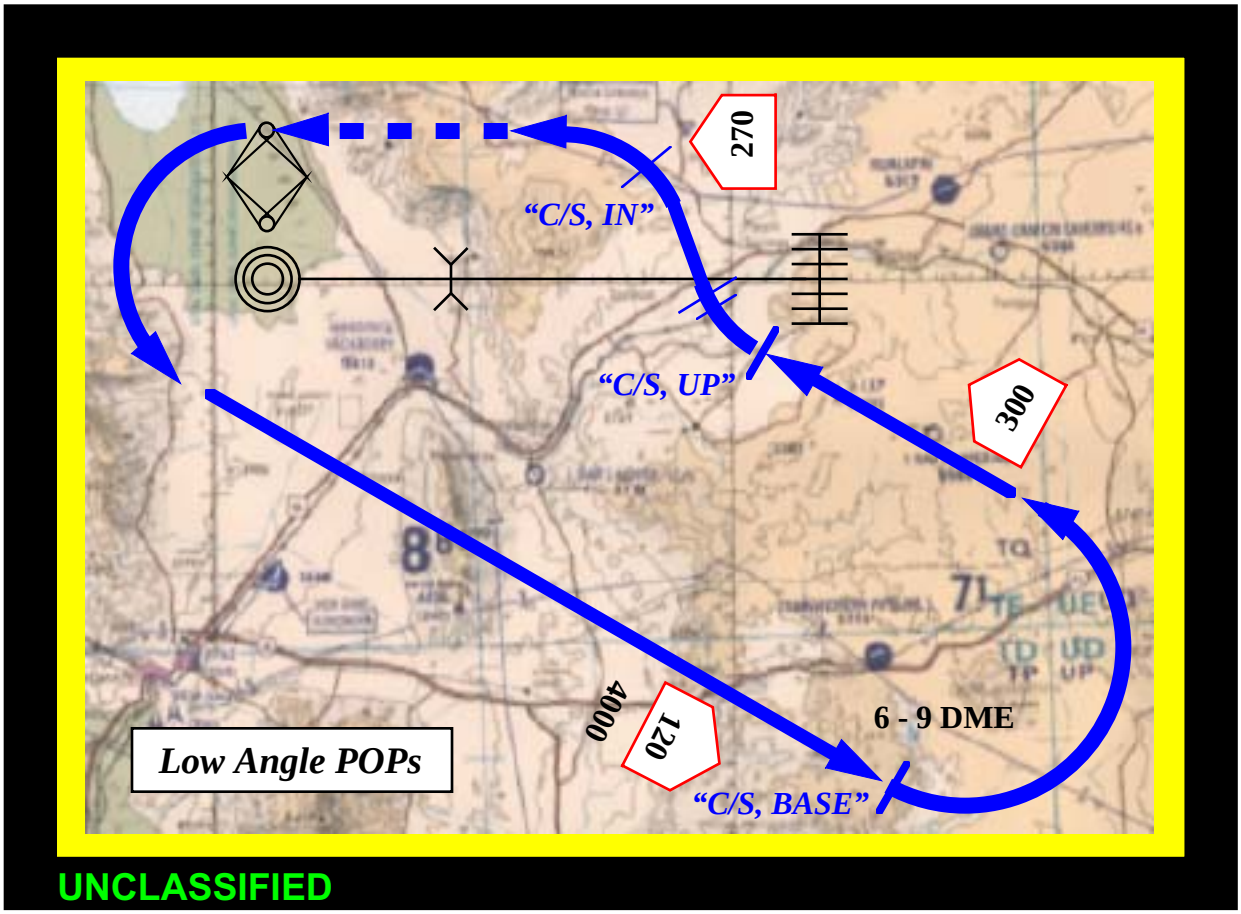
5.14.5 Avionics. After sanitizing the target area for A/A threats, the run-in is normally accomplished in the CCRP mode. This provides steering to the target in the HUD and system accuracy update opportunities (visual/radar/TGP). If your specific Block F-16 allows, and GM radar is not required for target acquisition, consider programming RWS as the radar mode in AG Master Mode, so that sanitizing can continue without exiting CCRP. CCRP is also valuable from the action point through the final attack axis by providing range, locator line, and ultimately, the TD box on the target (assuming good system accuracy). A good habit pattern is to stay in CCRP until the target is positively identified before stepping to CCIP/DTOS with the missile step button.

5.14.6 Low-Angle Strafe. Although the planned angle-off from the target can vary, normally the approach to the target is planned to be 15 to 30 degrees from the desired attack heading at approximately 450 KCAS. At the planned pop point, select Mil power and begin a 3- to 4-G pull-up to the desired climb angle. This is normally planned to be equal to the planned delivery dive angle plus 5 degrees. At the preplanned pull-down altitude, roll the aircraft and begin a pull-down to achieve the desired dive angle. Monitoring the HUD pitch lines in relation to the target simplifies achieving the planned dive angle. Roll out with the gun cross just above the target. After roll-out, track and fire just as in a curvilinear/box strafing pass.

5.14.7 Low-Angle High-Drag Bombing (Normally 10 to 15 Degrees). This attack maneuver is very similar to that of LAS. It is designed for low-angle delivery of high-drag weapons. The approach to the target is normally planned from a run-in heading offset 15 to 45 degrees from the attack heading at approximately 480 KCAS. At the desired pop point, a 3- to 4-G pull-up is initiated to the planned climb angle (usually dive angle plus 5 degrees). At the preplanned pull-down altitude, the aircraft should be rolled towards the target and the nose pulled down to roll out, the same as you would in any low-angle bomb delivery. Normally, this type of delivery is planned to allow 3 to 5 seconds of tracking/designate time prior to arriving at planned release altitude. For CCIP deliveries, roll out and set the appropriate IAA. This should place the target approximately one-half down the BFL. For manual deliveries, roll out with the IAA set if the FPM is available or plan the roll out to place the standby reticle at the pre-computed IPP. (See **Figure 5.14.8**, Low-Angle Pops.)

5.14.8 Low-Angle Low-Drag Bombing (Normally 10 to 20 Degrees). The delivery is designed for low-angle delivery of low-drag weapons. Exercise care in computing release altitudes to ensure fuze arming and safe escape. Planned angle-off for this type of delivery can vary from 15 to 90 degrees, although optimum angle is approximately 2 x climb angle. Accomplish pull-up to the planned climb angle and pull-down at the preplanned pull-down altitude. Take care to properly monitor the altimeter to determine the proper pull-down point since the apex altitude for a LALD delivery is considerably higher than for a LAHD delivery and visual cues can be deceiving. For CCIP deliveries roll out and set IAA, which should place the target slightly below halfway between the FPM and CCIP pipper. For DTOS, roll out with caged symbology slightly short of the target. Monitor slant range to ensure proper release parameters. Pay special attention to the altimeter to ensure delivery at or above the planned altitude.

Figure 5.48 Low-Angle Pops.



5.14.9 High-Altitude Dive Bombing (Normally 30 to 45 Degrees). This delivery is designed for high-angle delivery of low-drag weapons in a high-threat environment. During mission planning, aircraft configuration must be taken into account to ensure this type of approach is feasible (i.e., two wing tanks with six MK 82s may not allow enough energy to pop-up to a 45-degree diving delivery). The approach to the target is normally at 500 to 550 KCAS to an action point 4 to 5 NM short of the target. At this point, a check turn between 20 to 30 degrees is required to obtain the necessary offset. At the desired pop point, a 4-G pull-up is initiated to the planning climb angle (usually dive angle plus 15 degrees) in full afterburner. Once the pop-up is established, primary attention should be devoted to target acquisition. The target may be "hidden" below the canopy rail. Monitor the altimeter as the pull-down altitude approaches due to the rapid climb rate to ensure correct parameters. At the apex, the aircraft is at or nearly inverted, so care must be taken to roll out with the proper AOD. Attacks should be planned to provide 5 seconds of tracking/designate time prior to arriving at the release altitude. For CCIP deliveries, roll out and set IAA, which should place the target approximately one-half of the way down between the FPM and CCIP pipper. For DTOS deliveries, roll out with caged symbology short of the target. For manual deliveries, with the FPM available, roll out and set IAA. If the FPM is not available, plan to roll out with the proper IPP corrected for winds. If the parameters are bad or you have doubts about continuing the pass, either abort the pass or reposition. After releasing weapons, the threat dictates the type of recovery, but for

peacetime training recover with a 5-G pull until the nose is above the horizon then execute the egress plan. (See **Figure 5.30**, High-Angle Deliveries.)

5.14.10 Visual Level Delivery (0 to 5 Degrees). The visual level delivery (VLD) is flown using CCIP when the weather or threat precludes steeper dive angles. Ingress the target area at low altitude, while terrain masking, and constantly jinking until just prior to weapon release. Since your approach to the target is a random flight path, good planning is required to arrive at an action point where target acquisition is initiated and weapons delivery commenced. If a level delivery is planned, simply arrive at the target on your proper altitude with the CCIP pipper properly positioned. If a 5-degree diving delivery is planned, initiate a 10-degree pull-up followed by a pull-down/bunt approximately 500 feet below planned apex. Pay particularly close attention to precise release parameters and to the fuze arming/pull-up anticipation cue to ensure adequate fuze arming TOF, fragmentation clearance and ground avoidance. The recovery portion of this delivery must be emphasized to ensure safe escape criteria from your munition—know the recovery procedure cold and fly it!

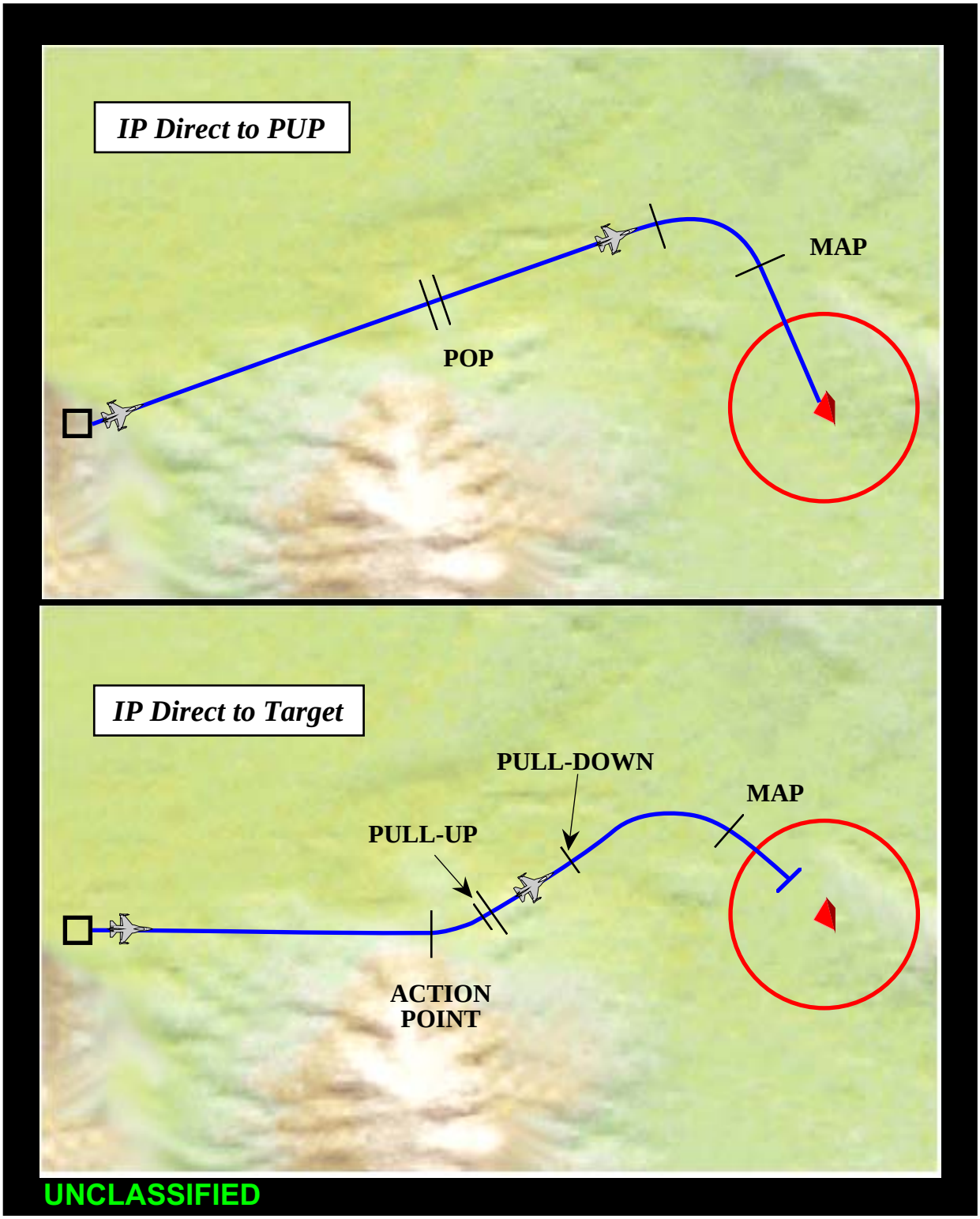
5.15 Pop-Up Planning. Precise planning is the key to destroying the target in low-altitude pop-up mission deliveries. Planning begins with the fragged target and ordnance load. The target and its environment may drive some attack parameters. For example, a cave at the base of a hill drastically limits your choice of attack headings. Weather and threat are also significant factors. Similarly, assigned ordnance may determine attack parameters. Allow enough time to visually acquire a pinpoint target when loaded with MK 82 LDGP. On the other hand, CBU may require less time on final to fine-tune aiming. Once the target and ordnance related restrictions are analyzed, determine the release parameters.

5.15.1 Timing. Determine how much time is needed on final. 3 to 5 seconds of wings-level time is enough for most deliveries. Specialized types of ordnance may require you to spend more time on final. Do not try to minimize exposure time to the point that you do not have time to acquire the target.

5.15.2 Select Initial Point and Attack Heading. Compute the MAP distance and then go back to the chart and choose a prominent and unique IP allows you to get to the MAP on an acceptable attack heading. Normally choose an IP 1 to 2 minutes from the target. There are two basic options used to get from the IP to the target: IP-to-pull-up point and depart the IP and fly direct to the target. (See **Figure 5.49**, IP-to-Target Options.)

5.15.2.1 IP-to-Pull-Up Point. One choice is to fly from the IP directly to the PUP. This approach course takes you direct to the pull-up point and the target area does not remain in the HUD during the ingress.

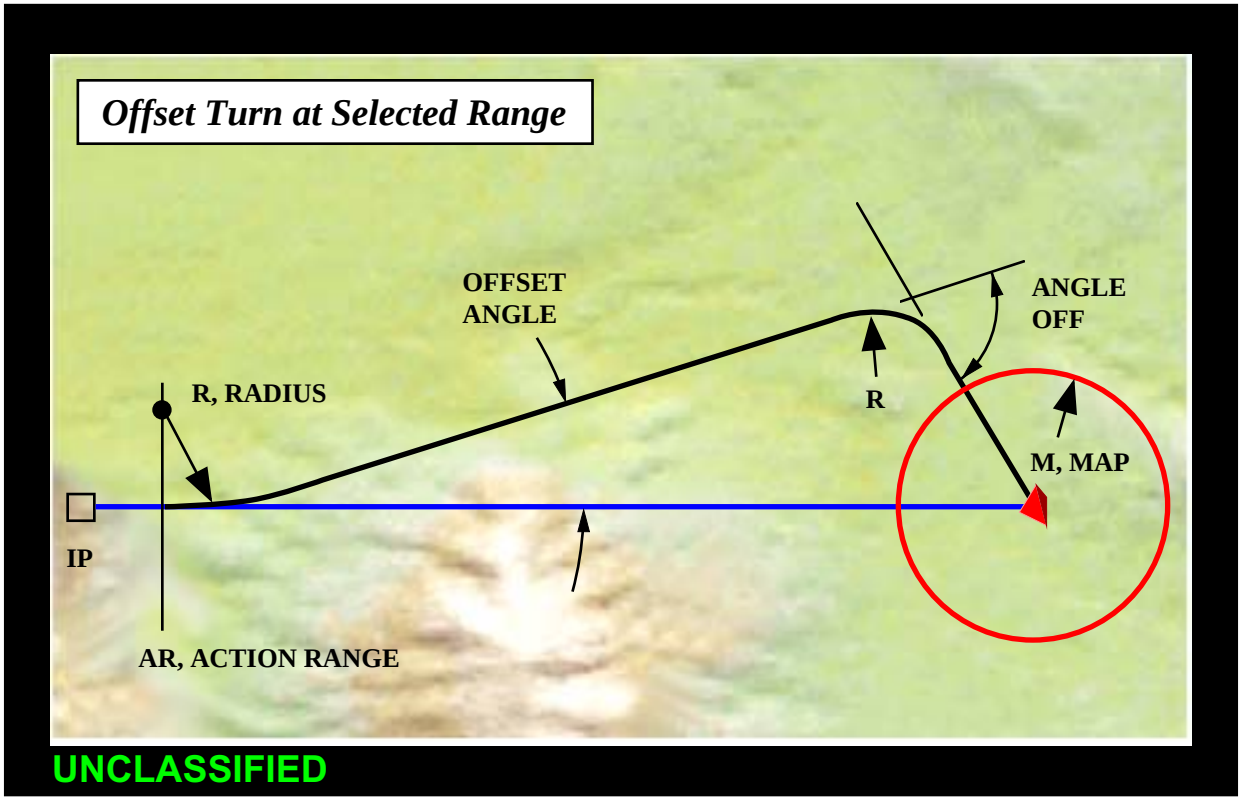
Figure 5.49 IP-to-Target Options.



5.15.2.2 Depart the IP/Direct to Target. The other choice is to depart the IP and fly directly at the target. At a given range from the target, turn to the side for offset and then pop up. Although it looks more complicated, this choice is often quicker to plan and is the much

more common choice among pilots. The reason is that the pop portion of the attack is the same for all IP-to-target distances (assuming the IP-to-target distance is outside the action range). Moreover, at any time, you can put the target on the nose and at the action range, turn a preplanned number of degrees to the side, go a preplanned distance, pop, pull-down, and attack. Consider the high-threat close air support (CAS) situation where you do not know the target location prior to contacting the forward air controller (FAC). In this case, the simplest way to make a pop-up attack is to depart the IP (if you have one) with the target on the nose and, at a preplanned action range, turn for offset and execute the attack. Over-reliance on the INS could prevent the safe execution of the attack. A faulty INS could cause you to action late resulting in attack parameters well in excess of that planned. Use all available navigation aids to determine the proper action point (i.e., clock and ground reference points). As shown in **Figure 5.50**, Offset Turn at Selected Range, the required information needed to fly directly toward the target prior to executing the attack is displayed.

Figure 5.50 Offset Turn at Selected Range.



5.15.3 Planning Element Attacks. When adding a second aircraft to an attack, complications are encountered due to frag and aircraft deconfliction. When multiple aircraft are tasked to attack a target and TOT compression is desired, a potential flight path and fragmentation conflict exists. The fragmentation problem depends on ordnance type, delivery profile, and number of aircraft attacking the target. Deconfliction can be achieved through time, altitude, lateral separation of aimpoints, distance separation from target, or a combination of each.

5.15.3.1 Fragmentation. First, look at the maximum bomb fragmentation travel chart in **Figure 5.51**, Maximum Bomb Fragment Travel. These data must be used to determine fragment deconfliction between multiple aircraft attacks. The envelopes present the maximum altitude and maximum horizontal range anticipated for the worst-case fragment of the bomb case, and the time from detonation until all bomb case fragments have settled to the ground. Data are provided for sea level and 5,000 feet target density altitudes. Interpolation between sea level and 5,000 feet and extrapolation up to 10,000 feet are permissible.

5.15.3.2 Time Deconfliction. Time separation between aircraft deliveries must be equal to or greater than the time the preceding weapon's fragments are in the air, plus the delivery TOF of the preceding munition. To ensure frag deconfliction from the last weapon in the string, attack intervals should include the time required for the ripple/train release.

5.15.3.2.1 90/90 Maneuver (VEER). The classic method to achieve time separation is to space the aircraft in elements 4 to 6 NM in trail. Transitioning from line abreast to a trail formation of 4 to 6 NM can be accomplished quickly using variations of a 90/90 maneuver.

- Wingman turns 90 degrees off the ingress heading for approximately 15 seconds.
- After 20 seconds, the flight leader should have traveled 3-4 NM and the wingman then turns back to the target. Spacing continues to increase during the wingman’s turn to yield the desired separation.
- Some visual contact may be lost; initiate the split close enough to the target to aid in threat acquisition, but far enough out to be able to execute the attack.

5.15.3.2.1.1 Advantages:

- A more flexible attack is possible if navigation accuracy or target acquisition is questionable.
- Subsequent flight members can bomb off of lead's bomb impact.

5.15.3.2.1.2 Disadvantages:

- Wingman flies single-ship close to the target area.
- Flight strings out, which reduces visual mutual support and complicates postattack rejoin.
- DMPI(s) may be obscured by the first aircraft’s weapons detonation/secondary explosions.
- Excessive turning in the target area, increasing threat exposure.
- May task saturate the wingman. Maneuver combines aggressive maneuvering, and requires precise flight parameters for success.

Figure 5.51 Maximum Bomb Fragment Travel.

Maximum Bomb Fragment Travel

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MUNITION	ALTITUDE (FEET) TDA		HORIZONTAL (FEET) TDA		TIME OF FLIGHT (SECONDS) TDA	
	SEA LEVEL	5000 FT	SEA LEVEL	5000 FT	SEA LEVEL	5000 FT
UNITARY WARHEADS						
MK-82 All Types	2140	2500	2550	2900	24.4	25.9
MK-84 All Types	2770	3150	3260	3715	28.0	29.7
BLU-109 All Types	3465	3915	4230	4795	30.3	32.1
INTACT CLUSTERS						
Mk-20 Rockeye	1380	1575	1645	1850	19.4	20.6
CBU-24 B/B: CBU-49 B/B; CBU-52 B/B; CBU-58/B; A/B CBU-71/B, A/B CBU-87/B	1895	2140	2290	2595	23.0	24.4
CLUSTER SUBMUNITIONS						
BLU-26/B (CBU-24B/B)	960	1085	1160	1310	16.3	17.3
BLU-59/B (CBU-49B/B)	665	755	775	880	14.2	15.0
BLU-61A/B (CBU-52B/B) BLU-63/B, A/B (CBU-58/B, A/B BLU-86/B, A/B (CBU-71/B, A/B	430	490	490	560	11.6	12.3
BLU-118 (MK-20 Rockeye)	695	790	800	915	14.7	15.5
BLU-97/B (CBU-87/B)	545	620	635	725	12.8	13.7

WARNING: The data in this table is for illustration only and should not be used for actual mission planning.

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5.15.3.2.2 Arcing VEER. Another means of achieving timing deconfliction is an arcing VEER attack. This retains the advantages of the 90/90 while reducing some of the disadvantages. The flight lead flies the same as in the 90/90, but the wingman turns 90

degrees at a preplanned point on the ingress to pick up an arc around the target sufficient to allow turning in to execute the pop-up attack at a precomputed time after the leader's bombs detonate. There are two common options for an arcing VEER. First, the arc may be placed far enough out for the wingman to turn in and bring the target to the nose, then execute a normal action to an offset pop. This option provides little advantage over a straight 90/90 delivery, since it is functionally the same thing. The second option is to plan the arc closer to the target, with the wingman planned to turn in only enough to place the target the correct distance left or right of the nose (using the CCRP target locator line) and then pop immediately. This second option generally places the arc at least one mile closer to the target compared to the first option. The second option generally improves mutual support by keeping the element mates closer together. VMS can be maintained throughout the second option.

5.15.3.3 Altitude Deconfliction. The following aircraft must recover above the maximum altitude for the fragment envelope for the preceding attacker's munition. For example, a 3,265 feet minimum recovery altitude is required for a MK 84 delivery at a 5,000 feet target density altitude. (See **Figure 5.51**, Maximum Bomb Fragment Travel.)

5.15.3.3.1 Advantages:

- Wingman has more time to acquire the target.
- High release enables a direct, radar-fuzed CBU delivery.
- Weapon effects may improve with increased impact angle.
- Allows simultaneous attacks on a point target.

5.15.3.3.2 Disadvantages:

- Weather must permit higher-altitude deliveries.
- Exposure time for wingmen is increased.
- Depending on release altitude, puts wingman in the heart of threat envelopes.
- Wingmen must achieve weapons release prior to the leader's weapons detonation, or the accuracy advantages of the wingman's CCIP attack will be lost due to the leader's detonation obscuring the target.

5.15.3.4 Horizontal Deconfliction. Horizontal deconfliction can be achieved by either attacking DMPIs separated by greater than the fragmentation envelope of the weapon, or by having the wingman deliver with a stand-off attack mode (DTOS, CCRP).

5.15.3.4.1 Separate DMPIs. Based on data from the same chart, targets separated by a lateral distance of more than 3,760 feet (TDA 5,000 feet) are clear of the frag envelope. This means that no portion of the delivery and recovery by succeeding aircraft should be closer to the target than the 3,760 feet minimum. If attack headings are not parallel, more lateral spacing between targets is required. Care must be given to ensure neither aircraft intrudes on the other's fragmentation pattern during the egress.

5.15.3.4.1.1 Advantages:

- Visual contact is maintained throughout.
- Simultaneous attack saturates defenses.

- Reduces flight exposure time.

5.15.3.4.1.2 Disadvantages:

- Minimal room for accuracy error on the separate DMPIs.
- Flight path conflict over the targets are possible.
- Less flexibility for threat reactions, etc.

5.15.3.4.2 Stand-off Attack. Regardless of the flight lead's attack mode, wingmen can achieve frag deconfliction on a point target by remaining outside the lateral fragmentation envelope of the lead's weapons. A DTOS or CCRP toss option can provide adequate stand-off if the wingmen's weapons release occurs at a distance equal to the leader's fragmentation envelope plus the range required for the wingman to roll the A/C and turn 90 degrees to the final attack heading. Advantages are simplicity, close attack spacing, and enhanced VMS. Disadvantages include the inherent inaccuracy of toss deliveries, potential for target obscuration by lead's weapons, and difficulty in wingman's target acquisition from the required designation ranges.

5.15.3.5 Aircraft Deconfliction. Depending on target separation, planning for the attack must deconflict aircraft within the attacking element. Types of deconfliction include time, altitude, and horizontal as mentioned above plus attack geometry.

5.15.3.5.1 The direct IP-to-target pop-up planning approach must be modified for a wingman in tactical formation.

5.15.3.5.2 The flight leader must plan the attack so each pilot regains mutual support after the attack while egressing the target area as fast as possible.

5.16 Flying a Tactical Pop-Up. Whether a leader or wingman, there are three things to do that greatly improve the chances of success: know the profile, navigate precisely, and recognize and correct for errors. It helps to have an attack card on your leg.

5.16.1 Navigation. Navigate precisely and be on speed before the IP. Choose an IP you can easily find and use all available cues to position yourself exactly over it. Use F-16 avionics along with basic navigation skills to maintain course.

5.16.2 Finding the Action. Identification of the action point or pull-up point is crucial to executing the attack as planned. Ground reference, time from the IP, and accurate FCC information make this possible. Accurate planning and assessment of the HUD symbology will improve the overall ability to find the action point.

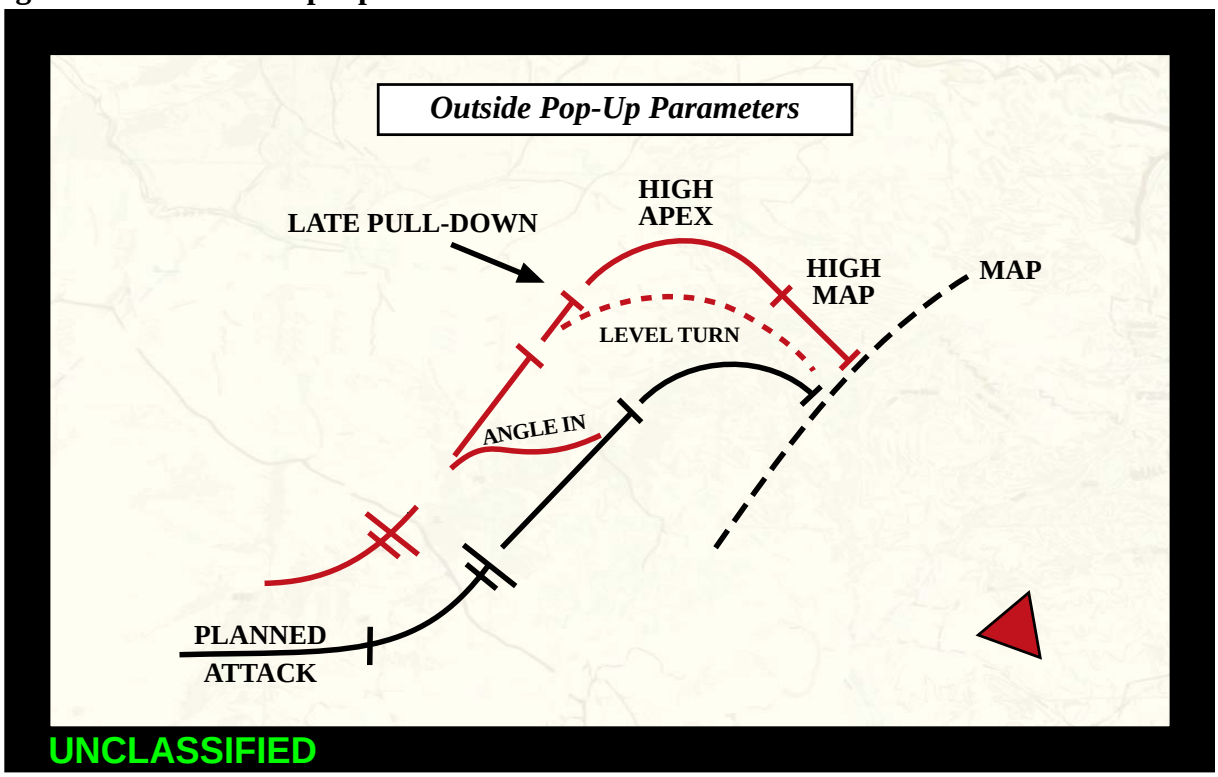
5.16.3 Camouflage, Concealment, and Deception Considerations. Potential adversaries have the capability of using CCD techniques to conceal or apparently relocate visual IPs and DMPIs. If INS appears to be performing well, and you have confidence in your IP and target coordinates, carefully study INS designated IPs and DMPIs for tone-down or false target insertions. Redesignating on false targets would cause you to miss the target; updating the INS on a falsified IP would degrade an otherwise accurate navigation system.

5.16.4 Recognize and Correct for Errors. There are any number of factors that could possibly prevent accurate positioning at the pull-up point. A few are poor navigation and reactions to enemy defenses. In any case, if you do not get to the proper pull-up point, three things must

happen. First, recognize that you are not at the preplanned parameters. Second, assess whether you have sufficient turning room to complete the attack by repositioning from your present position. Third, properly execute a reattack option, or abort the attack. The key to successful repositioning lies in early recognition of deviations from preplanned parameters. Two broad categories of errors exist in positioning relative to planned pop point and approach course—those that put you outside planned parameters and those that put you inside them. If you find yourself in this situation, consideration should be given to aborting the attack and descending back to low altitude as quickly as possible. Once back at low altitude, then assess the tactical situation and either egress or reattack. However, if conditions permit (low threat, weather, and SA), a repositioning maneuver may allow you to still put bombs on target in the following situations.

5.16.4.1 Pop-Up Outside of Planned Parameters. If you pop up and find that you are outside the preplanned parameters, you could be either outside the planned run-in line, or short of the planned pop point. (See **Figure 5.52**, Outside Pop-Up Parameters.)

Figure 5.52 Outside Pop-Up Parameters.



5.16.4.1.1 Outside the Run-In. If you are outside the planned run-in line you have the following repositioning options available (listed in order of preference):

5.16.4.1.1.1 Angle in toward the roll-in point during the pull-up.

5.16.4.1.1.2 Apex at a higher altitude to make good the preplanned dive angle, accepting additional tracking time.

5.16.4.1.1.3 Apex at the preplanned altitude, and making the last part of the turn to final fairly level and ease off the G as in a curvilinear pass.

5.16.4.1.2 Early Pop. When the actual pop point was short of the planned pop point:

- Reduce G and climb to arrive at the preplanned roll-in point.
- Apex at a higher altitude to make good preplanned dive angle and accept a new axis of attack.

5.16.4.1.3 Exposure to Threats. All these options increase exposure time. Tactical considerations likely determine the course of action to take. In tactical scenarios, anytime you are faced with additional time, make every effort to be unpredictable. Fly a curvilinear repositioning maneuver.

5.16.4.2 Pop-Up Inside Planned Parameters. If you pop-up and determine that you are inside planned parameters, you could be either inside the planned run-in line or past the pop point.

WARNING: These two situations are more difficult to compensate for, require earlier recognition, and are potentially far more dangerous than the previously discussed errors.

5.16.4.2.1 If you are inside the planned run-in line, you can pull back towards the planned run-in line and intercept it prior to the roll-in point. This is possible if you recognize the error early. (See **Figure 5.53**, Intercepting the Approach Heading.)

5.16.4.2.2 If the track point occurs inside the MAP, abort. If you attempt to fly the maneuver on the left of **Figure 5.54**, Late Pop-Up, you find yourself rolling out pointed at the AOD well inside the MAP, and probably excessively steep if you went to the planned apex altitude. The example on the right of **Figure 5.54**, Late Pop-Up, depicts a adjustment outside the planned line, allowing enough room to achieve the MAP. This creates an indirect pop-up situation.

5.16.4.2.3 How do you know you are inside the pop point? A preplanned ground reference point would be one way to tell. Another more common way is to look for the classic picture seen previously. The relationship of the target on the canopy is another indicator. For low angle-off attacks (15 to 60 degrees), the target should not be any further aft than 10:30 or 1:30. For higher angle-off attacks (60 to 90 degrees), the target should not be any further aft than 9:30 or 2:30. In most cases, the canopy rail should not hide the target.

5.17 Pop-Up Formulas. There are two methods to complete pop-up planning: use the F-16 CWDS available in the squadron weapons computer; or use the following formulas (all altitudes are in feet AGL) to determine pop-up parameters. Refer to **Figure 5.55**, Final Attack Diagram, for a diagram and definitions.

Figure 5.53 Intercepting the Approach Heading.

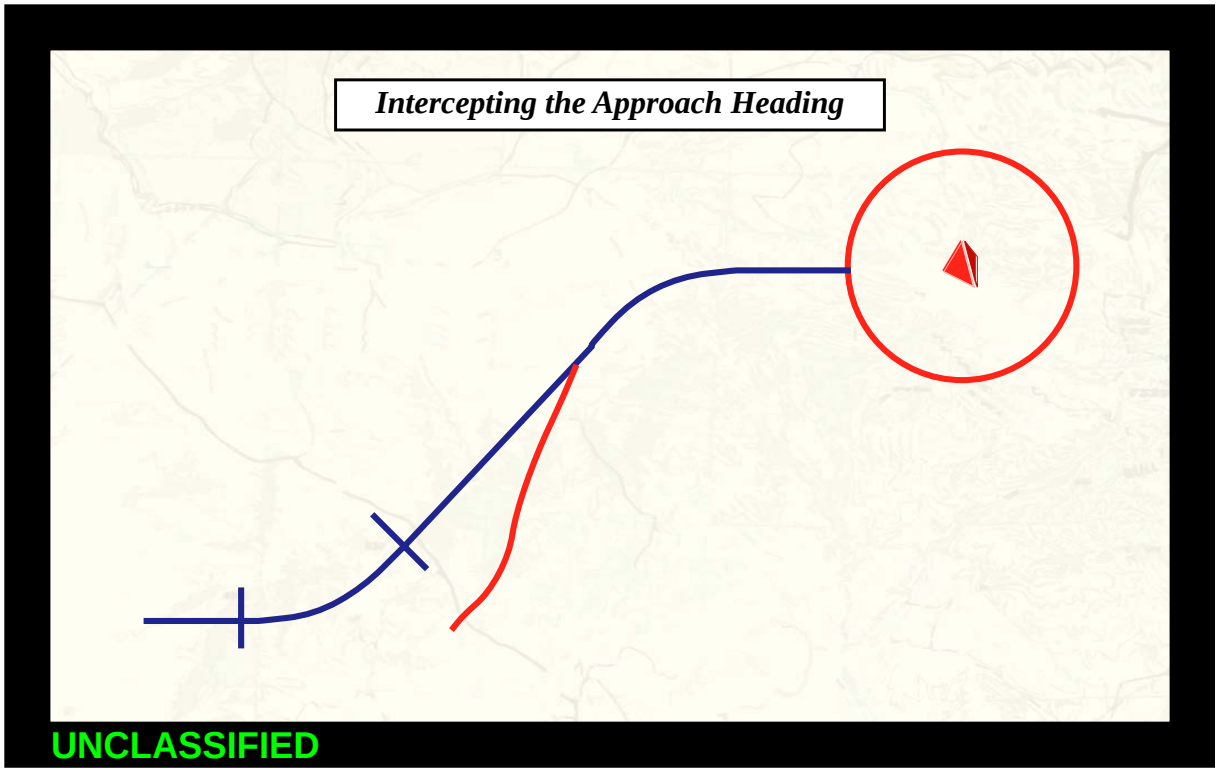


Figure 5.54 Late Pop-Up.

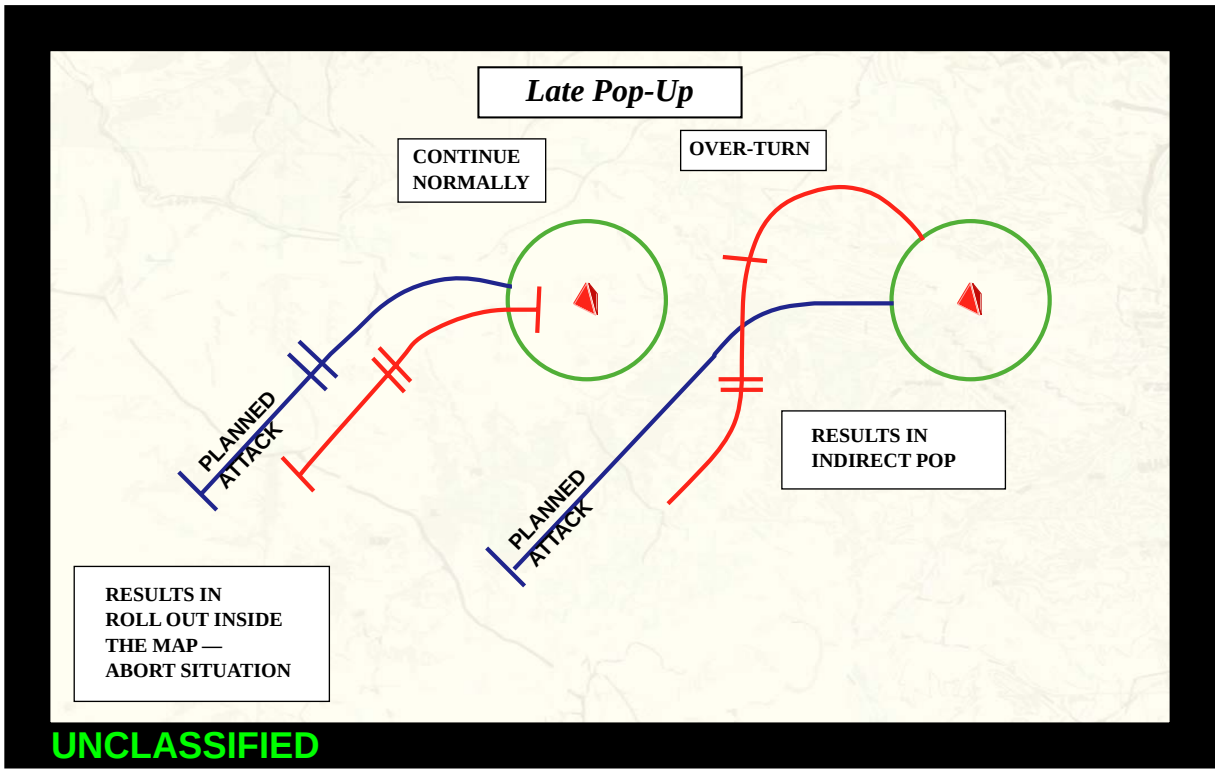
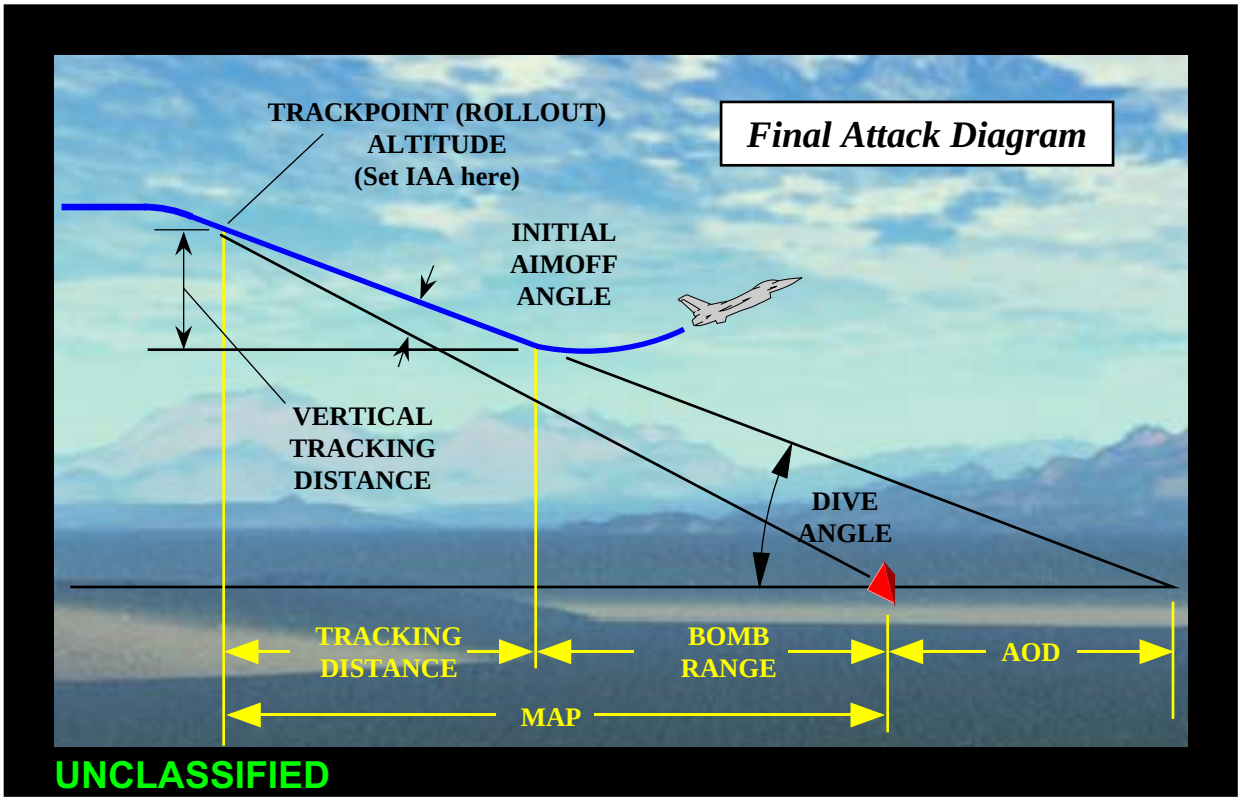


Figure 5.55 Final Attack Diagram.



- Tracking Distance.

Horizontal tracking distance = GS x 1.69 x tracking time
Where, GS (zero wind) = TAS x cos (dive angle)
Vertical tracking distance = TAS x 1.69 x track time x sin (dive angle)
MAP distance = bomb range + horizontal tracking distance
Track altitude = pickle altitude + vertical tracking distance
AOD = (release altitude)/(tan [dive angle]) - bomb range
Horizontal turn radius = $V^2/(G_R \times g) = (TAS \times 1.69)^2/(G_R \times 32.2)$
g = 32.2 and G_R = cockpit G
Climb angle = dive angle + 5 degrees for dive angles less than 15 degrees
Climb angle = dive angle + 10 degrees for dive angles less than 15 degrees
Angle off = 2 x climb angle

- Apex altitude. For 3- to 3.5-G pull-down.

Apex altitude = track altitude + (dive angle x 50)

- Apex altitude. For 4.5- to 5-G pull-down.

Apex altitude = track altitude + (dive angle x 37.5)

- Pull-down altitude. For 3- to 3.5-G pull-down.

Pull-down altitude = apex altitude - (climb angle x 50)

- Pull-down altitude. For 4.5- to 5-G pull down.

Pull-down altitude = apex altitude - (climb angle x 37.5)
Pop to pull-down distance = apex altitude (AGL) x 60/climb angle

5.17.1 Sample Pop-Up Attack Computation. Baseline target and ordnance information follow:

- Target: Tank maintenance complex.
- Ordnance: 6 x MK 82 LDGP with M904E2/M905 fuzing set at 4 seconds.
- Threat: Will force a pop-up attack but will not affect run-in or attack headings.
- Weather: 4,000 feet scattered and 4 NM visibility.

5.17.1.1 Selected Attack Profile. Make a 15-degree LALD pop-up attack dropping six-single bombs at 50-foot intervals. There are no run-in heading restrictions. Release parameters are taken from applicable Ballistics Tables.

- Dive angle: 15 degrees.
- Release altitude: 2,000 feet.
- Release speed: 520 KTAS.
- Release range to center of stick: 5,138 feet.
- Stick length: 122 feet.
- Time on final: 5 seconds.

MAP distance = bomb range + tracking distance
Bomb range = 5,138 feet
Tracking distance = 1.69 x GS x tracking time

5.17.1.2 Calculate MAP. TOs tell us that 520 KTAS in a 15-degree dive with no winds equates to about 500 knots GS. This chart is equivalent to the following equation:

GS = TAS x cos (dive angle) = 520 x cos (15 degrees) = 502 knots
Tracking distance = 1.69 x 502 x 5 = 4,242 feet
MAP distance = 5,138 + 4,242 = 9,380 feet

5.17.1.3 Calculate AOD. In this problem, in order to track the target for 5 seconds and then pickle at 2,000 feet AGL, you must arrive at a point 9,380 feet from the target with your nose on the aim-off point:

AOD = (release altitude/tan [dive angle]) - bomb range = 2,000/tan (15 degrees) - 5,138 = 2,326 feet
Vertical tracking distance = 520 x sin (15 degrees) x 1.69 x 5 = 1,137 feet

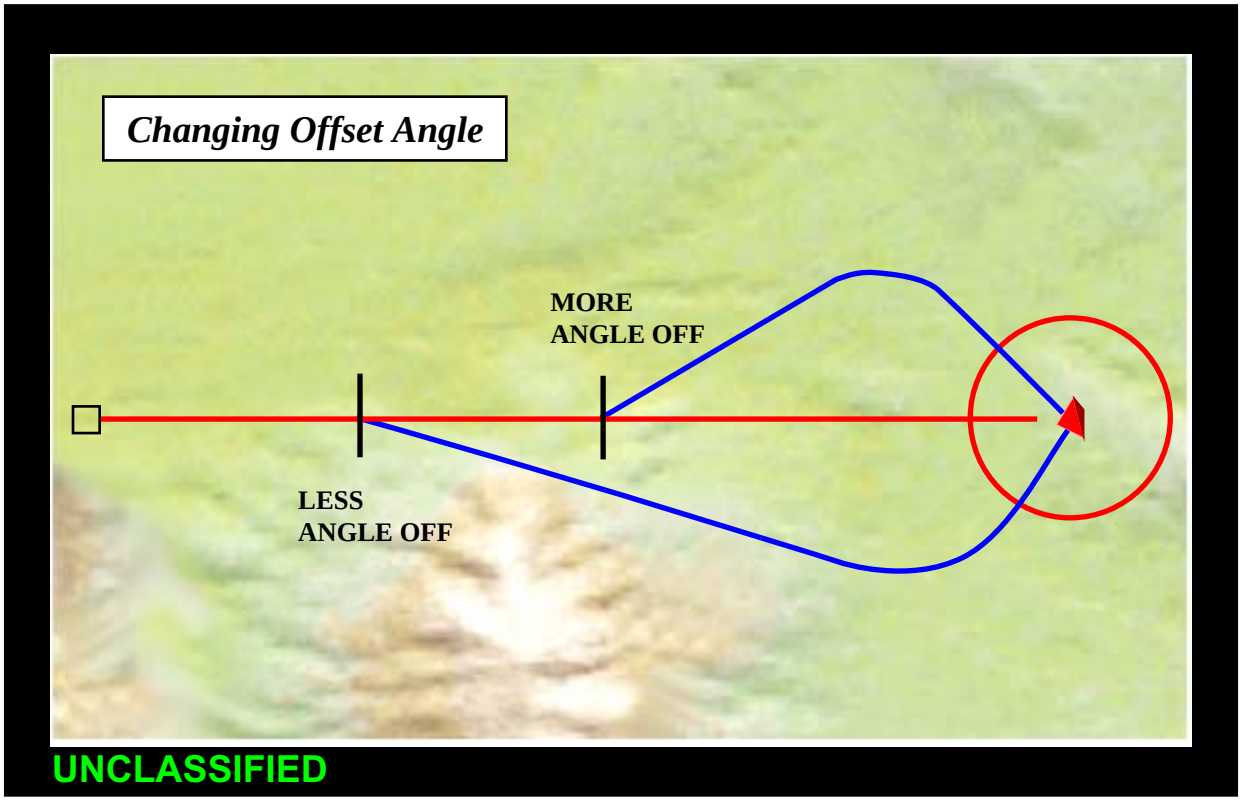
5.17.1.4 Choose the Angle-Off and IP. Smaller angles-off reduce exposure time but make the pop point more critical and repositioning more difficult. Experience has shown that as the dive angle increases, the angle-off also needs to increase to allow the pilot enough time to fly the pull-down and acquire the target. (See **Figure 5.56**, Changing Offset Angle.) As a general guide, use the following formula to determine angle-off:

Angle-off = 2 x climb angle

NOTE: Dive angles of 15 degrees or less, the climb angle equals dive angle plus 5 degrees.

Angle-off = 2 x (15 degrees + 5 degrees) = 40 degrees

Figure 5.56 Changing Offset Angle.



5.17.1.5 Calculate Pull-down and Apex. Use some other ROTs to calculate more required information: pop-to-pull-down distance, apex altitude, and pull-down altitude. Actually, there are two choices of ROT to use to derive some of this information depending on the G you want to use in the Pop-Up maneuver. One set of rules applies for 3.0- to 3.5-G maneuvering and a second set is for 4.5 to 5.0 Gs. In this problem, use the rules for the lesser. This choice was made for two reasons: to preserve energy and loosen the maneuver slightly to allow for error corrections. Increase maneuvering as well as decrease the tracking time to make a tighter maneuver thus, offering less threat exposure.

Track point altitude = pickle altitude + vertical tracking distance = 2,000 + 1,137 = 3,137 feet

NOTE: For 3.0 to 3.5 G roll-in:

Apex altitude = track point altitude + (dive angle x 50)

Apex altitude = 3,137 feet + (15 x 50) = 3,137 + 750 = 3,887 feet = Approximately 3,900 feet

Pull-down altitude = Apex altitude - (climb angle x 50) = 3,900 - (20 x 50) = 2,900 feet

Pop-to-pull-down distance = (Apex Altitude (AGL) x 60)/Climb Angle = 3900 x 60/2 = 11,700

Turn radius = $(KTAS \times 1.69)^2/(g \times G_R) = (520 \times 1.69)^2/(32.2 \times 3.5) = 6{,}853$ feet

$g = 32.2$ fps^2 and G_R = cockpit G

5.17.1.6 Selecting Action Range. With no restrictions on attack heading, choose the best IP available and then determine the approach heading that gives precisely the angle-off you are looking for, normally, twice the dive angle. Remember, when you fly directly from the IP-to-PUP, the offset angle changes when the IP-to-target distance changes. If you change

the IP you may have some replanning to do. Further, it means that the planning for this 15-degree LALD attack, a very common attack, is only good for one unique IP-to-target distance. Fix the offset angle by turning for offset at a constant distance from the target regardless of the IP-to-target distance. This way, the same pop-up planning can be used even if you must change IPs. In addition, use the same attack plan against other targets (i.e., create a library of pop-up profiles). Use a point 4.5 NM short of the target to take the offset.

5.17.1.7 Calculating the Hold Down Time. The pull-up point is 11,700 feet prior to the pull-down point as computed from the pop-to-pull-down formula. Measure the distance between the action point roll out and pull-up point. This results in 1,000 feet and requires 1.1 seconds hold-down time prior to pop up.

1,000/(520 x 1.69) = 1.1

5.17.2 Drawing the Attack. Once the action point, angle off, turn radius, and pop-up to pull-down distance is defined, draw the attack ground track on a 1:50 or 1:250 Map. The attack planning example gives additional attack drawing guidelines. The offset angle can be measured as the difference between the IP-to-target run-in heading and the action heading. The example resulted in a 17-degree check turn at the action point. The action-to-roll out distance can also be measured as the distance between the action point and the point at which roll out is pointed at the pull-up point and reflects a constant 3- to 3.5-G turn. This distance is measured to be 2,000 feet for our example computations. A visual depiction of these results are shown in **Figure 5.57**, Completed Attack.

5.17.3 Using Computers. The squadron weapons shop has a program on the weapons/flight planning computer that quickly computes the majority of the pop-up parameters.

5.17.4 Preparing Templates. If you draw the attack to scale to do a map study, this allows the second alternative for determining attack information and graphics. You may draw the attack directly on the map, but it is better to make a template out of a piece of paper or light cardboard. Use the template to adjust the attack profile and finally trace it on the map. In addition, add the template to the library of attack options. To make a template, decide on a scale. A 1:50,000 scale is suggested for two reasons: to derive headings and distances graphically, a scale large enough for accuracy is needed; and trace the profile on a 1:50,000 scale-map, this type map is commonly used in attack planning. Some paper or light cardboard, a plotter, and a compass or circle template (if you want round circles) is needed. (See **Figure 5.58**, Template Construction.)

Figure 5.57 Completed Attack.

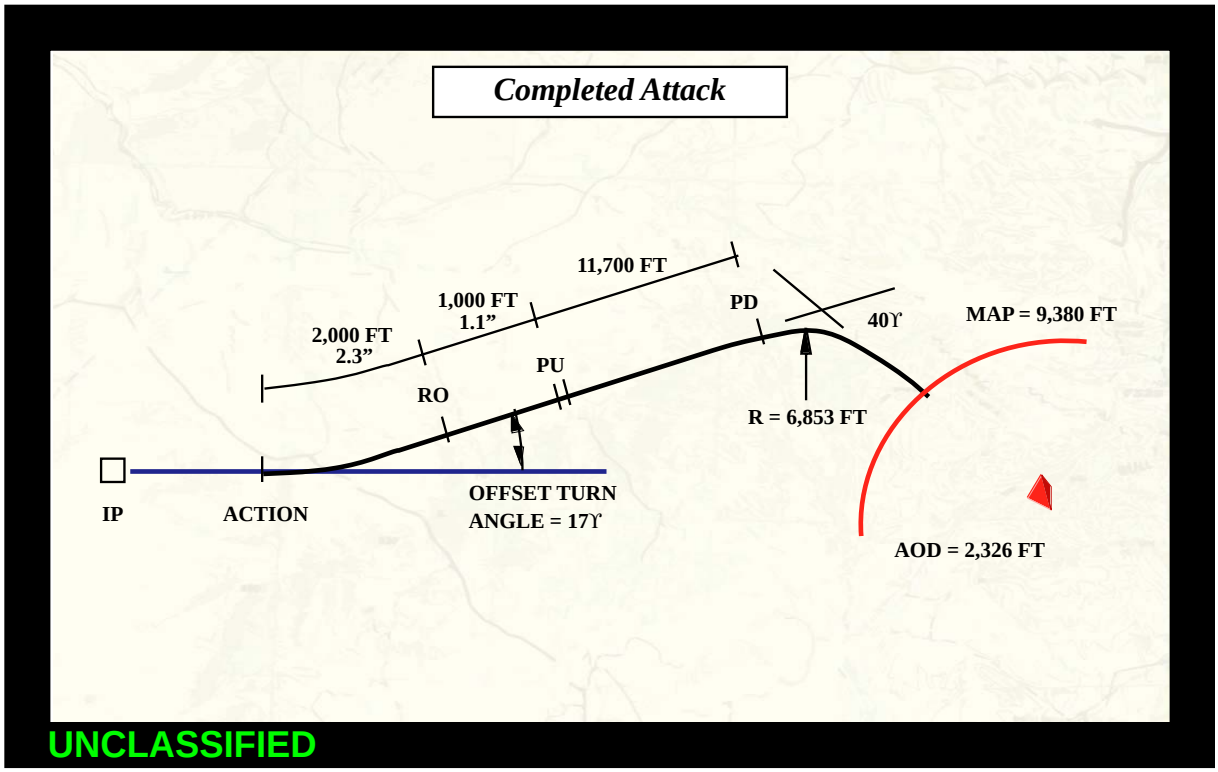
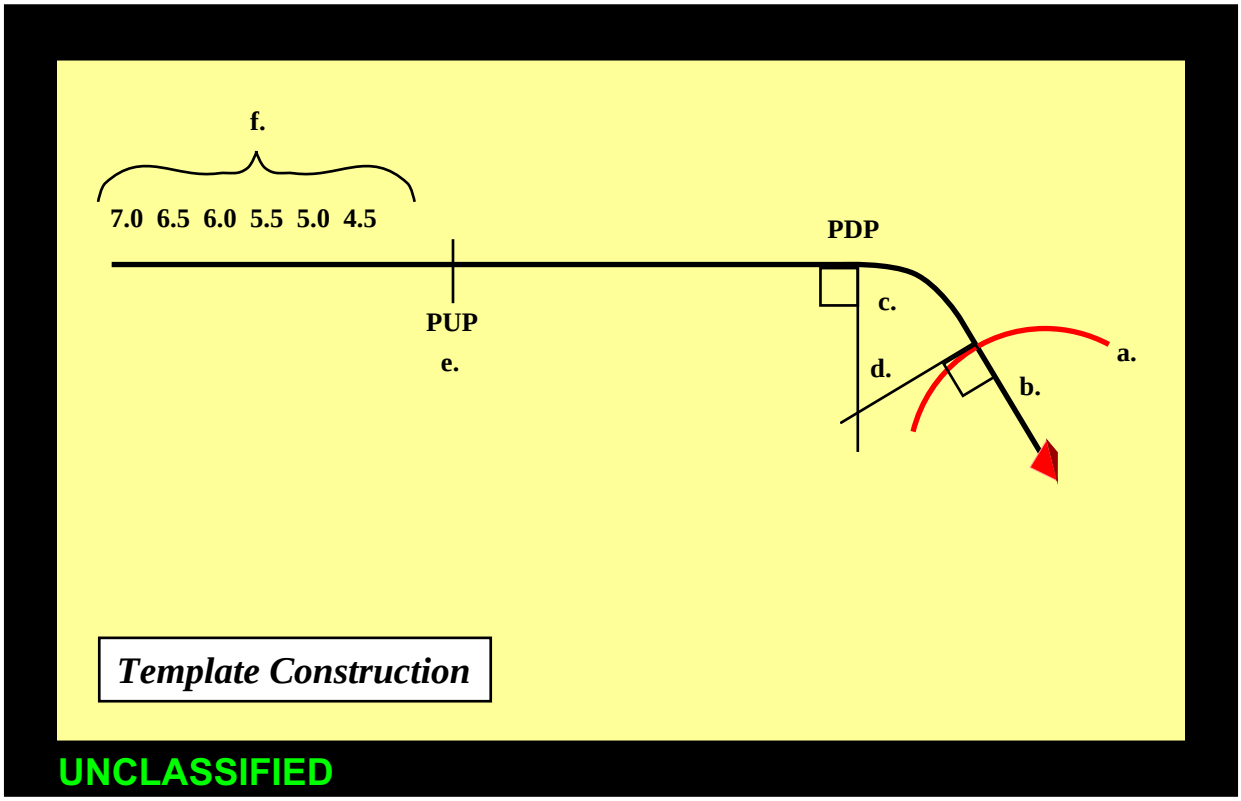


Figure 5.58 Template Construction.



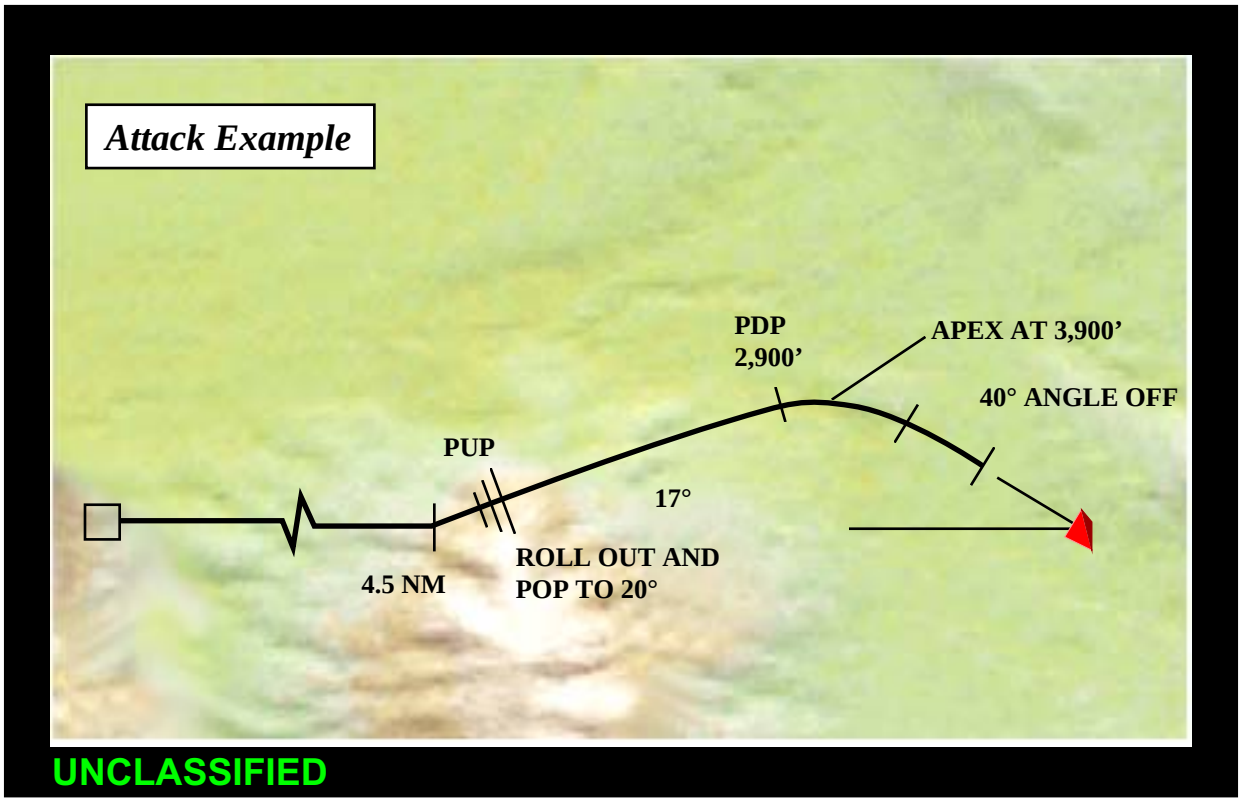
5.17.5 Finished Attack. For the example, pop-up calculations were used to plan the following attack.

- Dive angle: 15 degrees.
- Release altitude: 2,000 feet.
- Approach and release airspeed: 520 KTAS/500 KCAS.
- Time on final: 5 seconds.
- AOD: 2,326 feet.

5.17.6 Attack Description. An example is shown in **Figure 5.59**, Attack Example. A stick figure drawing may be included on the lineup card for easy access.

- Put target on the nose.
- At 4.5 NM take 17 degrees offset with a 3.5-G turn.
- Roll out and immediately pull up to a 20-degree climb.
- At 2,900 feet AGL, roll towards target.
- Pull down with 3.0 to 3.5 Gs. The heading change should be approximately 40 degrees.
- Roll out at 3,137 feet in 15-degree dive with the FPM 2,326 feet beyond target.
- Pickle at 2,000 feet.

Figure 5.59 Attack Example.



5.18 Fly-Up Attacks. Fly-up attacks are a derivative of the pop-up attack and are primarily used in the low-threat environment where AAA, small arms, and IR SAMs are the primary threats in the target area. Ingress is at low altitude due to en route threat or to effect tactical surprise. The fly-up is initiated at a distance from the target that allows a pull up to the base altitude of the planned delivery. Once at base altitude, the delivery is a curvilinear delivery with emphasis placed on recovery above the AAA/small arms envelope. Emphasis must be on element mutual support and accurate weapons delivery.

5.18.1 Sanitize the Target Area. The flight should use radars to sanitize the target area for airborne threats prior to the fly-up. Ingress and attack the target only when the whole attack and egress can be completed without enemy aircraft engagements.

5.18.2 Executing the Fly-Up. Fly-up at 10 to 8 NM from the target. The flight lead will check 10 to 20 degrees away from the target and initiate a climb (using AB, if necessary) to arrive at base altitude in a position to execute the delivery.

5.18.3 Wingman Considerations. When lead executes the fly-up, the wingman's primary job is visual lookout. Fly-up to place yourself in a position to visually support lead and execute the planned attack.

5.19 Two-Ship Employment Considerations. Deconfliction methods can include split, echelon, trail, shooter cover, and loft.

5.19.1 Deconfliction Options. To achieve altitude separation, the first aircraft can use a level, low-angle pop-up, VLD delivery, and offsetting as necessary for the planned delivery. The second aircraft splits at a predetermined point and pops to a high LALD or dive bomb delivery and pulls out above the frag envelope. (See **Figure 5.60**, Split, Altitude Deconfliction.) To achieve distance deconfliction, the second aircraft can use LAT or a loft delivery pulling out with separation from the frag. (See **Figure 5.61**, Split, Distance Deconfliction.) For timing separation a split at sufficient distance to achieve the desired spacing is effective but reduces mutual support after the split. (See **Figure 5.62**, Split, Time Deconfliction.) A split closer to the target requires arcing to remain within visual range and achieve timing separation. This allows the second aircraft to drop from a low-altitude delivery. The distance of the arc from the target depends on the turning room necessary to achieve delivery parameters.

5.19.2 Split Pop Attack. This option is designed for minimum exposure while splitting the defenses. Deconfliction can be achieved through altitude, distance, or timing.

WARNING: Altitude deconfliction may put the wingman into the heart of some threats. Use altitudes that recover above the threat versus frag to the maximum extent possible.

Figure 5.60 Split, Altitude Deconfliction.

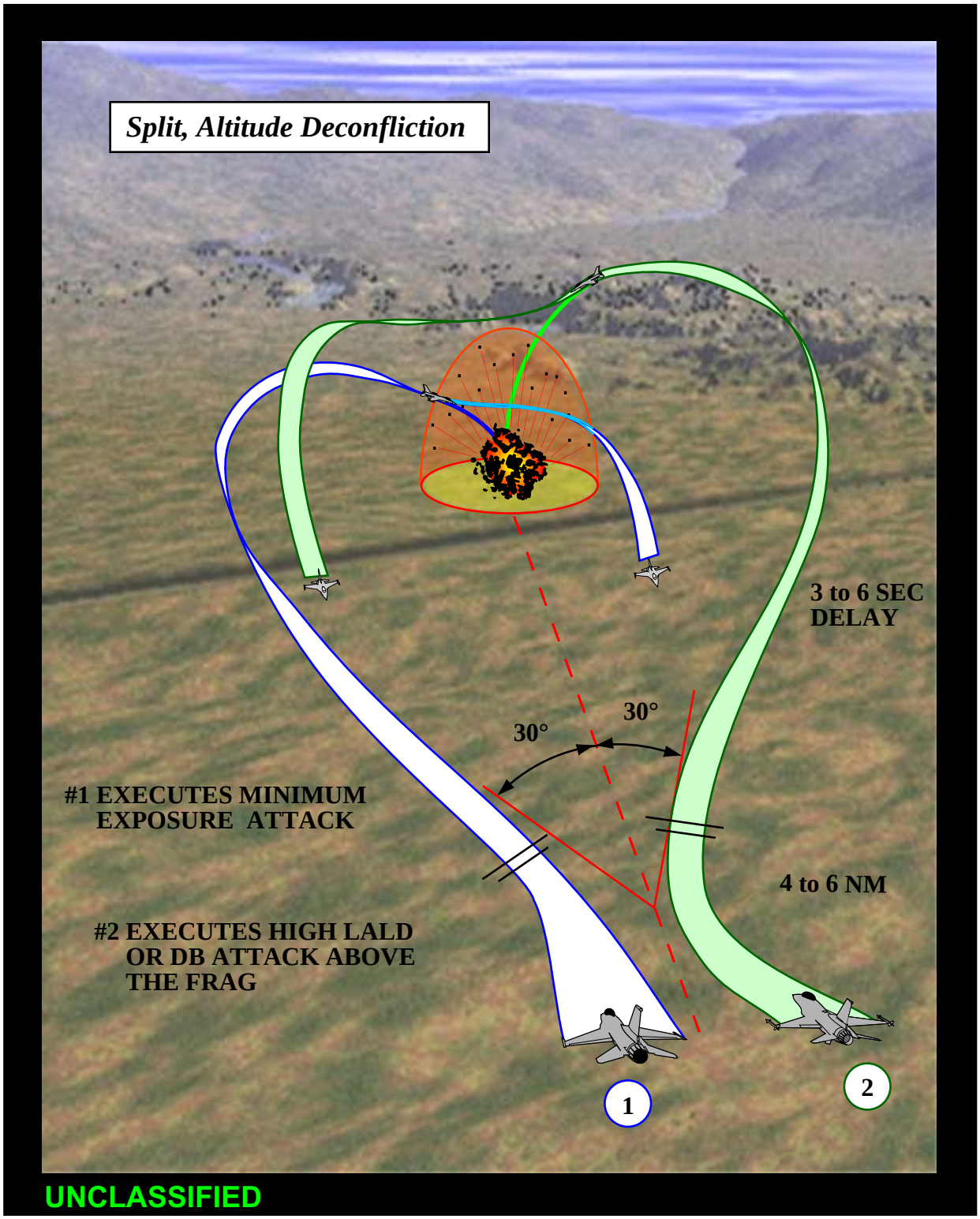


Figure 5.61 Split, Distance Deconfliction.

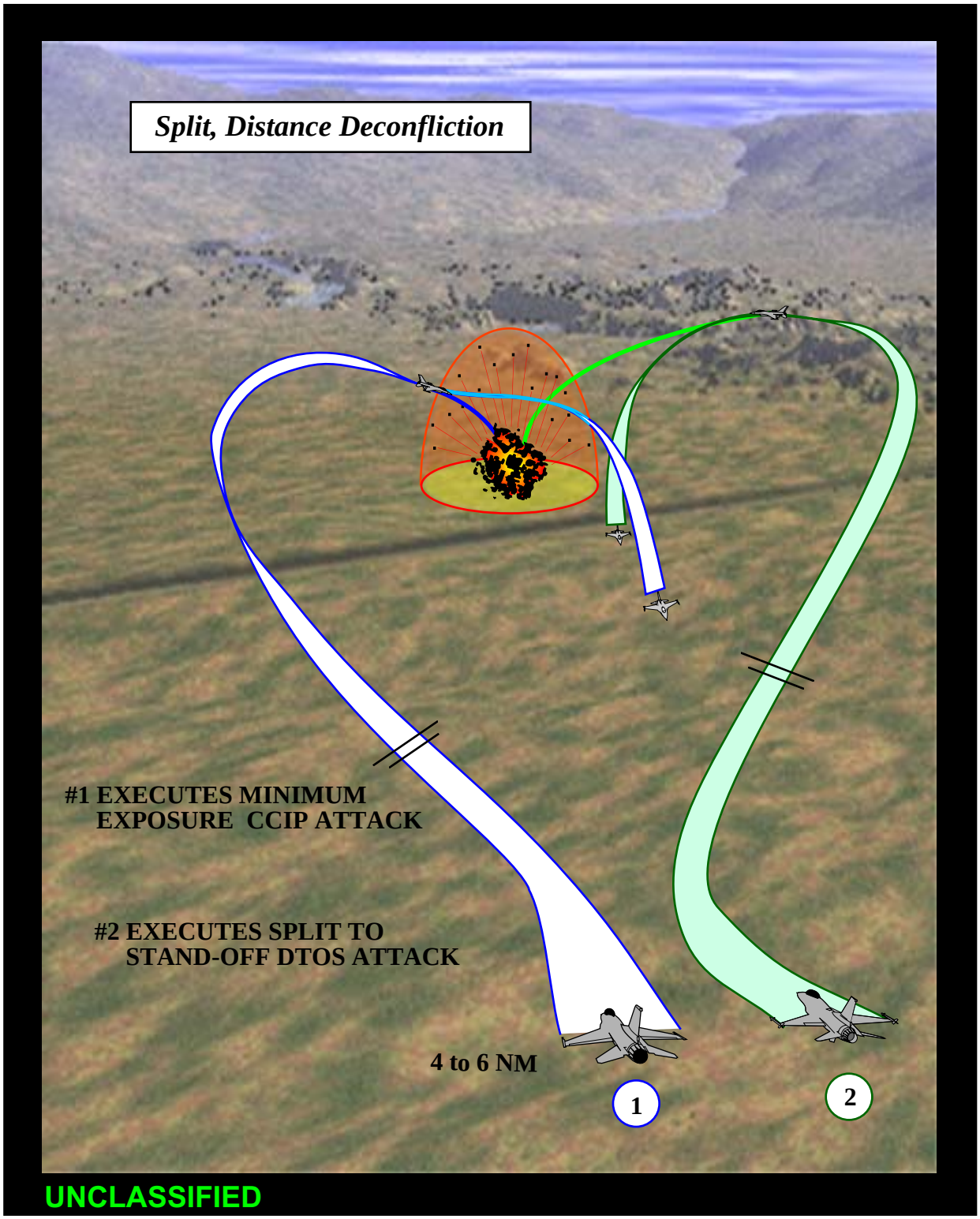
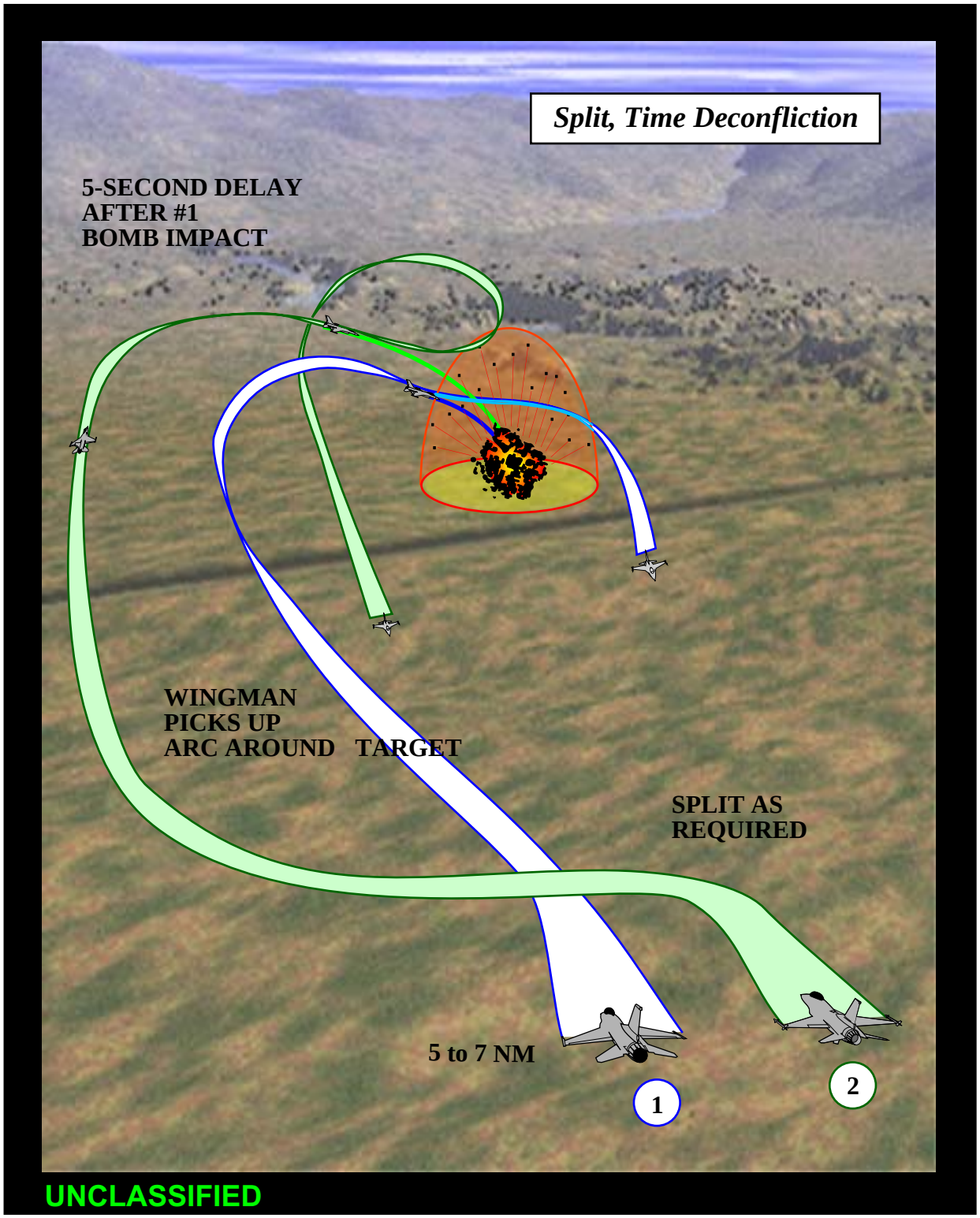


Figure 5.62 Split, Time Deconfliction.



5.19.3 Echelon Pop Attack. An echelon pop has both aircraft offset to one side of the target. This attack allows the element to maintain visual contact during the ingress, and allows the wingman to fly a visual formation during the attack. Deconfliction can be achieved through altitude, timing, and distance. Both aircraft turn away from the target at a predetermined point for offset pops. The lead aircraft can use a minimum exposure delivery such as VLD. The second aircraft can achieve altitude separation by popping to a high LALD or dive bomb delivery and pulling out above the frag. (See **Figure 5.63**, Echelon, Altitude Deconfliction.) Timing separation by arcing (**Figure 5.64**, Echelon, Time Deconfliction) or distance deconfliction by using LAT (**Figure 5.65**, Echelon, Distance Deconfliction) may also be used.

WARNING: Altitude deconfliction increases the wingman's vulnerability to many threats. The requirement for high power settings (AB) and long unmask times allows threat acquisition and engagement. Use altitudes that recover above the threat versus frag to the maximum extent possible.

5.19.4 Time Deconfliction. An example, is shown in **Figure 5.62**, Split, Time Deconfliction, the second aircraft arcs at 4 to 5 NM until the first aircraft's bombs explode, counts 5 seconds, turns to place the target at 10 or 2 o'clock, then executes a LALD, or VLD delivery to give approximately 30 seconds spacing. Timing deconfliction requires longer time in the target area than either distance or altitude deconfliction attacks. This technique should only be used for a single point target where accuracy is important and weather forces very low-altitude attacks. There are many available techniques to gain time deconfliction.

5.19.5 Trail Attacks. A trail attack provides timing deconfliction but gives up visual support for the second aircraft during ingress. Trail formation can be achieved by a spacing maneuver, such as a 90/90 or by airspeed. Both aircraft use deliveries such as VLD or loft that minimize exposure to the terminal threats. The first aircraft breaks away from the target after release with the second aircraft watching for SAM launches. To provide visual support for the second aircraft, the first aircraft turns back across the ingress heading. This helps to reacquire the second aircraft while beaming the threats. (See **Figure 5.66**, Two-Ship Trail Attack.)

5.19.6 Shooter/Cover. The shooter/cover option can be flown by a two-ship and allows one aircraft to attack the target using a preplanned profile. The second aircraft stays low and provides visual support by flying an arcing pattern outside the terminal threat. After the first aircraft has delivered ordnance, the second aircraft has the option of executing an attack, or egressing with the element mate (similar to the two-ship attack in **Figure 5.62**, Split, Time Deconfliction). This option is especially viable in a very high threat arena.

5.19.6.1 The shooter's role is to find and destroy the target. If necessary, inform the cover aircraft on target specifics and egress intentions. The shooter should adjust any follow-on attacks based on first-look observations.

5.19.6.2 The cover role includes providing visual look-out for air and surface threats. The cover pilot may engage or suppress pop-up threats according to pre-briefed criteria. The cover pilot must maintain overall battle SA while maintaining visual.

5.19.7 Loft Attacks. Loft deliveries allow weapons to be delivered simultaneously. In case of a degraded system aboard one aircraft, a loft can be made on the wing. Another option is the individual loft delivery.

Figure 5.63 Echelon, Altitude Deconfliction.

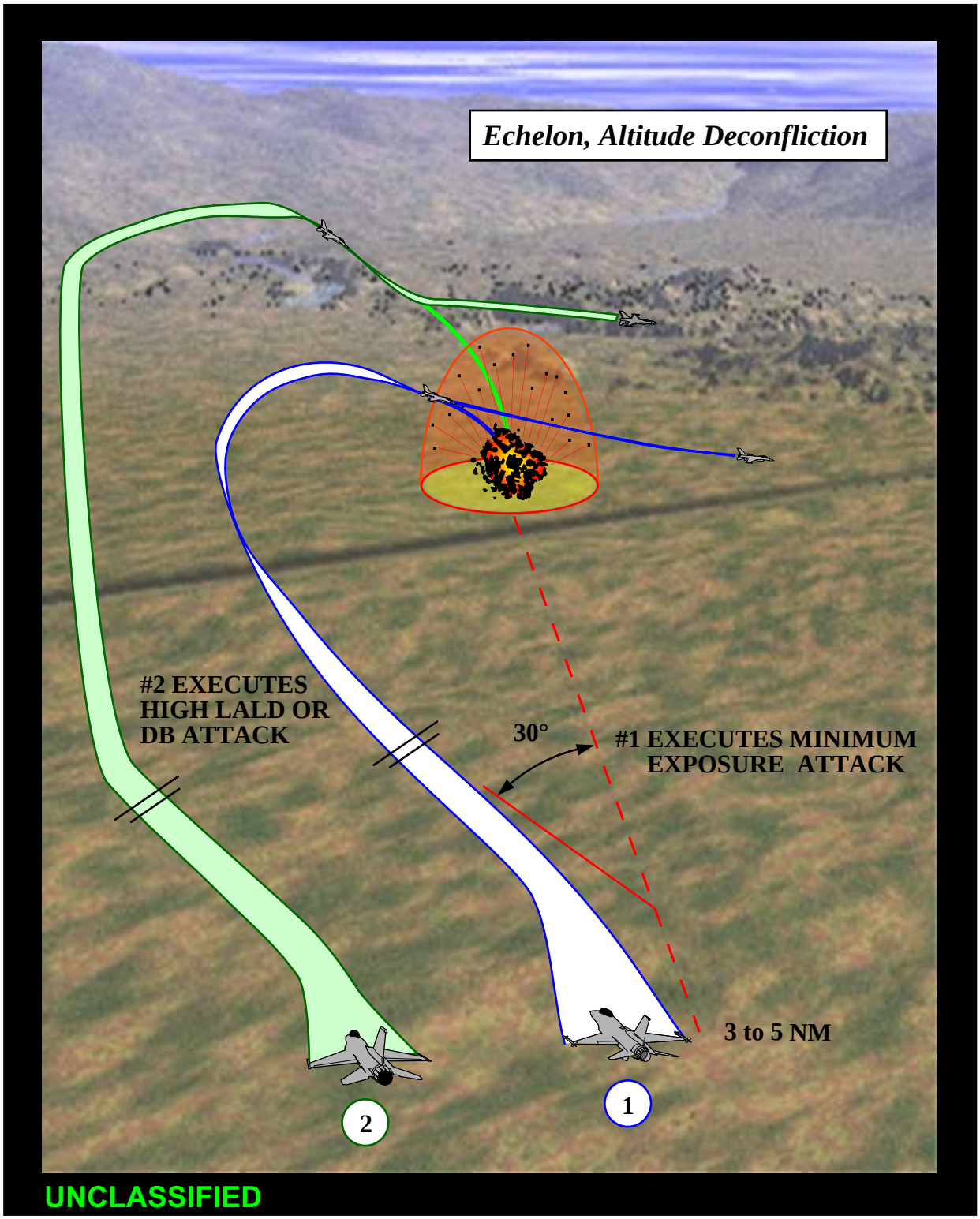


Figure 5.64 Echelon, Time Deconfliction.

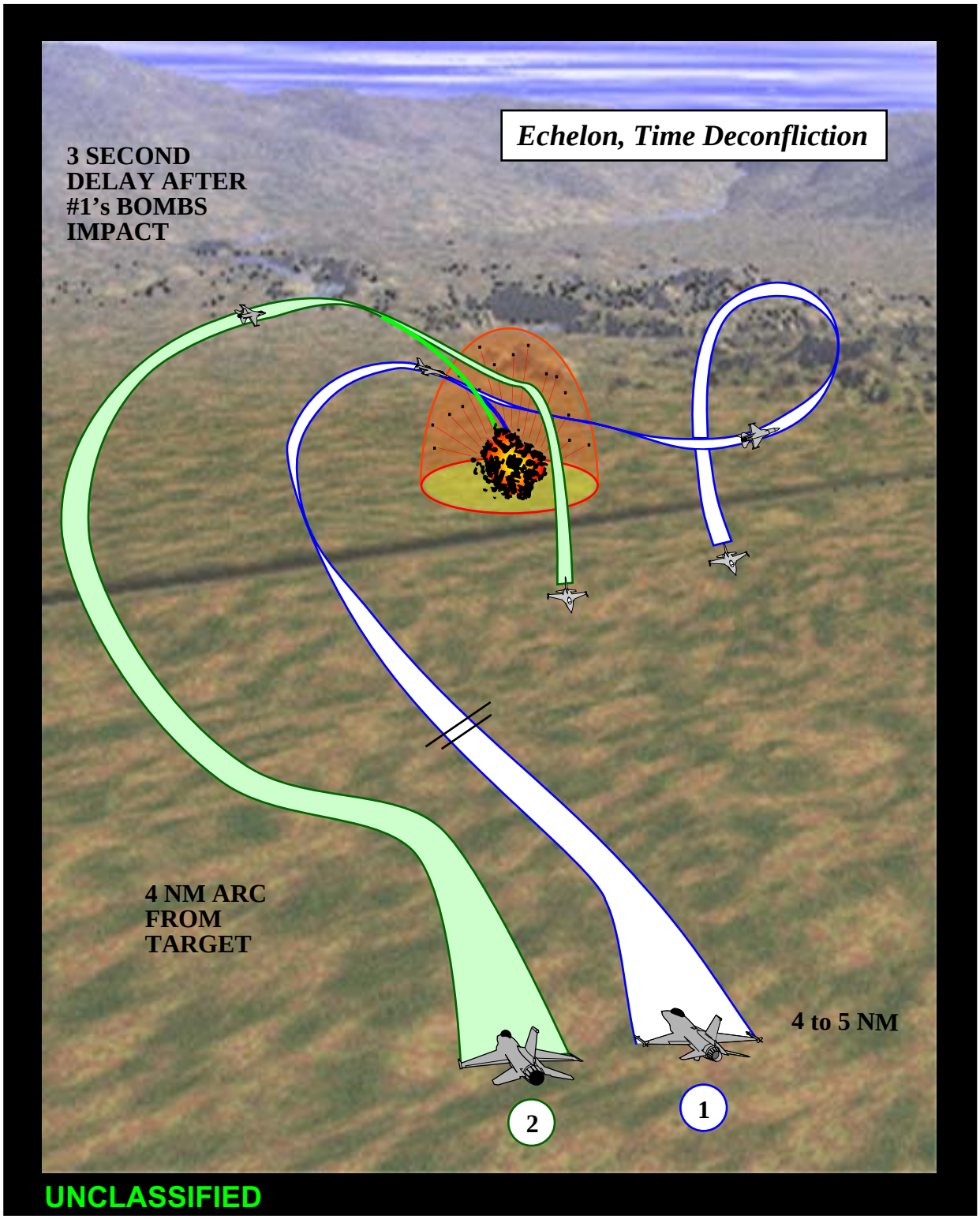


Figure 5.65 Echelon, Distance Deconfliction.

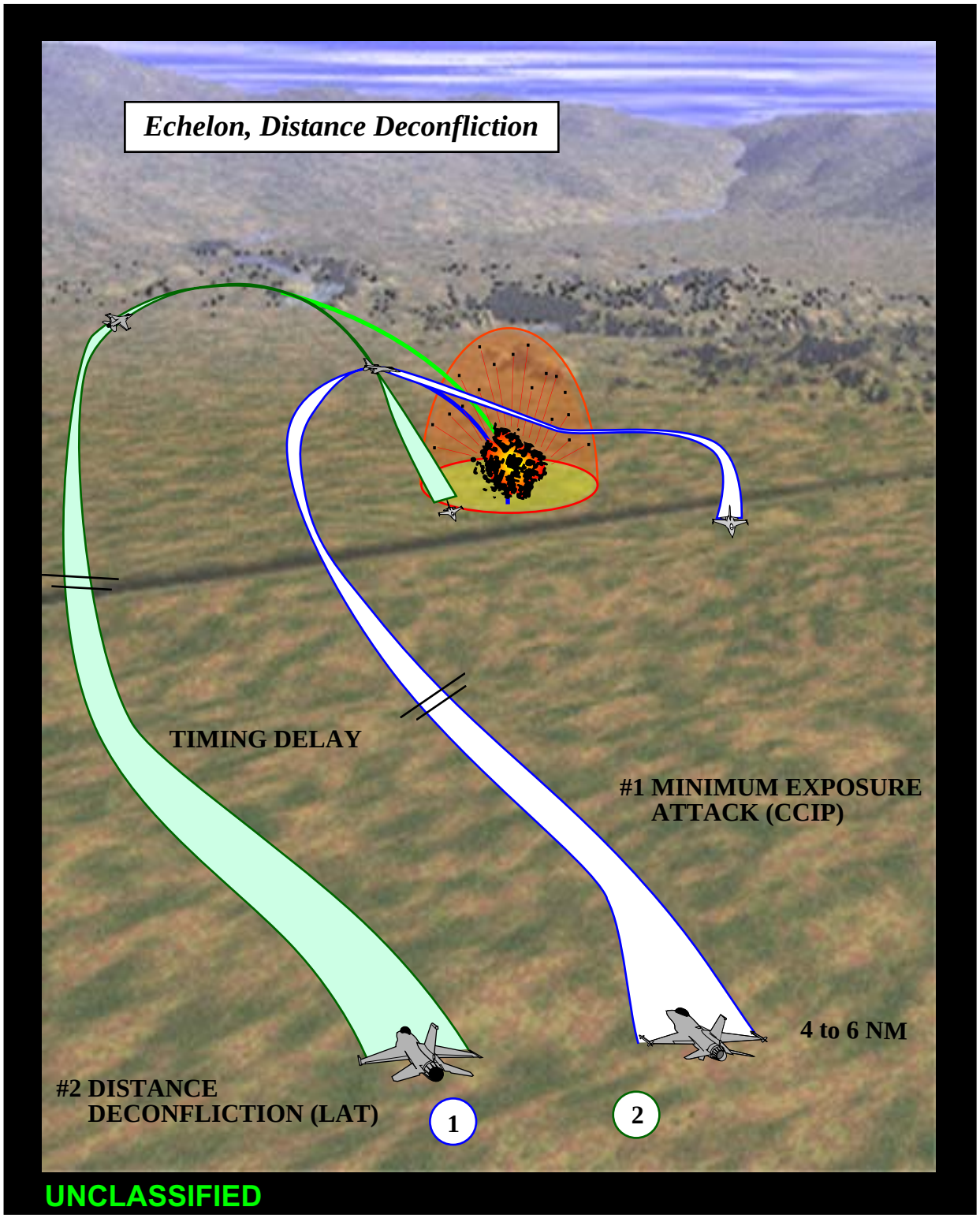
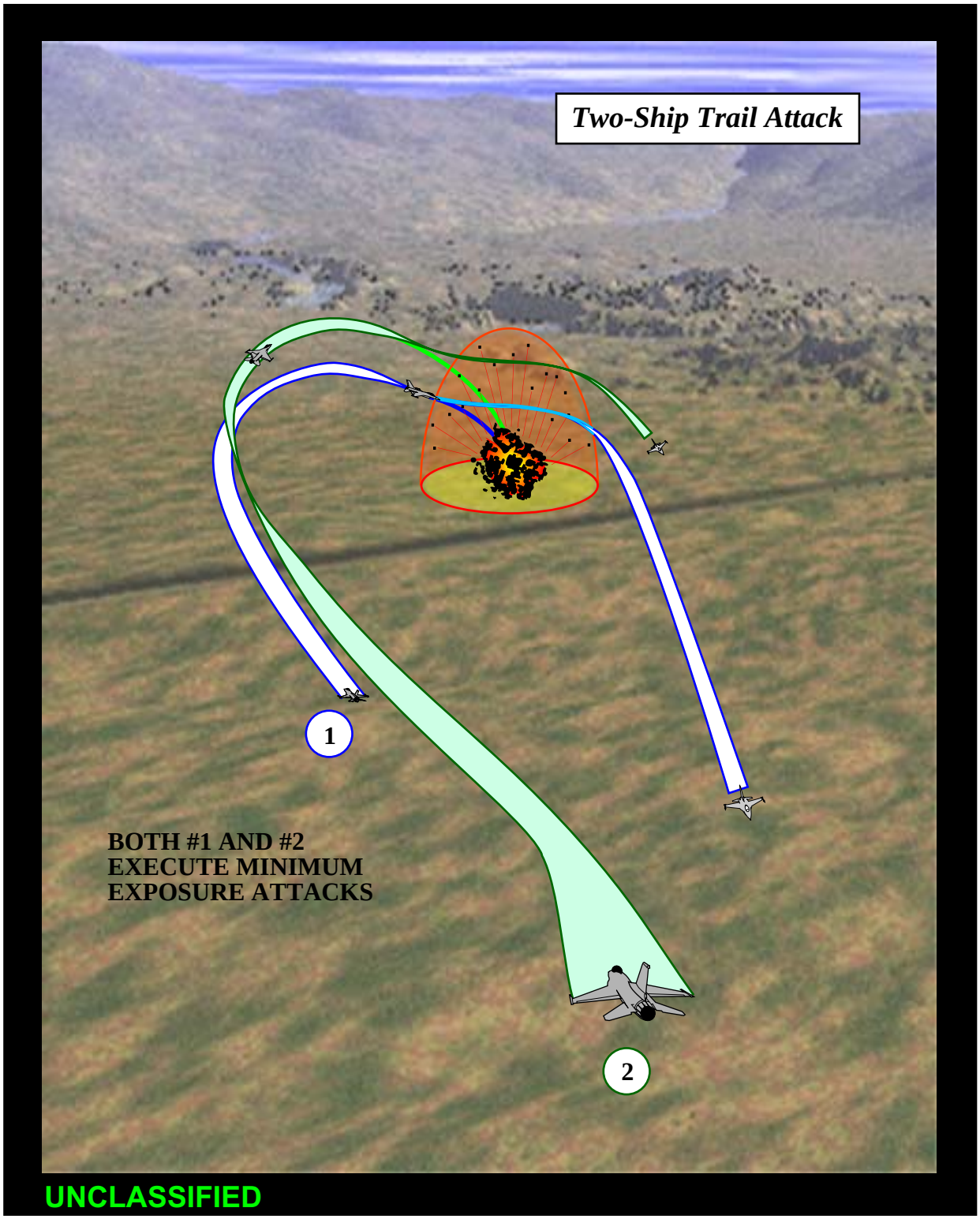


Figure 5.66 Two-Ship Trail Attack.



5.19.7.1 Simultaneous Loft. Both aircraft loft the ordnance from wedge. The formation should be spread 6,000 to 9,000 feet to compensate for convergence during the loft maneuver. Prior to pull-up, the wingman centers up the computed steering displayed on the HUD. An immediate roll or dive recovery after weapon release is recommended. Avoid a perfect 180-degree reversal as this would ease the tracking solution for ground threat systems. (See **Figure 5.67**, Simultaneous Loft.)

5.19.7.1.1 Advantages:

- The laterally spread formation causes confusion for ground threats.
- Provides stand off from target area threats.
- Each F-16 has independent loft accuracy.
- GPS-equipped aircraft can make accurate deliveries if target coordinates are accurate.
- Egress formation can be established quickly.

5.19.7.1.2 Disadvantages:

- Accurate deliveries may not be possible.
- Target coordinates may not be accurate.
- No good against mobile targets.
- Requires accurate system.
- Relatively good weather is necessary to maintain visual formation during pull.
- Mutual support is limited during the loft maneuver.

5.19.7.2 Loft on the Wing. One aircraft may be required to bomb, using the computed solution of the other aircraft due to system malfunction or weather constraints. In this case, the wingman flies within 500 feet of the lead aircraft, matches the pitch rate during the pull-up, and manually releases weapons in sequence with the leader's release.

5.19.7.3 Trail Loft. The wingman is positioned approximately 3 NM in trail. This distance puts ordnance on target for a longer time period and reduces the potential for conflict between the leader's egress maneuver and the wingman's loft maneuver. Lead should call the direction of break off after delivery if this has not been pre-briefed.

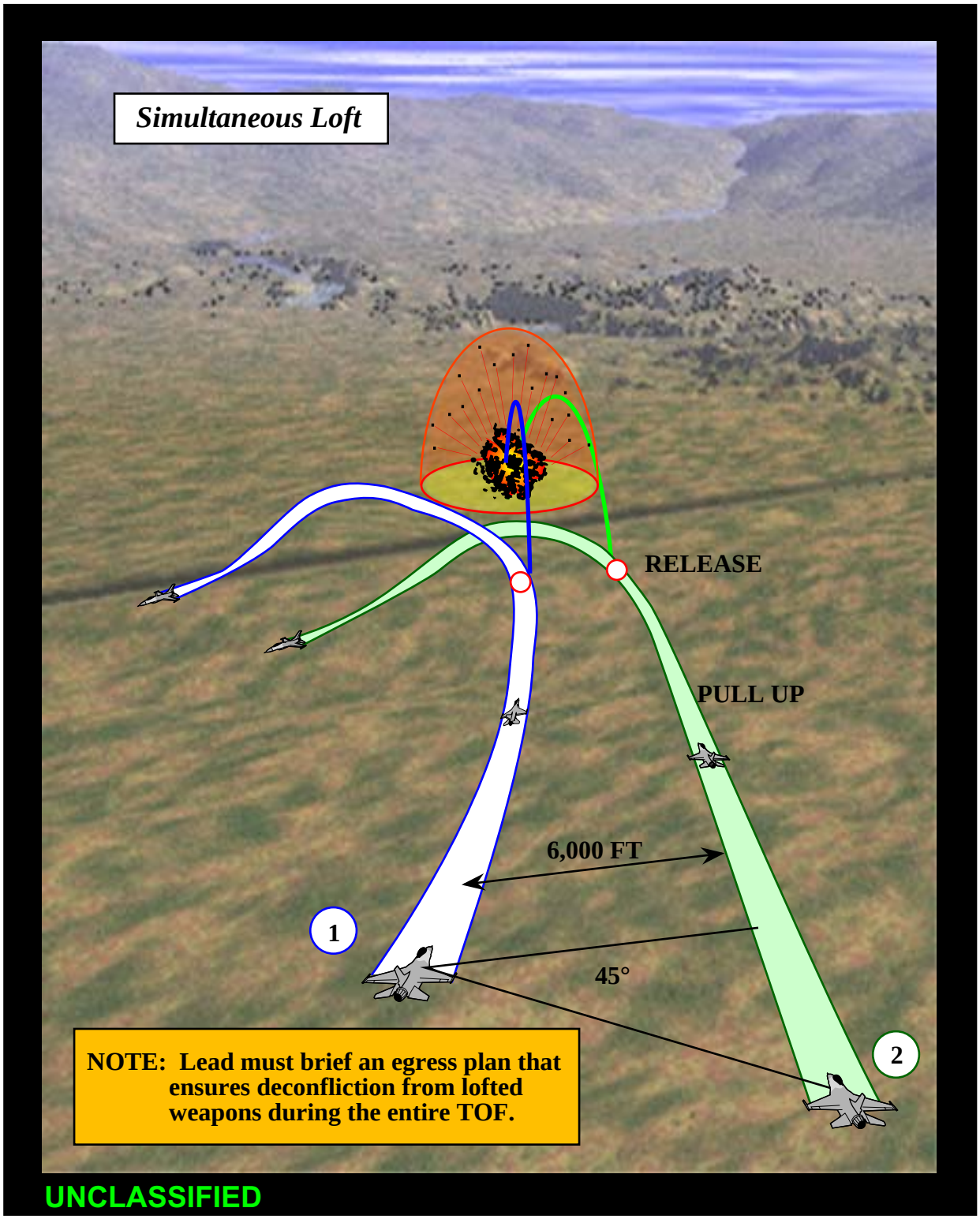
5.19.7.3.1 Advantages:

- Individual aircraft are free to maneuver during ingress and egress.
- Individual system accuracy increases the total mission probability of kill (P_k).

5.19.7.3.2 Disadvantages:

- Both aircraft must have full-up systems.
- Mutual support between aircraft is limited.
- Rejoin off target is difficult.

Figure 5.67 Simultaneous Loft.



5.19.7.4 Aircraft and Ordnance Deconfliction. Consideration must be given for deconfliction from lofted bombs during their TOF.

5.19.7.4.1 For element lofts, it is critical that the wingman not fly further forward than wedge, and the leader must turn away from the wingman during the egress turn. Failure to do so could result in the leader having a midair with the wingman's bombs.

5.19.7.4.2 For single-ship loft, following release, maneuver away from the bomb's trajectory. Maintain this lateral separation. There have been cases where after release, aircraft have turned back toward the target area and subsequently had a midair with their own lofted bombs.

5.20 Egress. The target area egress plan must be flexible, simple, and fully understood by all flight members. Reasons for egress and abort are as follows:

- Target destruction.
- Poor weather.
- Unacceptable target area defenses.
- Low fuel.
- Loss of mutual support.
- Loss of required aircraft systems.
- Target acquisition problems.
- Battle damage.

5.20.1 Egress Priorities. Egress priorities should be based on target area threat (type, intensity, and lethality), weather, follow-on attacks, status of follow-on attackers (engaged/offensive/defensive/ neutral). General priorities are as follows:

- Leave target area.
- Get away from threat envelope.
- Regain mutual support.

5.20.2 Blind or Separated. If a pilot becomes separated from the flight, follow the egress plan and provide your own threat lookout while proceeding to the pre-briefed tactical rendezvous point. This point should be relatively free of defenses, allow for battle damage checks, and provide possible initiation of a reattack. Most importantly, join with someone as soon as possible.

5.20.3 Two-Ship Egress. Following ordnance delivery, both aircraft should turn toward their pre-briefed egress heading. Line Abreast formation provides the most effective defensive lookout. However, it may be impractical to maneuver in the immediate target area to gain a line abreast position due to target area defenses. Therefore, adhere to the egress game plan with an accepted loss of visual cross coverage. A weave back to line abreast is advised when tactically acceptable.

5.20.4 Three-Ship Egress. If a three-ship is employed in the target area, the first aircraft off the target should turn the shortest direction to the egress heading and provide own lookout. The

two-ship element provides its own threat detection and maneuvers to cover the first aircraft's 6 o'clock when possible.

5.20.5 Four-Ship Egress. When a four-ship is employed in the target area, the elements will normally be separated by time or geographical reference within the target area for weapons deconfliction. They should maintain element integrity throughout the attack and egress as an element with visual mutual support. When clear of the target area, both elements should rejoin in an area relatively free of enemy defenses. Avoid excessive turning in the target area while attempting to rejoin a four-ship flight.

5.20.6 Egress Factors. The egress must be flexible, consider terrain, battle damage, communication, and flight responsibilities.

5.20.6.1 In mountainous terrain, an in-trail option may be appropriate to mask defenses. Flat terrain allows for good visual cross coverage while using a Line Abreast formation to provide threat warning.

5.20.6.2 Perform a battle damage check on each flight member.

5.20.6.3 Perform "Wounded Bird" procedures when egress cannot be flown at the pre-briefed airspeed. If the aircraft is flyable, initiate egress immediately. Prior to the forward edge of the battle area (FEBA), RTB. Past the FEBA, if unable to cross back over the FEBA, ejection in the safe areas should be considered. If unable to cross, initiate "Wounded Bird" procedures.

5.20.6.4 Pilots should be prepared to fly the entire egress plan without radios due to the possibility of comm jamming and to keep the frequency clear for other aircraft. Visual is assumed unless wingmen make a blind call. Adhere to pre-briefed flight paths and visual signals to reduce confusion during egress.

5.21 Wounded Bird. The first priority for the wounded bird's pilot is to communicate the aircraft's status. If the level of damage is severe and the enemy threat is high enough to greatly endanger escort aircraft, the decision may have to be made to leave the battle damaged aircraft on its own to preclude further and unnecessary losses.

5.21.1 Escort Actions. If the affected aircraft can maintain a minimum of 400 knots (or 0.8 Mach at high altitude), then it can be escorted in a standard formation, even though the escort aircraft will have to throttle back. The escort aircraft and the damaged aircraft should clean off any nonessential drag. If the damaged aircraft cannot maintain minimum speed, then the supporting aircraft will have to stand off from the damaged aircraft in a position from which the 6 o'clock can be protected. Weaves of 30 to 45 degrees for the egress heading will allow the supporting aircraft to maintain a minimum of 400 knots while maintaining a protective position on the slow aircraft. Using 400 knots and a 45-degree weave means that the escorted aircraft is flying at only 280 knots. Weaves up to 60 degrees will allow escort of a 200-knot aircraft. Weaves can be disorienting and may highlight the escort and/or the wounded bird. Another pattern option is for the escort to fly a Racetrack offset from the Wounded Bird, on course. This pattern allows the escort to look both at the Wounded Bird's 6 and 12 o'clock while giving the escort time to visually reacquire and check the Wounded Bird's progress. If the damaged aircraft has avionics, the pilot can assume the navigation and radar search respon-

sibilities. This allows the protector to concentrate on visual lookout for both aircraft. Offensive commit criteria is more constrained than normal. If an air-to-air commit is required, the escort takes the lead in the acceleration maneuver and merges with adversaries first. The damaged aircraft should use avionics and/or descriptive commentary to get a tally and possibly some ordnance in the air after it has a positive identification from the escort (engaged) fighter.

5.21.2 Engagements and Threats. If at any time during the egress, an active engagement ensues and an adversary approaches ordnance parameters on the damaged aircraft, the pilot must make the decision either to try a Last Ditch maneuver, or to eject. If the capability exists to spoil an attempted gunshot, the pilot should direct that move above the horizon in order to preserve altitude for a safe ejection.

5.21.3 Two-Ship Escort. In a three-ship formation with a slow, damaged aircraft, firepower is improved, but the escorting pattern is more complicated. Weaving behind a slow aircraft as a two-ship may do more to attract a bandit's attention. A close-tied Racetrack pattern around the damaged aircraft using radars to sanitize the 6 and 12 o'clock avenues of approach may be effective.

5.21.4 Three-Ship Escort. In a four-ship, consideration should be given to the threat arena, ordnance, and fuel available. Although you should never jeopardize all four to save one, the healthy element could be used to sweep for the damaged aircraft while element mate escorts.

5.21.5 Forward Edge of the Battle Area Crossing. As the flight approaches the FEBA or any heavily defended S/A arena, the healthy aircraft must accelerate to penetrate the defenses. The pilot of the disabled aircraft can observe the active threats as they attempt to engage the other flight members. This allows course changes to make the aircraft less vulnerable to the observed threats.

5.21.6 Friendly Airspace. Once across the FEBA, the flight member should orbit to pick up the damaged aircraft. The enemy's air order of battle (AOB) is still a threat, so “Wounded Bird” procedures must continue. Close to the landing base, appropriate emergency procedures should be accomplished.

5.22 Recovery. Recovery options should be based on factors such as fuel, safe passage procedures, and threat detection.

5.22.1 Fuel. Fuel is a primary concern on recovery. The engagement of an unexpected threat during egress may result in a fuel state that makes recovery to the primary base impossible. Pilots must have preplanned bingos during the entire recovery profile; know when to climb, when to divert, and when to jettison external tanks or suspension equipment in order to increase range.

5.22.2 Safe Passage. These procedures differ by theater. Knowledge of recovery options is mandatory. Inoperative identification, friend, or foe (IFF)/selective identification feature (SIF) equipment; and radio out may force rendezvous with other friendly aircraft for recovery.

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CHAPTER 6

AIR REFUELING

6.1 Introduction. When basic information is mastered, air refueling (AR) in the F-16 is relatively easy; it is very similar to Close Trail formation. The aircraft is stable on the boom, there is plenty of excess power available, and the visibility is exceptional. An in-depth knowledge of procedures is essential for safe and efficient AR. Most of these procedures are presented in this volume.

6.2 Mission Preparation. Prior to the briefing, review AR procedures in current TO guidance. Obtain the AR information including tanker call sign, refueling track, refueling altitude block, fuel off-load, refueling frequencies, air-to-air (A/A) tactical air navigation (TACAN) channel, and air refueling control time (ARCT). Determine the forecast weather for rendezvous and refueling.

NOTE: The position, coordinates, and TACAN fixes associated with the air refueling initial point (ARIP) and the air refueling control point (ARCP) can be found in FLIP AP/1B. AP1/1B also lists the primary and back-up radio frequencies, A/A TACAN channels, and altitude boundaries of the AR track.

6.3 Ground Operations. During normal after-start checks, check the AR system. Move the AR switch to the OPEN position and check the AR status lights for a blue RDY light on and the DISC light off. Depress the AR/nose wheel steering (NWS) DISC on the stick and check that the amber DISC light is on. Three seconds later, the RDY light should come back on and the DISC light should go out. Move the AR switch to CLOSE and check that the RDY light extinguishes. The crew chief will confirm operation of the AR door and slipway lights. Confirm that the slipway lights are also turned up to illuminate the refueling receptacle. (See **Figure 6.1**, Cockpit Switches.)

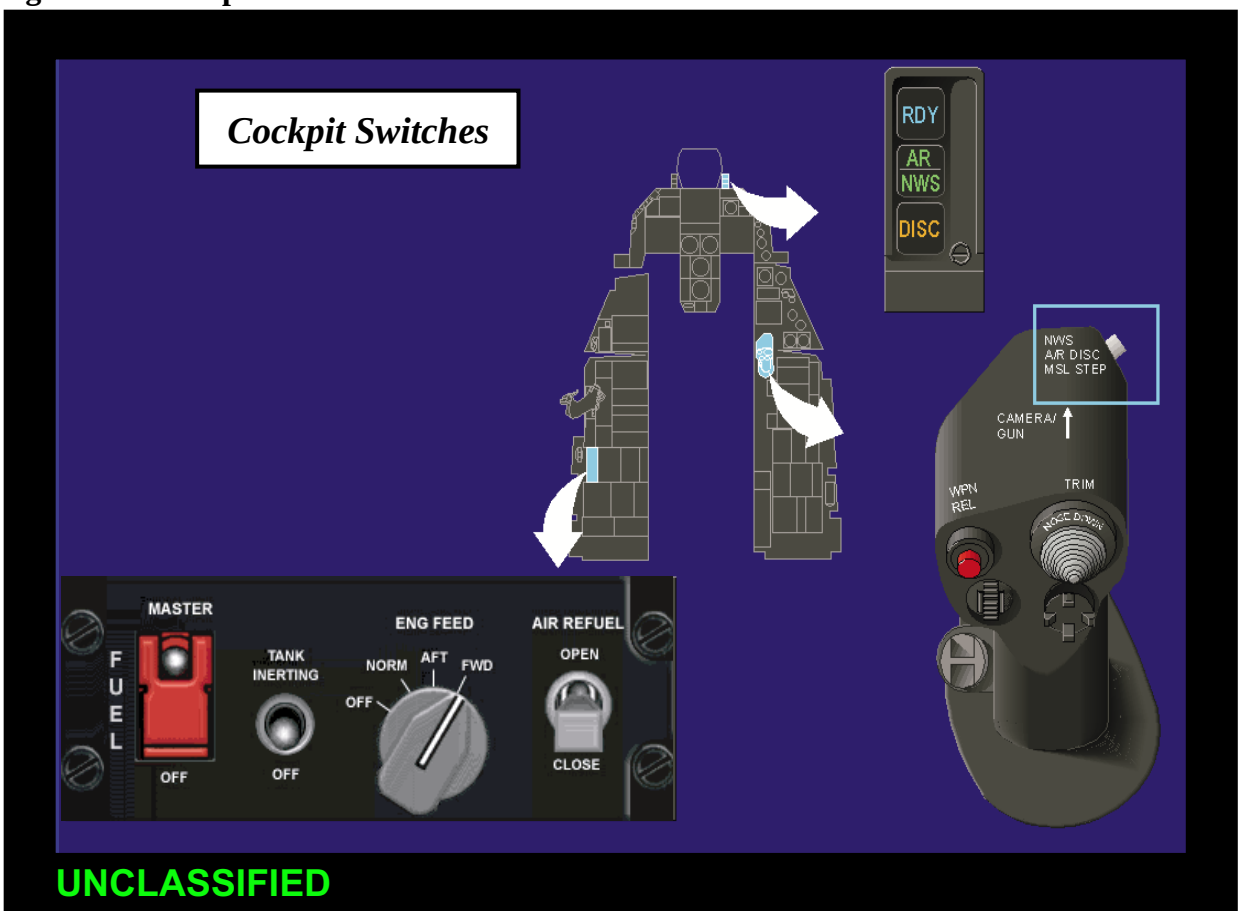
CAUTION: On the ground, depressing the AR/NWS button cycles the NWS. After closing the AR switch, check NWS light on prior to taxiing.

6.4 En Route. There are several different techniques for setting up the radar to search for the tanker. A common technique is to select 80 NM range, and 2-bar, with the acquisition symbols initially positioned at 50 percent scope, elevation set to bracket the tanker's expected altitude. The steerpoint should correspond with either the ARIP or ARCP. If bullseye will be referenced, ensure it is mode selected. Use A/A TACAN to receive the range to the tanker. Ensure the master arm switch is in SAFE.

6.5 Rendezvous. Point parallel and fighter turn-on are tanker rendezvous methods. Point parallel is normally used any time the tanker has no aircraft currently rejoined. Fighter turn-on is generally used when there are several flights scheduled for the same tanker, and one flight is joined as the next flight begins its rendezvous, or when the tanker is in an anchor pattern. Brief and use GCI/AWACS, as well as data link to the maximum extent, but monitor the intercept geometry to ensure an efficient rendezvous. Use the inertial navigation system (INS), radar, and A/A TACAN to monitor the rendezvous. Visualize the rendezvous geometry to detect deviations as they develop (e.g., insufficient lateral separation or excessive heading crossing angle [HCA]). Ensure altitude

separation with the tanker is maintained until visual contact is established. Complete the armament safety check prior to putting the tanker in a weapons employment zone (WEZ).

Figure 6.1 Cockpit Switches.



6.5.1 Point Parallel. Radio contact will be established with the tanker prior to arriving at the ARIP. Emission control option 2 (EMCON 2) will be used as the normal AR communication procedure. If both the tanker and receivers are on a common GCI/ATC frequency to obtain ground rendezvous assistance, the change to the AR frequency may be delayed until positive radar/visual contact is established. If under radar control, obtain bearing and distance to the tanker prior to changing to the AR frequency. As soon as reliable radio contact has been established with the tanker, position information from a common TACAN may be exchanged (if available). GCI/ATC or the tanker should clear the flight to depart the ARIP. Maintain 1,000 feet below the tanker until visual contact is made with the tanker.

6.5.1.1 Point Parallel Rejoin.

6.5.1.1.1 Proceed from the ARIP to the ARCP using all aids necessary to maintain track course. Range information to the tanker is available from A/A TACAN or ATC/GCI. One flight member (normally the lead) will set the assigned A/A TACAN prior to departing the ARIP. All flight members will monitor the rendezvous with on-board radars. If the rendezvous is proceeding properly, lead should call the tanker's turn to refueling heading at 26-degree azimuth and 21-NM range, with 180 degrees HCA.

Radar display progression is depicted in **Figure 6.2**, Rendezvous Options. The terminal stage of the rendezvous is critical. The point parallel rendezvous will result with the tanker 3 NM in front of the fighters. If the tanker turns too late or too slowly, an overshoot may develop. If the tanker turns early or with higher rate, a "cold" roll out (the tanker more than 3 NM ahead) results. During the turn, the tanker should be 45 degrees left at 13 NM with 90-degree HCA, and 34 degrees left at 8 NM. If the range is less at either point, reduce speed to 300 KCAS and advise the tanker to "PUSH IT UP." A slight turn away from the tanker will also preserve range. If range is greater at a point, increase speed (350 KCAS). Be aware that the radar may enter the coast mode or break lock at 9 AA. In visual meteorological conditions (VMC), visual with the tanker is normally acquired before this point. If not, maintain heading and altitude while attempting to reacquire. The checkpoints are based on the following conditions:

- Speed: tanker 290 KCAS, fighter 310 KCAS.
- Altitude: FL 250 to 300.
- As a ROT, accelerating to 350 KCAS as the tanker starts the turn, decreases roll-out range by 2 NM, thus allowing the fighters to roll out 1 NM behind the tanker.

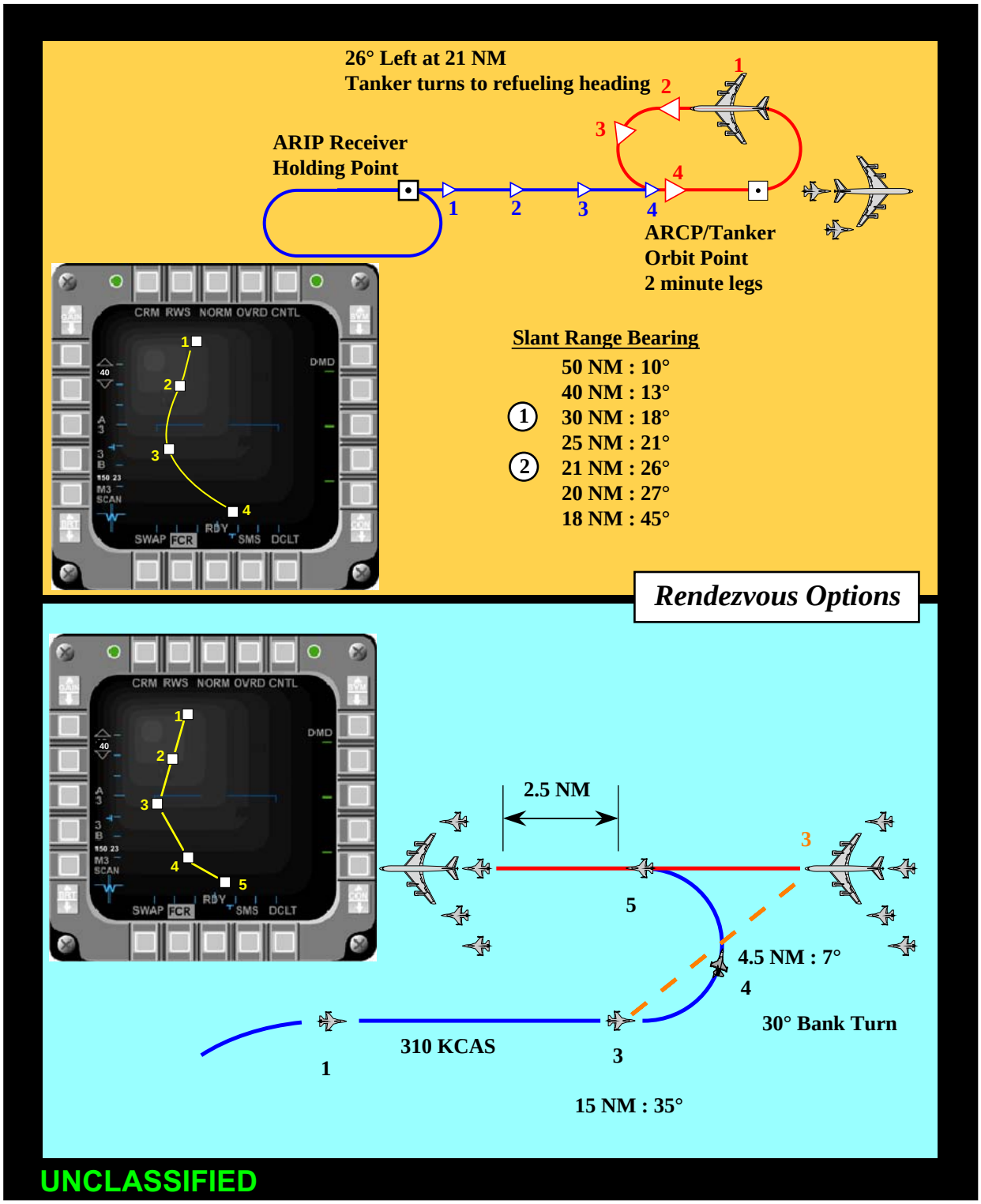
6.5.1.1.2 Ensure altitude separation until established behind the tanker with visual contact. AR airspeed is 310 KCAS; the tanker will maintain 290 KCAS until the receiver "PUSH IT UP" call.

6.5.2 Fighter Turn-On. Although you may use normal intercept techniques for a fighter turn-on rendezvous, these steps allow for a controlled rejoin, normal for ATC operations or while in instrument meteorological conditions (IMC).

- The fighters turn instead of the tanker, using 30 degrees of bank, and maintain 350 KCAS throughout the rendezvous until the closure rate dictates an airspeed adjustment.
- The fighters' start the conversion when the tanker is at 35 degrees relative bearing and 15 NM range.

6.5.2.1 Fighter Turn-On Rejoin. The tanker should be at 7-degree relative bearing and 4.5 NM when the fighters are halfway through the turn. (See **Figure 6.2**, Rendezvous Options.) The tanker will establish refueling airspeed when requested by the flight lead. The fighters will adjust airspeed as needed to achieve the desired closure rate. At the completion of this turn, the fighters will normally arrive in 2.5 NM trail. Be aware that the radar may enter coast mode or break lock. React in the same manner as the point parallel while maintaining 30 degrees bank. Use caution during the rendezvous; confirm the radar continues to track the tanker. It may transfer to the flight on the tanker as they depart. Be alert for maneuvers that do not match the expected tanker track—if in doubt, query the tanker. Also, compare radar range with A/A TACAN range.

Figure 6.2 Rendezvous Options.



6.6 Emission Control Options. There are four levels of emission control options: 1, 2, 3, and 4. Although, EMCON refers to what level of emissions the aircraft could send out (i.e., radar on or off), it has communication levels that mirror the emission levels. Level one is unrestricted, level

two is partially restricted, level three is very restricted, and level four is completely restricted (i.e., no emissions or communications). Your initial AR will be EMCON 1. The mandatory boomer calls for EMCON 1 are cleared pre-contact, cleared contact, contact/disconnect, verbal corrections, and any advisory calls. After the initial refueling, EMCON 2 will be the standard. The only mandatory boomer calls during EMCON 2 are cleared pre-contact.

6.7 Rendezvous Overrun. When a rendezvous overrun occurs, the tanker or receiver pilot will immediately transmit a warning to all flight members and initiate rendezvous overrun procedures. In the event of an overrun, the receivers will pass 1,000 feet below the tanker to ensure positive vertical separation. The receivers will decelerate to 290 KCAS and maintain AR heading. The tanker will accelerate to 350 KIAS or 0.90 Mach, whichever is lower, and maintain AR heading. When the receiver regains the 3/9 line and visual with the tanker, the receiver pilot will ask the tanker to slow to 310 and complete the rejoin. The tanker will decelerate to AR airspeed and normal closure procedures will be employed to establish contact.

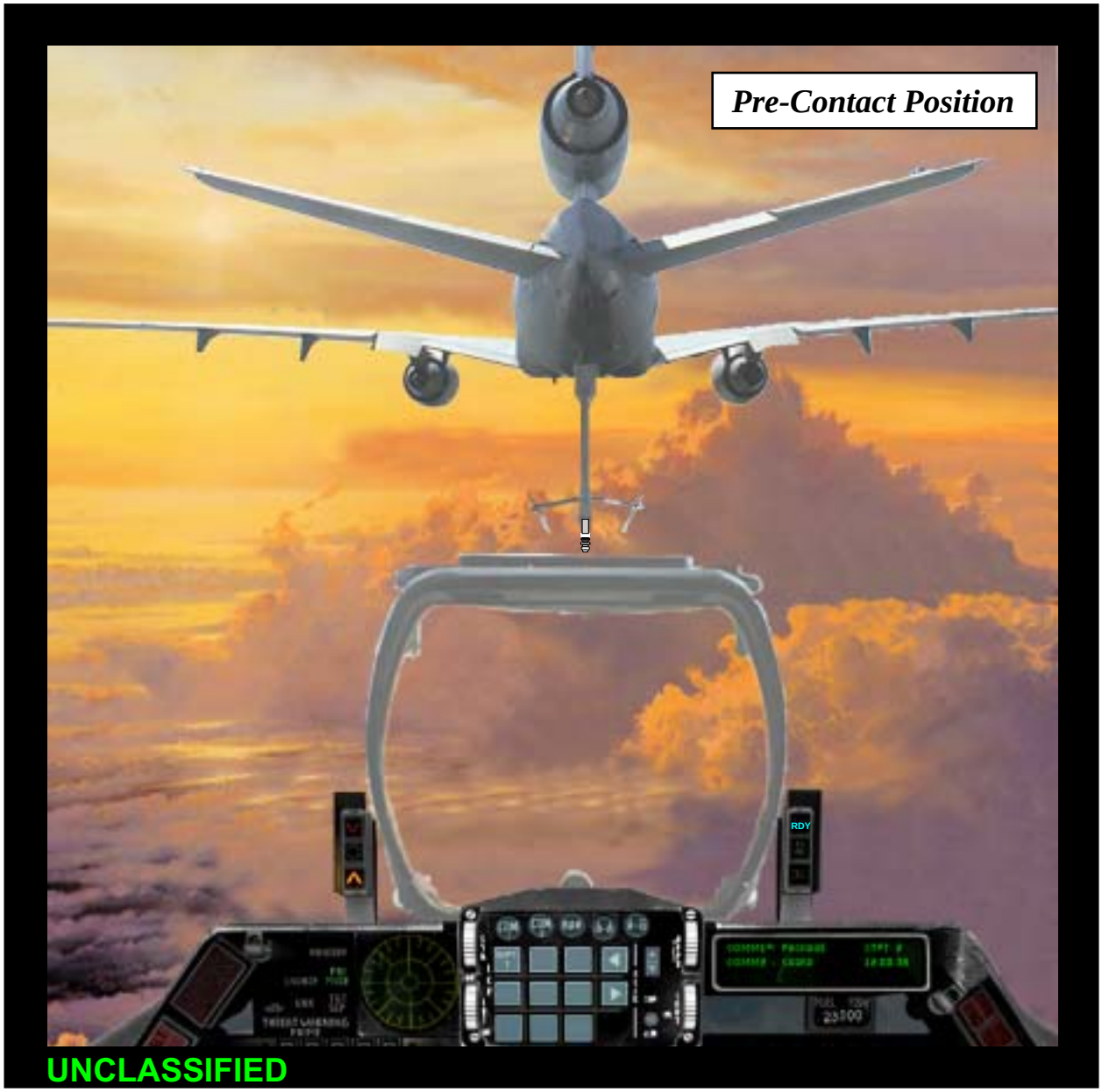
6.8 Observation Position. As the flight approaches the tanker, the lead should direct a channel change to “boom” frequency. After check in, the boom operator may initiate a radio check that must be acknowledged by all flight members. Wingmen move to the observation position when cleared by the lead. This position allows the aircraft in the refueling position freedom of movement to the contact position. Receivers in the observation position will maintain a position slightly behind the tanker wing and one F-16 wingspan clearance laterally, unless in-flight refueling (IFR) or night operations require less spacing. For a reference, align the tanker wingtip light with the fuselage window aft of the wing root. Stack vertically so the opposite wing and the outside engine root is visible above the tanker's fuselage. This should put the top of the tanker's tail on the horizon. (See **Figure 6.3**, Observation Positions.)

6.9 Prerefueling Checks. Follow procedures detailed in the checklist. Ensure all ordnance is safe and aircraft systems which emit electrical signals (TACAN, IFF, radar, radar altimeter [RALT], and ECM) are in standby. If carrying external tanks, the AR door should be opened 3 to 5 minutes prior to commencing refueling, so they can depressurize and be filled. Centerline tanks frequently may not completely fill, regardless of depressurization time. Flight control gains change, but only slight trim adjustments may be required. Check for a blue RDY light and await clearance to the pre-contact position. Listen to lead's radio calls and be prepared to copy them.

6.10 Pre-Contact Position. When the contact position is clear, and either the boom operator clears you or EMCON flow was briefed, reduce power slightly to move the aircraft back and down to the pre-contact position. Stabilize in a position approximately 50 feet behind and slightly (1 to 2 feet) below the boom. A common error is to slowly drift too far aft or be too low. Relax! Stabilize! Notify the boomer you are ready by calling “VIPER 2, STABILIZED and READY.” Stay in the pre-contact position until cleared by the boomer to move into contact. The boom operator will then clear you into the contact position on the radio, or by a steady “F” light (EMCON). Acknowledge and advance power slightly to ease forward. (See **Figure 6.4**, Pre-Contact Position.)

Figure 6.3 Observation Positions.

Figure 6.4 Pre-Contact Position.



6.11 Contact Position. Movement in the vicinity of the boom must be smooth and deliberate. From the pre-contact position, add only a small amount of power and wait for that power change to move you forward. As you move forward, bring the receiver director lights into your field of view (FOV). A steady light means a large correction is required and a blinking light means a small correction is required. As you slowly (1 to 2 knots) move forward, offset the boom slightly (2 to 3 feet) left or right, and maintain the slightly low position. As the boom approaches your canopy, it should pass 2 to 3 feet next to your head. As the boom passes out of your FOV, continue to move slowly forward and align the aircraft with the painted lateral reference line on the bottom of the tanker. Approaching the desired contact position, the boomer will call “STABILIZE” or the direc-

tor lights may extinguish or start blinking (EMCON). Since your rate of closure has been small, a very small reduction in power is all that is required.

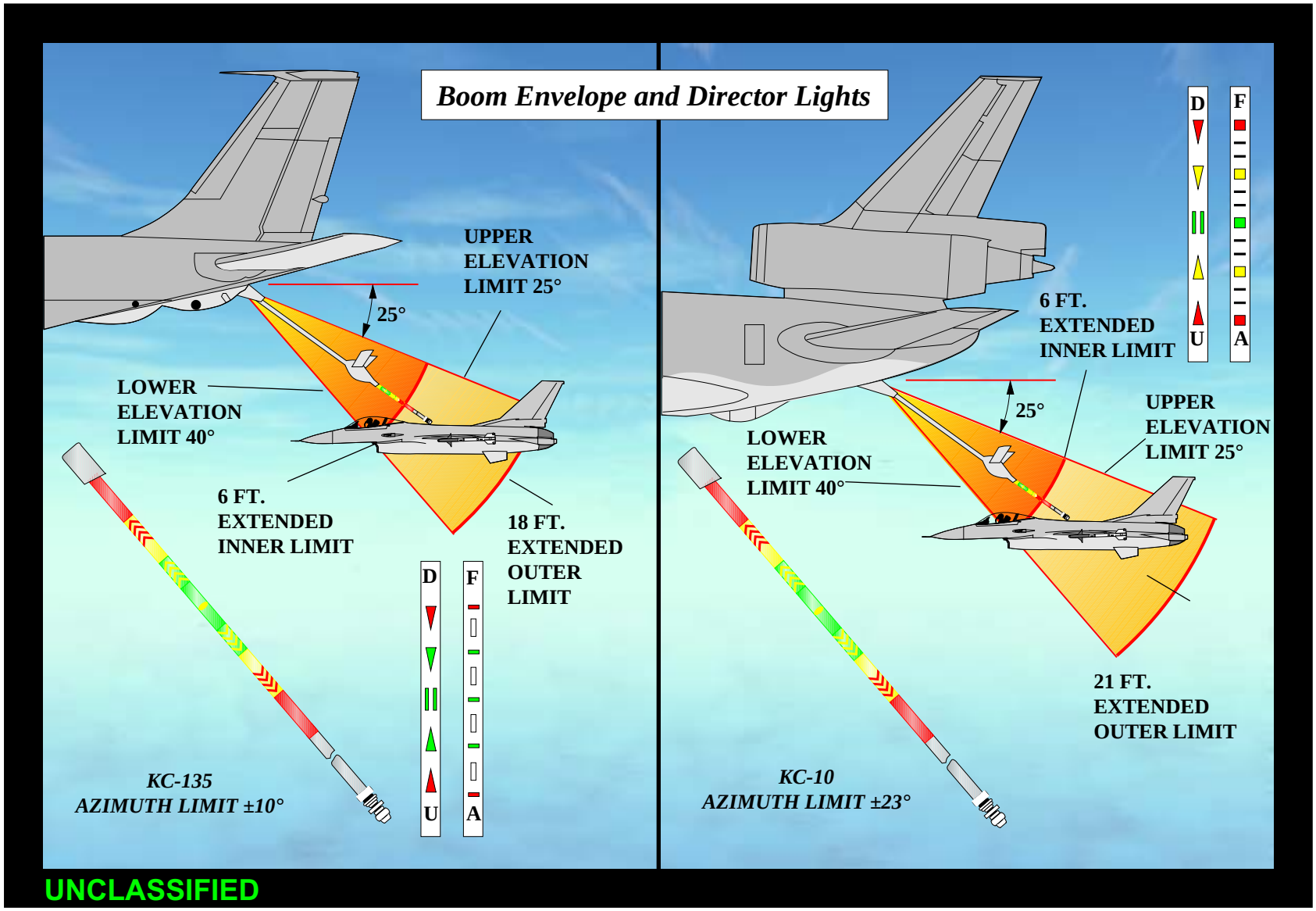
NOTE: Common errors include maintaining the tanker's same relative size after passing the boom (this causes the aircraft to drop low) and making large power corrections and/or moving too fast (this causes either "charging" the boom or falling out of the contact position). Once the boomer has plugged into you, the receiver director lights function, the blue RDY light on the indexer extinguishes, and the green AR/NWS light illuminates. Many tankers are configured for communication through the boom, so be in HOT MIC with the volume turned up. If, after contact, the director lights fail to illuminate, disconnect and return to the pre-contact position. If the tanker crew cannot fix the problem, you may still refuel but should ask the boomer for verbal corrections.

6.12 Maintaining Contact. After contact, continue to fly formation referencing the tanker director lights. It may be difficult to perceive small movements of your aircraft visually. The proper up-down and fore-aft position is indicated on the lights by the illumination of the center "captain's bars" on both columns of lights. If a light other than the "captain's bars" is illuminated on either column of lights, a correction is required. Mentally preface the D, F, U, and A lights with the word "GO," and accomplish the move directed (e.g., GO "D"own or GO "A"ft). To correct for position deviations, make small flight control and power changes. Do not delay these corrections, but make them smoothly and then wait to see the results of the correction—avoid over controlling. Maintain general position by visual reference to the tanker and refine position via the receiver director lights or the boomer verbally. In limited visibility, use the tanker as the attitude indicator while in the contact position. (See **Figure 6.5**, Boom Envelope and Director Lights.)

6.13 Position Indications. If you move out of position in only one direction, lights on both columns may change. For example, moving down increases the boom angle and a GO UP indication will display. In addition, you may get a GO FORWARD indication because the pure downward movement has extended the boom. Understand this relationship when making corrections (e.g., if you have both the GO UP and GO FORWARD lights, you may only have to move up a little to extinguish both of them). KC-135 and KC-10 differences follow:

- The KC-135 lights only indicate position. You may be moving rapidly aft but when passing through the ideal position, both captain's bars will light.
- The KC-10, on the other hand, incorporates position and trend. In the same example, moving rapidly aft will produce a GO FORWARD command even when in ideal position. Thus, the KC-10 lights may seem a little more sensitive.
- The positions of the KC-135 engines produce slight turbulence for an F-16 in an ideal contact position. This turbulence gets worse as the tanker increases its inboard engine power settings. So anticipate this turbulence, particularly at high altitude or with a tanker at high gross weight. This is not a problem with KC-10 tankers.

Figure 6.5 Boom Envelope and Director Lights.



6.14 Disconnect. Disconnect if a trend toward any limit develops. If an unintentional disconnect occurs, follow tanker directions. Return to the pre-contact position, stabilize, and await clearance back to the contact position. Do not hesitate to initiate a disconnect at any time, especially if you feel safety of flight requires such action. If the F-16 approaches the upper boom limit on a KC-135, the boom could strike the aircraft. So, the upper limit for F-16 operations is 25 degrees. If you get high, the boomer will disconnect you before you see a red GO-DOWN indication.

6.14.1 Automatic Disconnect. The boom will automatically disconnect when the tanks are full (based on sensed overpressure). Centerline tanks frequently do not fill completely before automatic disconnect. Expect a tendency to move forward immediately after disconnect due to the sudden absence of boom pressure. Anticipate the automatic disconnect by monitoring fuel quantity and compensate for that tendency. If you do not get a top-off, the boomer will advise you when you have the briefed off-load. At this time, initiate the disconnect. Most pilots will advise the boomer of disconnect by saying, “DISCONNECT NOW.” Remain in the contact position until the boom is clear. Both the receiver and the boom operator will acknowledge the disconnect.

6.14.2 Disconnect Indications. After disconnect, the green AR/NWS disconnect light is extinguished and the amber DISC light illuminates. The AR system will automatically recycle itself, and the blue RDY light will again illuminate in approximately 3 seconds. Slide back to the pre-contact position. If no additional hookups are required, close the AR door and proceed as briefed or return to the observation position. Check fuel quantity prior to departing the tanker.

6.15 Air Refueling Emergency Procedures.

6.15.1 Breakaway. The breakaway is an emergency maneuver designed to ensure a separation between the receiver on the boom and the tanker. The tanker or receiver will initiate the breakaway by calling “TANKER CALL SIGN, BREAKAWAY, BREAKAWAY, BREAKAWAY” and flash all the director lights. Expect the tanker to increase power and initiate a slight climb when clear of the receiver.

6.15.2 Contact Position. If in the contact position, depress the AR disconnect, ensure the boom is clear, and reduce power to drop back and down until the entire tanker is in sight. Use speed brakes if necessary. Stay with the tanker unless another emergency dictates.

6.15.3 Observation Position. If in the observation position, stay on the tanker's wing. If a “BREAKAWAY” is called prior to any receiver reaching the observation position, the entire flight will stay together and not proceed to the pre-contact or observation positions.

6.15.4 Receiver Door Will Not Close. If the door will not close, normal flight control gains and tank pressurization will be gained with the AR switch in the CLOSE position. The RDY-AR/NWS-DISC lights may not indicate normally, and the NWS light will not illuminate when NWS is engaged.

6.15.5 Systems Malfunction. If any system malfunctions, or conditions exist which could jeopardize safety, AR will not be accomplished except during actual fuel emergencies. Any time receiver fuel venting is noticed, the boomer or other flight members will inform you. The flight lead retains the decision to continue. A small amount of fuel spray from the nozzle/

receptacle during fuel transfer is normal. Either the tanker or pilot experiencing difficulties can terminate refueling if required.

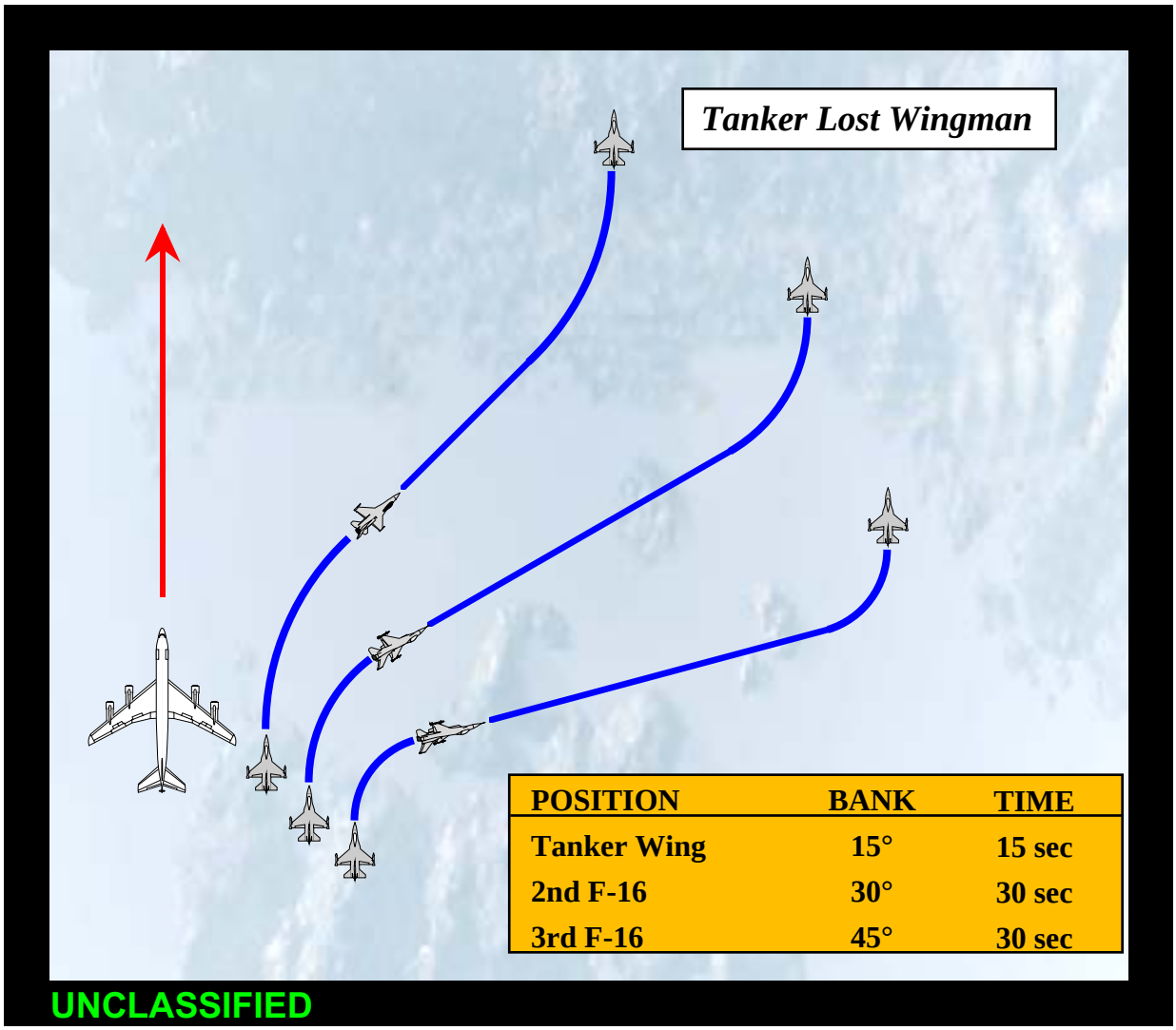
6.15.6 Manual Refueling. This mode of refueling will not be used in training, unless a fuel emergency exists. Manual refueling occurs when the tanker is unable to initiate a disconnect. The receiver must initiate all disconnects and remain particularly aware of the boom limits. Initiate a disconnect before arriving in position from which a safe disconnect cannot be accomplished.

6.15.7 Pressure Refueling. The tanker uses this emergency refueling procedure when all other means of fuel transfer has failed and a fuel emergency exists. The boomer will keep positive boom pressure on the receptacle so the fighter may require unusual stick inputs to maintain position. Because of the boom pressure, the disconnect is critical. The receiver and the boomer must coordinate it verbally.

6.15.8 Nonoperative Radio Refueling. Refer to the current AR TO for tanker and receiver visual signals during nonoperative radio (NORDO) refueling. NORDO refueling will only be used in an emergency situation.

6.15.9 Lost Wingman. Refer to **Figure 6.6**, Tanker Lost Wingman, for in-depth details.

Figure 6.6 Tanker Lost Wingman.



6.16 Post Refueling. Follow procedures detailed in the checklist. Do not change switches "heads down" when inside the pre-contact position. Verify the switch and door are closed before continuing with the mission. External fuel will not transfer with the AR switch in the OPEN position. Increased awareness of fuel distribution within the aircraft is imperative after AR. Fuel can fill external tanks before internal, and if not topped-off, may have to feed through the transfer system to be usable. External fuel will not transfer if the AR door switch is in the OPEN position.

6.17 After Landing. Perform a thorough postflight check to assure aircraft was not damaged during refueling. This must include a visual check of the upper aircraft surfaces while exiting the cockpit or while on the ladder. Enter the off-load data in the aircraft forms: Include tanker call sign, track designation, and fuel on-load.

CHAPTER 7

NIGHT OPERATIONS

7.1 Introduction. The information in this chapter will prepare pilots for safe and effective night flying.

7.2 Night Ground Operations. Special care should be taken during night ground operations. Allow extra time to complete the exterior preflight, since flashlight illumination is minimal. Ensure the canopy is clean. Check the exterior lights during preflight to ensure they are not missing or broken.

7.2.1 Operations Checks. The only lights available from battery power are the utility light and the cockpit spotlights (eyebrow lights). Remove the utility light from its retaining post prior to strap-in, as desired. Ensure you are able to monitor engine revolutions per minute (rpm) and fan turbine inlet temperature (FTIT) during start until the generator is on line and additional lighting is available; use your flashlight if necessary. After start and any other time the aircraft is stopped on the ground (maintenance quick check/arming/de-arming), the position lights should be bright and steady, and the anti-collision strobe should be set to OFF. This helps prevent possible ground crew disorientation and gives them better illumination with which to complete their operations. Check the operation of landing and taxi lights immediately after engine start.

7.2.2 Taxi. When ready to taxi, turn the strobe on, the position lights to flash, and the taxi light on. Because the nosewheel door blocks some illumination of the taxi light (NA for Block 40/50), visibility to the left of the nose is limited. The landing light may be used during left turns.

7.3 Night Takeoff. The night takeoff is essentially an instrument takeoff. Either the taxi light or landing light may be used. A recommended technique is to set the head-up display (HUD) de-clutter switch to attitude (ATT)/flight path marker (FPM) for night and/or instrument takeoffs; otherwise, you will lose the HUD pitch/attitude ladder when the gear is retracted. Use the HUD/attitude director indicator (ADI) in combination with available visual references (e.g., runway lights) to maintain runway alignment. Establish the climb attitude in the HUD and cross-check with primary control and performance instruments. Special consideration should be given to a potential visual illusion of increasing pitch attitude due to landing gear retraction caused by the position of the landing/taxi light.

7.4 Night Formation. Night formations are greatly dependent on environmental conditions. On clear nights with high-moon illumination, formations can be used which are very much like day formations. As conditions degrade, formations must be modified to accommodate reduced visibility and depth perception.

7.4.1 Night Weather Formation. Night weather formation flying requires modification to daytime weather procedures. Anticipate weather entry and accomplish either a rejoin or split up the formation while visual meteorological condition (VMC) exists. The preferred formation is non-standard radar trail with 1 to 2 NM between element mates. If join-up is desired, ensure all flight members turn their strobe light off upon weather entry to avoid possible spatial dis-

orientation. Use smooth corrections and avoid rapid or erratic control inputs. Lost wingman procedures should be used if you lose visual references in route or close formation or positional awareness in radar trail.

7.4.2 Route Formation. Flown in the same position as day formation. However, many visual cues may be absent or more difficult to observe. (See **Figure 7.1**, Route.)

Figure 7.1 Route.

7.4.2.1 Day/Night Similarities. The night position is the same as the daylight route formation position.

7.4.3 Trail Formations. Trail formations form the fundamental basis for in-flight deconfliction as well as provide for mutual support. Additionally, deconfliction is optimized with altitude separation between flight members. The primary reference for station keeping (spacing and position) is the radar, backed up by the air-to-air (A/A) tactical air navigation (TACAN). For admin/en route trail, normal spacing is 2 to 5 NM between trailing flight members. For ingress and egress trail, spacing will normally be a function of the A/A game plan and/or target area deconfliction considerations (reference AEM for detailed tactical trail considerations). A technique for monitoring position is to continue normal radar search while maintaining awareness of lead's position near the bottom of the scope. A ROT is to position the radar hit of the preceding aircraft on the top of the 10-/20-/30-degree azimuth tick on a 40-NM scope. In all cases, lead should thoroughly brief desired range and aspect for the wingman's position to ensure formation integrity. The disadvantages of trail formation are the same as day: a loss of visual lookout and visual mutual support.

7.4.4 Lead Considerations.

7.4.4.1 Lighting. As lead, configure exterior lights according to the wingman's desires as much as possible. The anti-collision strobe should be flashing until the wingman has completed the rejoin and then placed in the OFF position. Initially, try a setting of dim/steady for the fuselage and position lights and mid-range for the formation lights. In dim/steady/strobe off, all exterior light toggle switches will be aft/inboard (non-NVIS- modified cockpit).

7.4.4.2 Maneuvering. Make all maneuvers smooth and coordinated to minimize the possibility of inducing spatial disorientation. Make frequent cross-checks of the wingman's position. If formation break-up is required, do so in straight and level, unaccelerated flight and only after determining that the wingman has operational navigational equipment and understands his/her position, heading, altitude, airspeed, and clearance. Monitor the wingman closely as the separation proceeds.

7.4.5 Wingman Considerations.

7.4.5.1 Formation Flying. Flying the wing position at night presents some of the same difficulties as flying formation in the weather. As such, spatial disorientation will be of special interest. To the greatest extent possible, keep abreast of the situation and plan ahead to predict maneuvers. Whenever possible, cross-check the HUD and control/performance instruments to verify attitude.

7.4.5.2 Night Formation Specifics. The lack of visual cues, coupled with the lack of depth perception, contribute to night formation problems. In close formation, use the alignment of the formation lights to maintain fore, aft, and vertical position and learn to gauge separation from the size and spacing of these lights. Stay alert for any clearances transmitted or any other indications of imminent changes in flight position, heading, altitude, and airspeed. Be prepared to accept the lead of the flight at any time if required by an emergency or other flight break-up situation. Know the planned instrument recovery and minimums before takeoff. If operations inside the cockpit are required (e.g., radio frequency changes), make slow, deliberate changes and glance inside the cockpit briefly to check the results. Do not take your eyes off the lead aircraft for any extended period of time.

7.5 Night/Weather Intercepts. Night or weather intercepts present a unique challenge since, in addition to flying good instruments, you must include the radar in your instrument cross-check. Primary consideration must be given to maintaining aircraft control by instruments, and very little time (if any) should be devoted to outside visual references or attempting to get a tally. This is contrary to what was taught during day VMC intercept missions. Attempting to attack another aircraft at night or in the weather is demanding and can be spatially disorienting, especially in the F-16.

7.5.1 Cockpit Setup and the Bubble Canopy. It is important to have the cockpit and switches set up as early as possible. This helps you stay ahead of the aircraft. Set up cockpit lighting as low as comfortable. Use caution to ensure you do not lower MFD contrast too low and cut off target histories. The pilot must compensate for the vertigo-inducing effects of canopy reflections with a good composite instrument cross-check. A good technique is to use the symbology, brightness, and contrast (SBC) night reset option on the multifunction display (MFD) for default night settings, then adjust as desired for comfort.

7.5.2 Ground-Controlled Intercept. At night or in weather, ground-controlled intercept (GCI) control can be of great value; be aware of controller and radar limitations. Pay attention to the controller's instructions. Remember, radar situation awareness (SA) provides an accurate way to update information.

7.5.3 Altitude. Altitude separation from the target should be reduced during night/instrument meteorological conditions (IMC) to avoid large pitch changes at the merge. Usually 2,000 to 4,000 feet above or below the target is sufficient. Continually monitor your altitude during all phases of the intercept. This helps to avoid deviations which could violate the target's altitude block or cause impact with the ground.

7.5.4 Autopilot. This may be used, but constantly monitor its performance. Remember, it will not maintain altitude at high angle of attack (AOA)/slow airspeed. No warning occurs in the Block 30 if the autopilot is unable to hold altitude. Block 40/50 have an autopilot caution light that illuminates if set altitude cannot be maintained.

7.5.5 Turns. In night/weather conditions, make all turns at the lowest G that is appropriate. When making turns, concentrate on aircraft control and do not allow yourself to be distracted with radar, GCI, or other inputs. One technique is never use more than 60 degrees of bank without full attention on instrument flying. At night, increase lateral displacement so that the conversion turn requires less G. Throughout the intercept, keep the aircraft stabilized as much as possible in altitude, airspeed, and bank angle so that you do not become preoccupied with large corrections back to the desired parameters. This will allow you more time to analyze the radar and basic intercept geometry.

7.5.6 Instrument Cross-Check. It is tempting to rely on occasional outside visual references and other unreliable sensory cues rather than on instruments to maintain aircraft attitude. It is critical to develop a composite cross-check to maintain situational/spatial awareness. Large and often insidious changes in aircraft attitude, altitude, and airspeed can go undetected, unless there is frequent reference to instruments.

7.5.7 Seating Height. Consider a lower sitting position at night. A high sitting position requires you to look well down into the cockpit to check instruments. The head movements made between HUD references and cockpit instruments can contribute to spatial disorientation. The primary means to fly night/IMC intercept must be via instruments.

7.5.8 Head-Up Display. Since some basic attitude information and almost all weapons information is displayed on the HUD, it may be tempting to allow too much time to the HUD cross-check at the expense of a basic instrument scan. This, in turn, may tempt you into noticing/searching for outside visual cues. While use of the HUD may be helpful, do not let it become distracting.

7.5.9 Afterburner. If selected, the rapid acceleration can cause a climbing illusion. Selection of the afterburner in weather will sometimes cause a startling bright flash. The use of afterburner at night will also highlight your position.

7.5.10 Lost Contact. A lost contact during the intercept should not be a cause for hasty or improper action. The first priority (as always) is to maintain aircraft control and ensure proper altitude separation. Do not be reluctant to skip it, knock it off, or blow through if SA or other circumstances dictate. If you elect to continue the intercept, reestablish GCI control by calling

for “BOGEY DOPE” and request close control, until contact is regained. If outside Minimum Abort Range (MAR) with no contact, consider aborting. Inside MAR, use slewable air combat maneuvering (ACM) or 10 NM radar scope and bracket the target's last known altitude. If in the conversion turn when contact is lost, ease off the turn (or roll out momentarily) to ensure you will end up behind the target and remain in your block. Then turn to the last known target heading and begin searching for the target with the radar (if you can confirm the target is not maneuvering).

WARNING: DO NOT drive (for long) on any heading other than the target's and DO NOT use visual references in an attempt to save the intercept. This invariably results in large altitude/attitude deviations, seldom saves the intercept, and often leads to spatial disorientation.

7.5.11 Visual Reference Considerations. The tendency to use the HUD as you would in a visual attack can be unsafe during night or IMC. Some reasons for this are as follows:

- You do not know if you are looking at the real target or just some “other” light.
- You cannot judge range and closure rate.
- You may be visually maneuvering your aircraft into an unusual attitude. Furthermore, a real target will probably not have his beacon on at night. You must perform frequent instrument cross-checks during night/IMC intercepts. The emphasis should be on instruments until approaching weapons launch range.

7.6 Night Surface Attack. Preparation for flying night missions, especially night surface attack, demands thorough and accurate planning. All of the normal items required for daytime operations need to be accomplished and double-checked for accuracy. Errors which you might easily catch in flight during the day can mislead you at night and go undetected for too long. Be sure the inertial navigation system (INS) and weapons data are good. In addition to the usual items, review the following subjects:

- Aircraft interior lighting.
- Aircraft exterior lighting.
- Emergency lighting (generator failure).
- Night visual signals (radio out).
- Alternate airfield night lighting.

7.6.1 En Route Procedures. Route of flight and en route procedures will vary IAW local procedures. Your route to the range may include a night air refueling, a night low-level, or simply be a medium-altitude direct route. Procedures at night are similar to daytime with the following exceptions:

- Visual ordnance checks are not made at night.
- Formation position changes are directed over the radio.
- Low-level routes are flown at higher minimum altitudes.

7.6.2 Range Layouts. The specific layout of night ranges vary with each local range. Three of the more common layouts are shown in **Figure 7.2**, Typical Night Ground Illumination—1; **Figure 7.3**, Typical Night Ground Illumination—2; and **Figure 7.4**, Typical Night Ground

Illumination—3. The individual marking devices could be either flare pots, lanterns, or electric lights. Most ranges use flare pots on the “bull” since it is likely to take numerous hits.

7.6.2.1 Target Illumination. No matter which type of ground illumination is used, the intensity of the markers is normally quite dim. In addition, some of the lights may be out for various reasons. These factors can combine to make it difficult to distinguish the target from other lights in the area. Each range has its own peculiar set of false lights and illusions. Positive identification of the target is absolutely essential, so be sure you know exactly what to look for.

7.6.2.2 Lightning Compensation. On a real “dark night” you may have to maintain your position by reference to target area lighting only. Realize that the array of lights around the target will have a different appearance, depending on the angle at which you view them. Other lights that may help maintain orientation are the obstruction lights on the main and flank towers. These lights should be distinguishable by their different color (red).

7.6.2.3 Flares. If flare support is available from another aircraft, your job of seeing the range/target area can be vastly simplified. However, you may have to find the range on your own prior to the flareship dropping any flares.

7.6.3 Range Entry Considerations. Getting clearance on the range is similar to daytime operations, with certain additional requirements.

7.6.3.1 Range Control Officer (RCO) Operations. Clearance must be received from the RCO who must ensure deconfliction between the fighters and any flare support aircraft. This is normally done by altitude separation. Target identification is often difficult and the RCO may be needed to help direct the flight to the range.

7.6.3.2 Pattern Limits. A maximum of three (four if FLIR or NVG-equipped) aircraft will be allowed in the pattern (one may be a flareship).

7.6.3.3 Radar Entry and Events. It is common to enter the night range pattern from a non-conventional delivery pass. Night non-conventional procedures are similar to day with the following exceptions and special considerations.

Figure 7.2 Typical Night Ground Illumination—1.

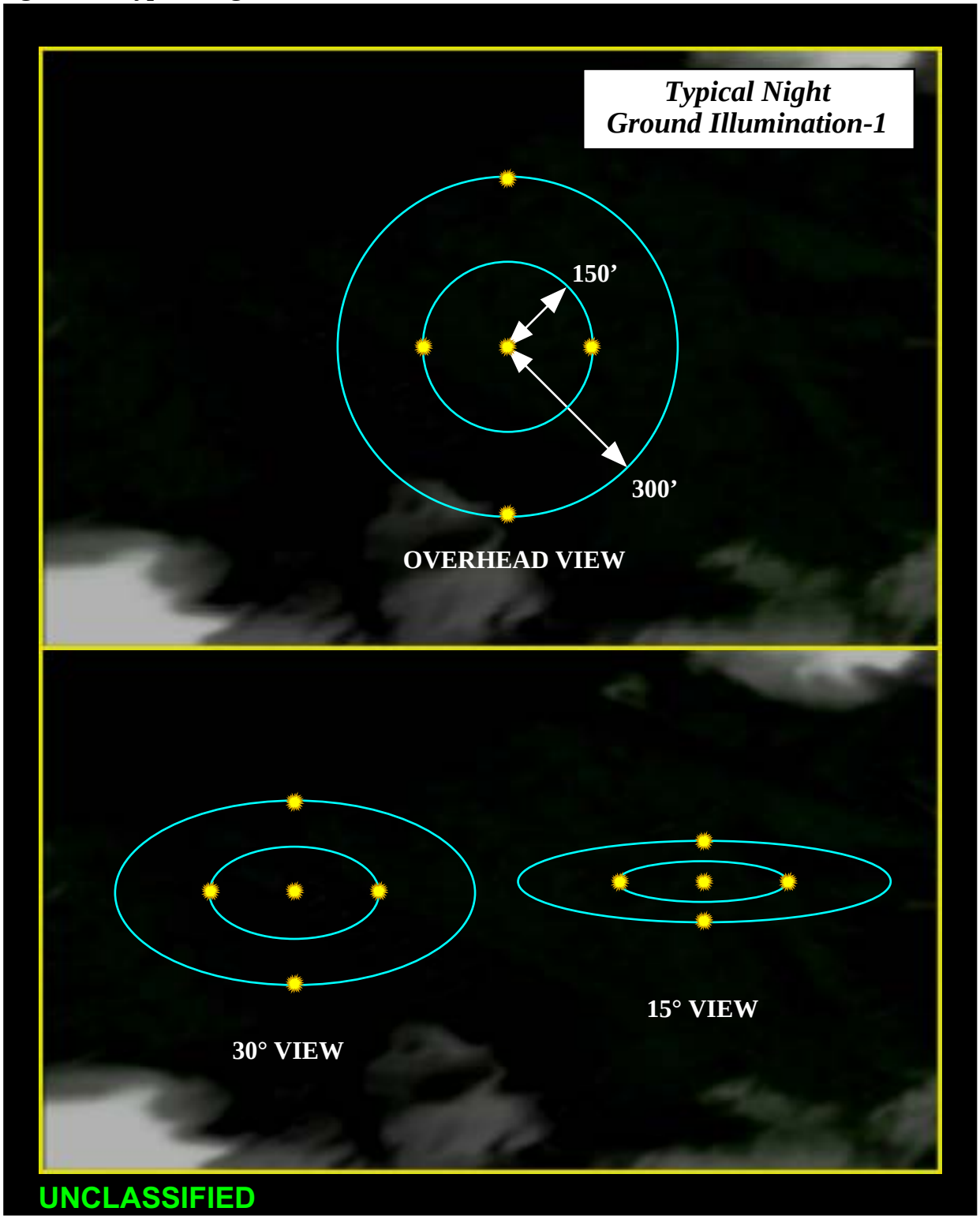


Figure 7.3 Typical Night Ground Illumination—2.

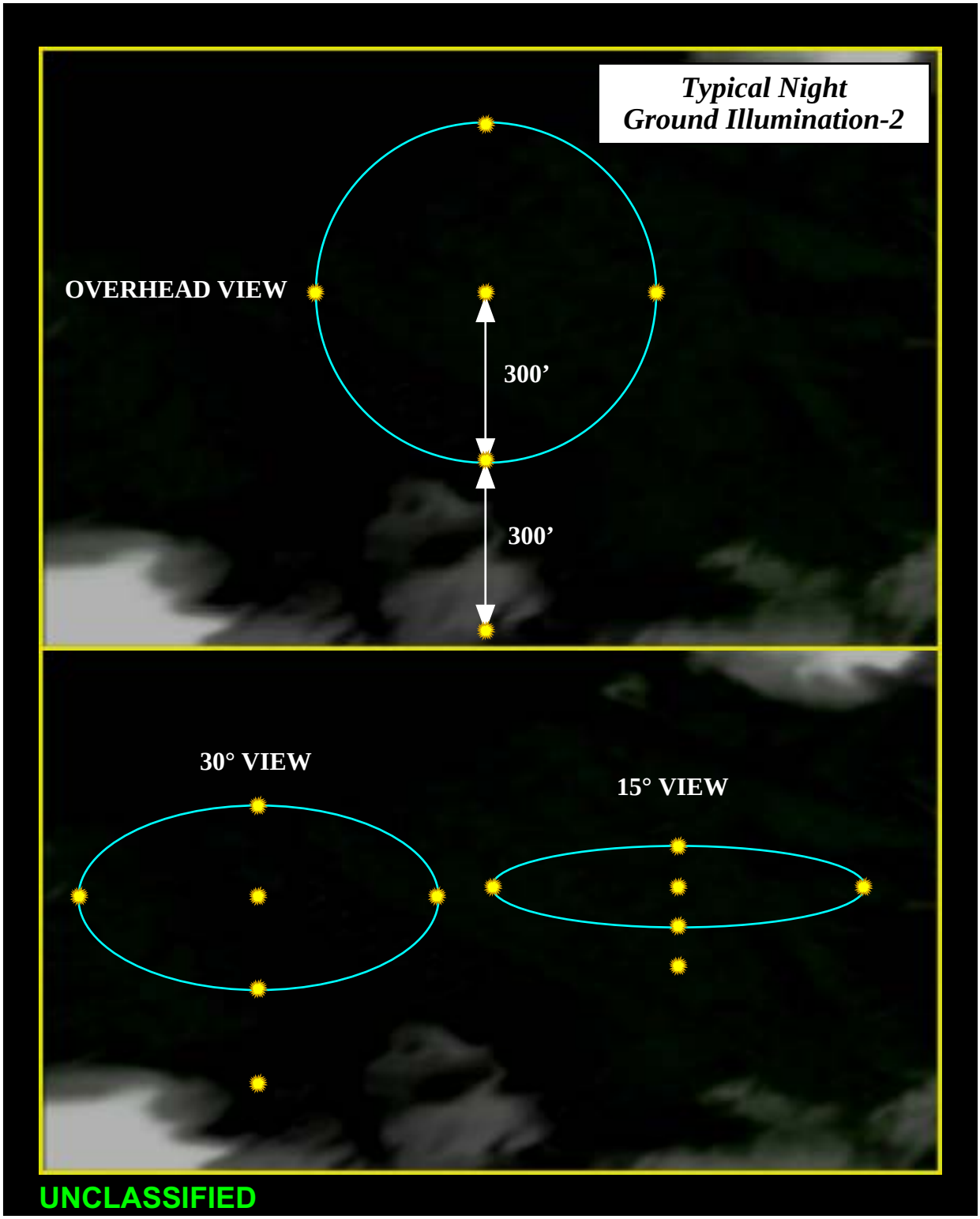
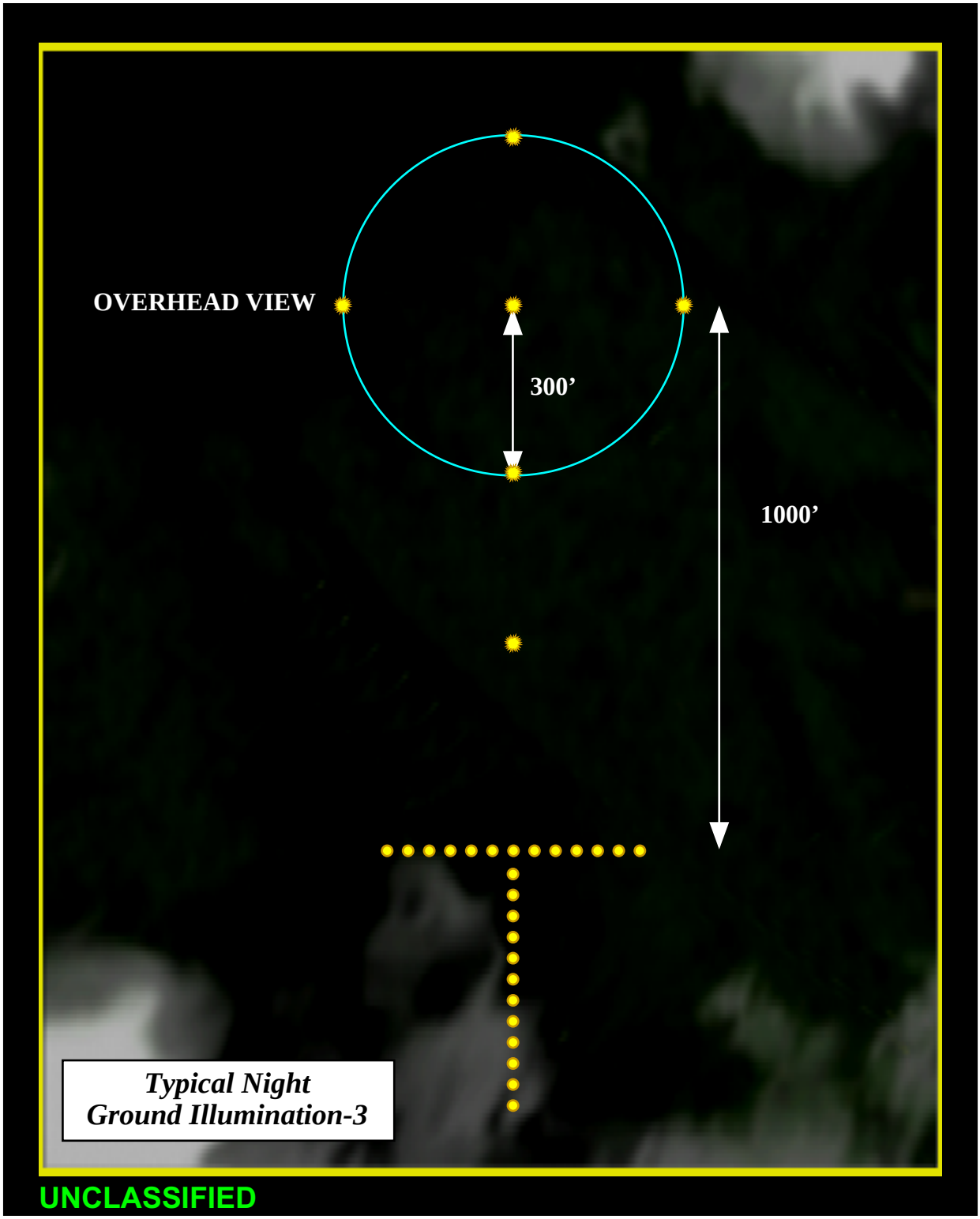


Figure 7.4 Typical Night Ground Illumination—3.



7.6.3.3.1 Altitudes. Minimum run-in altitude should be the same as night low-level navigation. Minimum downwind altitude is 1,500 feet AGL.

7.6.3.3.2 Communications. Call “FINAL, (EVENT), (ALTITUDE)” at the initial point (IP).

7.6.3.3.3 Event Illumination. Non-conventional targets do not have to be illuminated at night.

7.6.3.4 Flight Discipline. Strict discipline with respect to maintaining proper altitude, heading, and airspeed is critical. There are many tasks to be performed in the cockpit in order to make a radar delivery, but the most vital ones are maintaining aircraft control and not hitting the ground. You simply cannot afford to spend any extended period of time doing things like reading a map/checklist, or adjusting the radar gains, without cross-checking your instruments. Good preflight planning, to include the pacing of your tasks, will go a long way toward minimizing mis-prioritization.

7.6.3.5 Autopilot Use. Just as in daytime, the autopilot can be useful in maintaining altitude while doing other tasks. However, THE AUTOPILOT MUST BE MONITORED. Always check its function after you turn it on and ensure that you are in the altitude hold function of the autopilot. There are several autopilot failure modes that do not give the pilot warning.

7.6.4 Foul Avoidance. The RCO's judgment of foul parameters is impaired by darkness. The RCO may foul you prematurely, or even worse, fail to foul you when you really deserve one. Fly your aircraft like a professional and neither one will happen. ***NOTE:*** Night controlled range minimum recovery altitudes are shown in **Table 7.1**, Minimum Recovery Altitude (Night Controlled Range).

Table 7.1 Minimum Recovery Altitude (Night Controlled Range).

Event	Minimum Recovery Altitude
Greater than 35 degrees	4,500 feet AGL
35 to 20 degrees	2,000 feet AGL
Less than 20 degrees	1,000 feet AGL
NOTES: 1. Planned deliveries exceeding a 45-degree dive angle will not be flown. 2. Regulations or pilot TFR minimums, whichever is higher.	
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7.6.5 Night Box Pattern. Essentially, the night attack patterns on a controlled range are the same as those flown in the daytime. Because of visibility restrictions, a slightly larger pattern is recommended.

7.6.5.1 Spacer Pass. The spacer pass may be flown from a standard formation pass over the target, or it might be from a simple pitch up to downwind from a non-conventional pass. No matter how you split up, it is critical that you take the pre-briefed spacing and

pitch up in a manner that does not immediately induce vertigo. Use about 45 to 60 degrees of bank and 2 to 3 Gs in the break. Have the horizontal situation indicator (HSI) set up with a reference on the run-in heading so that you can quickly assess your heading with respect to the pattern headings. The night pattern should be flown much more "mechanically" than in the day.

7.6.5.2 Crosswind. When turning crosswind any time in the night attack pattern, there is a stronger chance you will turn inside of the preceding aircraft. Rolling out wings-level momentarily (3 to 5 seconds), and looking outside as well as inside your turn, will help to avoid passing or colliding with other flight members. In addition, this momentary roll out will aid in keeping the pattern from becoming uncomfortably tight.

7.6.5.3 Downwind. Daytime considerations apply. Avoid the "moth effect" tendency to allow the pattern to gradually become tighter and tighter around the small, well-lit target area. All switch changes will be accomplished wings-level on downwind. Turn position lights to bright-flash, strobe light on, and formation lights full bright unless NVG-equipped (NVG-equipped aircraft will use NVG compatible lighting according to local guidance).

7.6.5.4 Base. Determine the required base leg distance from the target for the particular event being flown. Exact base leg position is harder to fly at night since you do not have the normal daytime ground references. Here are some commonly used techniques:

7.6.5.4.1 Time your downwind leg from a point abeam the target. Time approximately 6 to 8 seconds from the point abeam the target. Start a 2 to 3 G turn to base at the end of this time.

7.6.5.4.2 Use the same angular relationship of the target position over the canopy rail as you do in the daytime. ***CAUTION:*** Be sure you are wings-level. A shallow bank into the target will cause you to angle-in.

7.6.5.4.3 Reference to the length of the lighted "T," or other run-in markers, (if available) will help get your base correct.

7.6.5.5 Roll In. Night roll in is similar to daytime, except that you need to cross-check attitude instruments to avoid getting disoriented. There is a tendency to undershoot final on the first few patterns. Reference the lighting on other objects, such as the range/flank tower, to give the idea of when to begin the roll in. All night patterns will be basic versus tactical deliveries.

7.6.5.6 Final. At night, place additional emphasis on the parameters of each pass (dive angle, altitude, and airspeed).

7.6.5.7 Recovery. Recover so as not to descend below minimum recovery altitudes, regardless of whether ordnance is released or not. Strict attention to cockpit instruments is of paramount importance. Initiate recovery using a wings-level 5-G pull up and do not initiate turns until the aircraft nose is definitely above the horizon. DO NOT attempt to observe your own bomb impact at night. The lack of visual attitude recognition can lead to spatial disorientation.

7.6.6 Night Range Radio Procedures. The need for strict radio discipline increases dramatically in the night range pattern. The following radio calls are tied to the pattern locations:

- When directly abeam the bomb circle, transmit: “VIPER 2, DOWNWIND.”
- Starting the turn onto base, transmit: “VIPER 2, BASE.”
- As you start the turn onto final, transmit: “VIPER 2, IN” (add “FLARE SHIP IN SIGHT,” if required).

•During recovery, transmit: “VIPER 2, OFF WET” OR “VIPER 2, OFF DRY.”

7.6.6.1 Crucial Radio Calls. The additional radio calls in the night pattern increase the chances of blocking out the two most important calls which are the call “IN” by the aircraft turning final and the clearance call by the RCO. If necessary, delay other calls when you sense these two calls are about to take place.

7.6.6.2 Hung Bomb Call. A “NO SPOT” from the RCO should be interpreted as a hung bomb at night. Continue range operations (if range restrictions allow) and recover using hung bomb procedures IAW local directives.

7.6.7 Night Range Departure Procedures. With a few minor exceptions, the night range departure is similar to the day procedure. Battle damage checks are not required at night (but are authorized for NVG-equipped pilots). If you recover as a formation the following guidelines apply:

- Wingmen will acknowledge the number of aircraft in sight.
- Avoid dropping low during the rejoin.
- Expect lead to roll out.
- Lead will transmit exact heading and altitude.
- Wingmen will join in order.

7.6.8 Night Computed Bombing. Computer-assisted bombing in the F-16 makes it possible to deliver ordnance accurately. Attention to parameters is important in order to avoid fouls and get actual bomb release near the desired altitude.

7.6.8.1 Cockpit Lightning. Because of the large reflective canopy of the F-16, nearly all of the bright spots inside the cockpit will reflect inside. These can distract your attention and make it hard to distinguish dimly lit ground targets. Keep your console and instrument panel lights at the minimum that will still allow you to read them. If NVG-equipped refer to **Chapter 8**, “Night Systems: Night Vision Goggles and LANTIRN,” for cockpit lighting guidelines.

7.6.8.2 HUD Brightness. Find an optimum HUD brightness level that suits the prevailing atmospheric condition and your individual vision. An overly bright HUD may not seem like a problem until you experiment and reduce the brilliance at which time the target may become much easier to see.

7.6.8.3 Radar Display Intensity. Set-up the radar and MFD using all three controls: intensity, contrast, and symbology. Since the radar display is not used in visual bombing you may want to simply turn the intensity down until it is nearly black while you work the range. The best radar display picture can be obtained by turning down the “contrast” first, then adjusting the other two controls.

7.6.8.4 Built-In Resets. The MFD SBC reset function makes initial night setup easy and only minor adjustments will be necessary for A/A operation. However, if ground map (GM) is selected, the MFD intensity will be well above a usable level and gain/brightness/ contrast should be readjusted. Attempt this initial adjustment prior to takeoff if possible using the shades of gray displayed during the radar built-in test (BIT) check.

7.6.8.5 Delivery Modes. The preferred mode for night visual surface attack is continuously computed impact point (CCIP). The dive toss (DTOS) mode can also be used, but it is better suited to long range, high-altitude deliveries. CCIP offers the inherent advantage that the bomb fall line (BFL) always points down perpendicular to the horizon. Although you can still get the "leans" trying to steer out the pass, as long as the pipper is at the bottom of the HUD, pulling G will move the nose up. Thus, the CCIP symbology acts like an attitude indicator and aids in maintaining orientation. Continuously computed release point (CCRP) is the preferred delivery mode for targets that cannot be visually identified at night. The decision to accomplish level or loft deliveries should be based on desired delivery altitude, weapons effect, and target area considerations.

7.6.8.6 Aim-off/BFL Use. When you roll out on final you will have to rely solely on the HUD cues to establish an aim-off point and pipper placement. If you are accustomed to using a visual aim-off point on the ground, it will probably not be visible at night. Thus, you will need to roll out with the target about one-half to two-thirds of the way down the BFL. There is a strong tendency to pull the CCIP pipper up to the target and release high. While this technique is safe, it is not necessarily desirable because it causes larger miss distances. A controlled pass with release occurring at or near the preplanned release altitude is best. Do not over compensate for this tendency and press below planned release altitude. Above all, any time you feel uncomfortable, or you lose awareness of exactly where you are, abort the pass. DO NOT PRESS.

7.6.9 Flare Procedures. Although the F-16 is not certified for carriage of MK 24 flares, you may have a chance to drop using flares released by other aircraft. Flares are used for night close air support (CAS) and other missions where complete illumination of the target is required. Flare illumination makes it possible to fly by visual reference to the ground for attitude control, but a continual instrument cross-check is necessary, especially during recovery, changing armament switches, or when vertigo is suspected.

7.6.9.1 Flare Considerations. The LUU-2 flare will burn for 5 minutes and produce illumination rated at 2.0 million candlepower. A normal value for flare coverage is a circle with a 1 NM diameter. The flare descends 500 to 600 feet per minute. Directly beneath each burning flare, there is an area of subdued light caused by design characteristics. When two flares are dropped, the light overlaps and brightens the area of reduced intensity directly underneath each flare. Flares normally burn out at approximately 2,500 to 3,000 feet below ignition altitude. Attack conditions become marginal after the burning flare drops below 500 feet AGL due to the area of subdued light directly beneath the burning flare.

7.6.9.2 Environment. Sky and atmospheric conditions have a serious effect on the quality of flare illumination.

7.6.9.2.1 Weather. Low ragged overcast, fog, haze, or drizzle will cause flare light to be diffused and less effective. The probability of spatial disorientation is increased.

Highly diffused light generally means no visible horizon and few orienting ground references; the total “world” is centered around the flare which creates a 3-dimensional sphere of light. This is referred to as the “milk bowl effect.” Difficulty may be encountered in determining the aircraft's attitude and the vertical might appear to be in the direction of the flares. Use of flight instruments cannot be overemphasized.

7.6.9.2.2 Overcast. Flares burning under a medium or low overcast with good visibility will produce added light due to reflection. However, reflection can also produce deceiving perception problems. From a tactical standpoint, an aircraft is easily silhouetted against an overcast sky and readily discernible by enemy gunners.

7.6.9.2.3 Clear Skies. Clear weather, with moonlight and some ground illumination, provides excellent conditions for flare lighting, and attacks can be executed with minimum reference to flight instruments.

7.6.9.3 Flare Deconfliction. Flares can cause pilot disorientation and flight profiles must compensate for flare positioning and flight path deconfliction.

7.6.9.3.1 Flare Horizon. There is an apparent haze layer at the altitude of the burning flare. In a dive, as the aircraft approaches the flare's altitude, visibility becomes restricted; target and ground acquisition become more difficult. This problem can be reduced by releasing above or below, not level with, the burning flare.

7.6.9.3.2 Flare Illusion. Flying below the altitude of burning flares is unwise but at times cannot be avoided. Extreme caution should be used, as the flare may appear to be at a reasonably high altitude when actually it is on, or close to, the ground.

7.6.9.3.3 Flare Positioning. The pilot must avoid any flares that drift into the approach path. Flares, as obstacles, usually generate a restriction to attack direction. Avoid the 6 o'clock low area to the flare ship. The pilot dispensing flares will offset accordingly for range wind and crosswind.

7.6.9.3.4 Flare Prediction. There will be approximately a 20- to 30-second delay from the radio call “FLARES AWAY” until you actually see the flares. Approximately 15 seconds are required for flares to reach maximum intensity after ignition. Observing night minimum recovery altitudes should keep you safely above spent flares. However, on some occasions, these empty flare chutes, referred to as “ghosts,” will ride thermals. They will be near or even above burnout altitude and downwind of the burnout point. Avoidance of these nearly invisible hazards is important during ordnance delivery and recovery. Also unseen, more dangerous, but less prevalent, are unignited flares suspended in their chutes. This type of dud (occurring at a rate of 12 to 15 percent) is always found below the ignited flares since it descends faster than an ignited flare. Avoid a dud flare by counting the lit flares and remaining above the altitude of the ignited flares dropped on the same pass.

7.6.9.3.5 Flare Monitoring. The RCO, upon hearing the flare pilot state the number of flares released, will have the primary responsibility for calling out dud flares. The RCO should also notify the flight of any flares burning on the ground. Flight members will assist in calling out the locations of hazardous flares. When the position of the lighted flares in the group indicates that the dud flare is in the proximity of the final approach,

the pass will be aborted. Any time the RCO considers flares to be a hazard to safe flight operations will cease.

7.7 Night Landing. Night landings are normally made from a precision approach. The approach should be flown the same as in the daytime. However, at night and in weather, the landing light may cause a distraction if it reflects off of the clouds. In this case, the landing light may be turned off until on short final. The landing light provides adequate reference for a normal landing. HUD intensity may have to be adjusted to adequately view symbology while still affording a clear view of the runway environment. Follow local guidance for landing out of instrument approaches and avoid the tendency to visually "duck under" the desired glide path. Visual references can be deceiving at night.

7.8 Night Refueling. Night refueling procedures are basically the same as day procedures, but standard night flying considerations apply. At night, you must be smooth to avoid inducing spatial disorientation. Perform the rendezvous like an IMC intercept, relying on GCI and your radar to complete the rendezvous. In the observation position, the forward nacelle light on the tanker may be distracting. Request the tanker to dim this light or fly a formation position that blocks the light with the tanker's wingtip. If any other light bothers you, ask the tanker to turn it off or down. As a courtesy, avoid making such requests when another flight member is on the boom. Pre-contact, contact, and post-contact procedures remain unchanged. Be prepared to transition to instrument flight if visual contact with the tanker is lost (lost wingman).

7.9 Night Emergencies. Emergencies at night are typically compounded at night due to the lack of visual references and reliance on the aircraft attitude and position instruments. Emergencies which affect aircraft lighting also have a dramatic effect on the pilot's ability to monitor aircraft performance and reference in-flight publications (checklist, pilot aid, and approach plates). Always fly with a flashlight at night and ensure the batteries are operational prior to flight. In addition, an extra chemstick or other illumination device is also recommended for night flight. Emergencies that affect aircraft lighting (i.e., multiple generator failure) and game plans for handling these types of emergencies should be thoroughly briefed prior to night flight. Airfield lighting and instrument approaches at the divert bases should also be briefed.

7.10 In-Flight Distress Signals—Night Visual. The following in-flight distress signals (night visual) will be used only when the radio is inoperative and will be acknowledged by a steady light. (See **Table 7.2**, In-Flight Distress Signals.)

Table 7.2 In-Flight Distress Signals.

Distress Signal	Explanation
Aircraft Emergency (Must Land As Soon As Possible)	Signal escort aircraft by repeated intermittent flashes with a flashlight, then assume the wing position-this signal indicates a aircraft approach speed of 130 knots. If a higher approach speed is desired, the pilot must pause after the basic signal and then blink the flashlight at the top of the canopy-once for each 10-knot increase desired. The escort pilot will lead to the nearest suitable field, declare an emergency with the controlling agency, then fly a straight-in approach with the distressed aircraft on the wing. The distressed aircraft lands and the escort executes a go-around. On a straight-in approach, the escort aircraft pilot turns the position lights to BRIGHT/STEADY to alert the wingman to prepare to lower landing gear. The corresponding signal of execution will be for the escort aircraft pilot to return position lights to DIM/STEADY. If the aircraft is only equipped with a STEADY-BRIGHT light position, it will blink the lights for the alerting signal and for the execution signal.
Attention	Attention should be attracted by whatever means of illumination are available (e.g., flashlight and position lights on-off).
Change Lead	Pilot of the distressed aircraft holds the flashlight parallel with the canopy rail and sends a steady light while making a straight line from rear toward the front of the canopy.
Complete Electrical Failure (No Assist Aircraft Available)	Procedures are the same as day visual signals
Descent To Lowest Practical Altitude	The pilot makes a rapid vertical movement with a flashlight
Radio Inoperative	Make a large circular motion with a flashlight.
Radio Inoperative (No Assist Aircraft Available)	Follow day radio inoperative procedures
Signal Acknowledgment	Point a steady light from the flashlight at the signaling aircraft.
Night Approach-End Barrier Engagement Without Radio	Fly parallel to the active runway, 1,000 feet AGL, flashing the landing light. Proceed as with day approach-end barrier engagement without radio.
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CHAPTER 8

NIGHT SYSTEMS: NIGHT VISION GOGGLES AND LANTIRN

8.1 Introduction. Night systems missions comprise operations aided or augmented by night vision goggles (NVG) and the LANTIRN system. NVGs are rapidly becoming the standard by which the F-16 community employs night. The LANTIRN system is the preferred method of employing precision weapons both day and night and from either medium or low altitude. Additionally, this chapter discusses combining NVGs with medium-altitude LANTIRN tactics and how to effectively integrate goggles with the LANTIRN system.

8.2 Night Vision Goggle Operations.

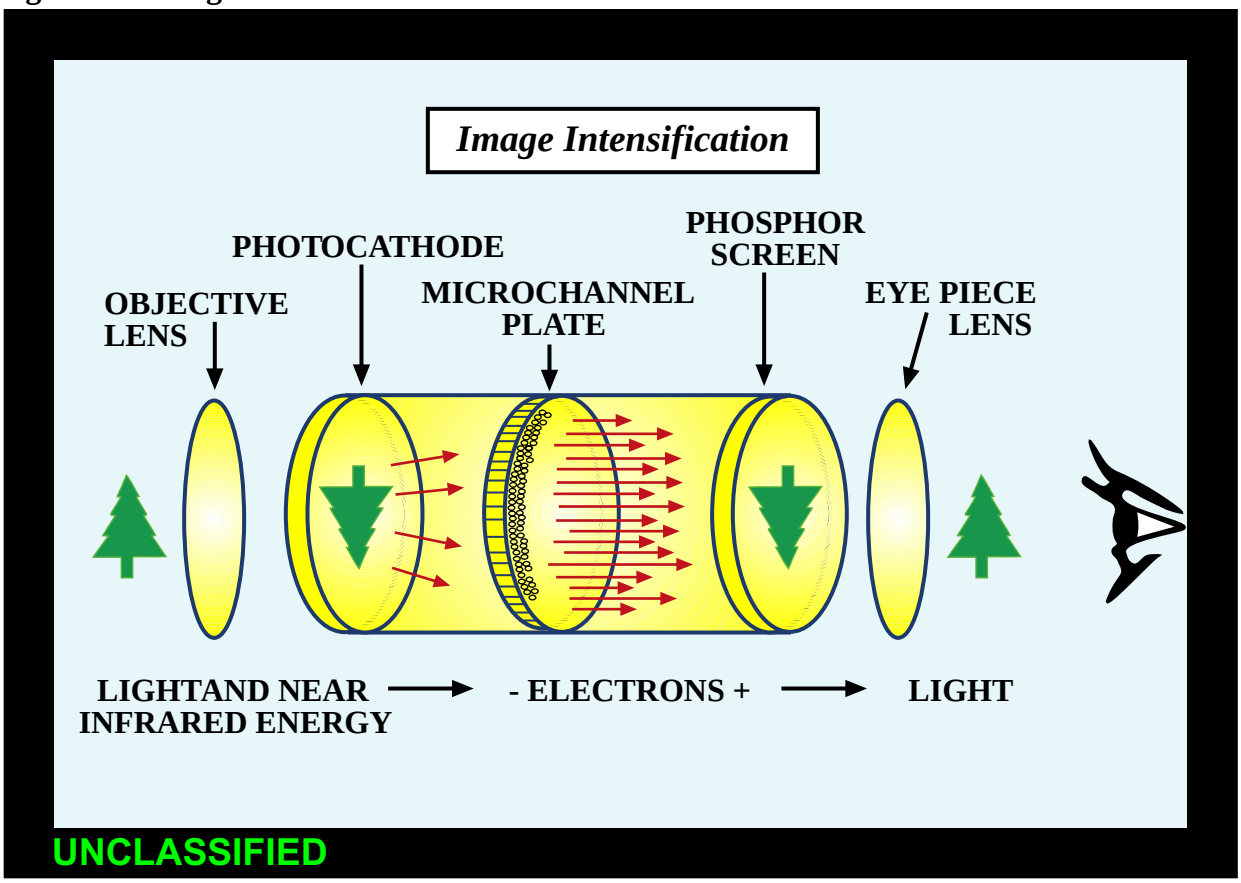
8.2.1 Night Vision Goggle Description. NVGs used in F-16 operations currently consist of two image intensifier tubes mounted on a fully adjustable, lightweight binocular bracket. These image intensifier tubes produce a monochromatic (green) image of the outside world during illumination conditions too low for normal vision. A forward-looking infrared (FLIR) uses the far infrared (IR) area of the electromagnetic spectrum to create an image based on the relative emission of heat by different objects in the scene. NVGs use the red portion of the visible spectrum and near IR energy to produce their own unique visible image of the world. Under adequate conditions of illumination, NVGs can enhance SA, terrain avoidance, navigation, target detection, and identification.

8.2.1.1 Image Intensifier Tubes. An image intensifier tube is an electronic device that amplifies available ambient light reflected from an object. (See **Figure 8.1**, Image Intensification.) The reflected light enters the goggles and is focused by the objective lens onto the image intensifier's photocathode, which is receptive to both visible and near-IR radiation. The photons of light striking the photocathode cause a release of electrons, proportionate in number to the amount of light transmitted through the lens. An electrical field that is supplied by the device's power source then accelerates the released electrons away from the photocathode surface. The released photoelectrons are amplified (increased in number) and accelerated (increased in energy) onto a phosphor screen. This impact causes the screen to glow. The phosphor screen emits an amount of light proportional to both the number and velocity of electrons striking it. Generally, image intensifier technology is expressed in terms of first, second, third and fourth-generation systems.

8.2.1.2 Third-Generation Intensifiers. Third-generation intensifiers are preferred NVGs for the combat air forces (CAF) and incorporate at least third-generation intensifier tube technology. There are two major changes between second-generation and third-generation tubes. An improved photocathode is used and a metal oxide film is applied to the micro-channel plate (MCP). Using an improved photocathode results in third-generation tubes being far more sensitive in the region where near-IR radiation from the night sky is plentiful. (See **Figure 8.2**, Comparison of the Human Eye and Third-Generation NVGs.) Adding a metal oxide film to the MCP in third-generation tubes greatly extends their service life over that of second-generation tubes. It must be noted that the quality of the image itself can vary slightly between different sets of goggles because of the difficulty in consistently manufacturing third-generation tubes. Indeed, only a certain percentage of the tubes

produced meet the specifications established for third-generation intensifier tube performance. The third-generation NVG hardware is the Type 1, direct view, aviator's night vision imaging system (ANVIS)-9/F-4949 NVGs. Direct view goggles present the image directly from the image intensifier tube to the pilot's eyes. In addition, third-generation NVGs use a minus blue filter, also called a red spectral filter, to limit their response in the lower part of the NVG spectrum.

Figure 8.1 Image Intensification.



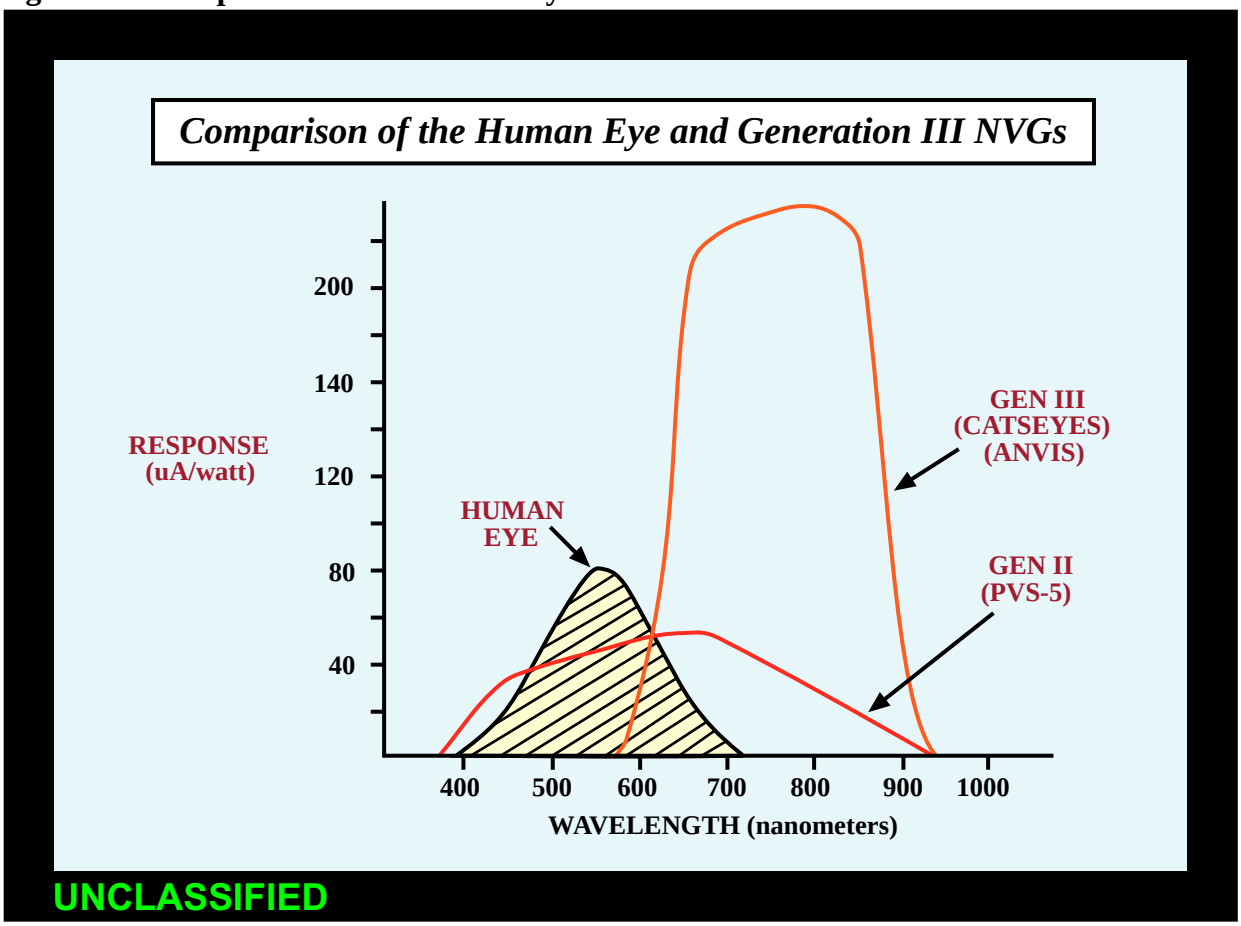
8.2.1.3 ANVIS-9 NVG. The Air Force currently uses the ANVIS-9/F-4949 NVG featuring a redesigned MCP that improves the resolution of the goggle from approximately 20/45 to 20/30. The latest versions of the ANVIS-9 have visual acuities as good as 20/25, and come with modified “leaky green” filters which makes them compatible with the F-16 Block 40/42 holographic head-up display (HUD). (See **Figure 8.3**, ANVIS-9 NVG.)

8.2.2 Support Equipment. NVGs have no built-in test (BIT) provisions to determine their serviceability. The only means of determining whether they are performing adequately is through a visual check. Visual checks are accomplished by using a Hoffman ANV-20/20 NVD Infinity Focus System, or an eye test lane.

8.2.2.1 Hoffman ANV-20/20 NVD Infinity Focus System. The Hoffman Tester is the preferred method for pilots to focus their NVGs prior to flight. Each pilot dons their NVGs, looks into the test equipment window, and focuses the goggles to infinity on the reticle

inside. This deployable tester eliminates the need for a dedicated blacked out room and has the added benefit of allowing the user to focus their NVGs to infinity.

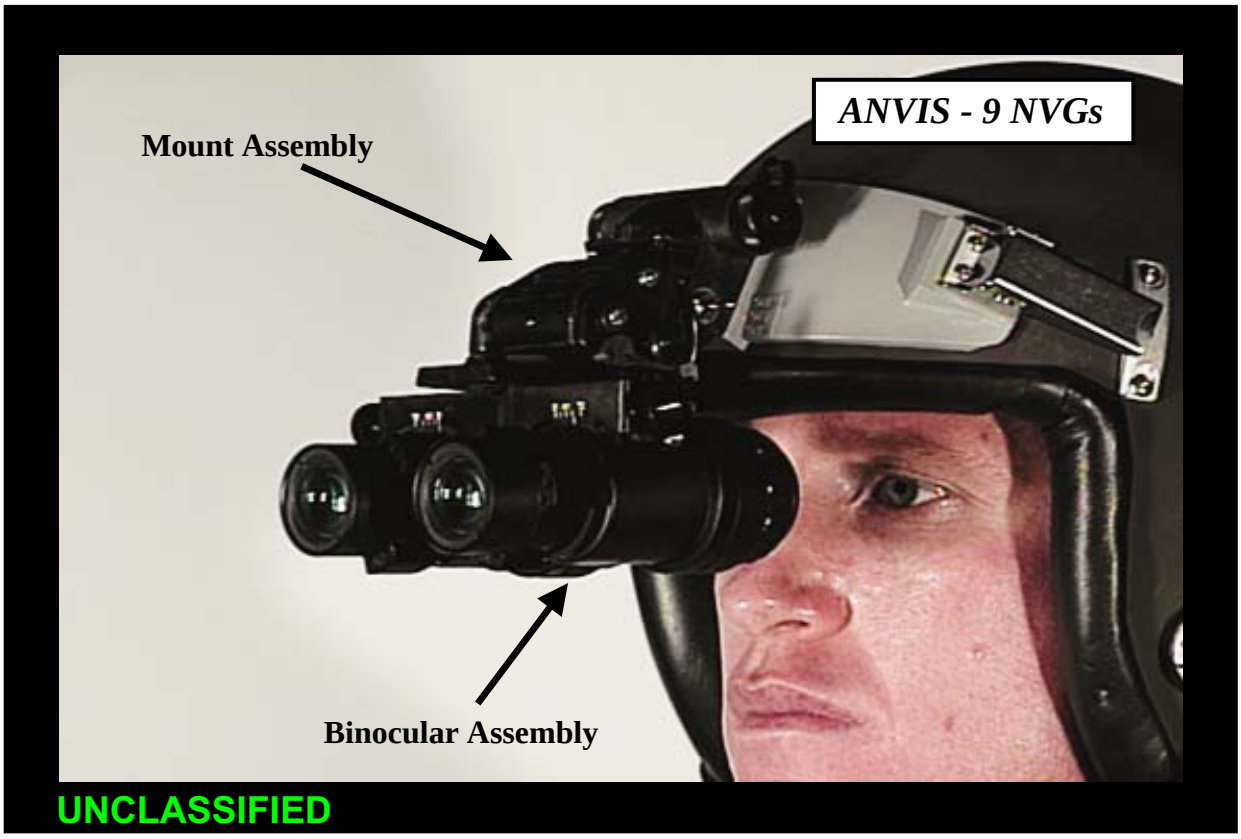
Figure 8.2 Comparison of the Human Eye and Third-Generation NVGs.



8.2.2.2 Eye Lane. An eye lane is a corridor, room, or facility approximately 25 feet long that can be sealed from external light. This allows pilots to focus their NVGs under controlled conditions prior to flight. A resolution chart is placed at one end of the eye lane to determine goggle performance. In order to obtain valid results, the chart must be viewed from exactly 20 feet. A light source is placed in the eye lane 10 feet from the resolution chart off to one side reflecting across the width of the eye lane. Pilots don their NVGs, look down the eye lane, and focus their goggles on the resolution chart. After using an eye lane, aircrews must re-adjust their NVG focus from 20 feet to infinity.

8.2.2.3 NVG Supplies. Two selectable 1.5V lithium or alkaline batteries power NVGs and are located inside the mounting bracket. Battery life varies, and batteries should be switched after about 10 hours of use. At least one extra battery should be carried in flight per mission requirements. Most life support shops have NVG kits designed to hold the goggles as well as an extra battery and any cockpit modification supplies.

Figure 8.3 ANVIS-9 NVG.



8.2.3 Interior Aircraft Lighting. Conventional cockpit lighting operates within visible and near-IR wavelengths that may render NVGs virtually unusable, even when turned down to the lowest light intensity. This is due to the automatic gain control feature of the NVGs. In addition, an incompatible light does not have to be within the NVG field of view (FOV) for it to effect NVG gain and performance, due to the reflection of light off the canopy and other cockpit components. Light bulbs and other light sources in the cockpit must be coated or treated in some way to block the emission of near-IR energy in order to make them NVG-compatible.

8.2.3.1 LED Modified Cockpit. This lighting scheme is composed of a string of light-emitting diodes (LED), a battery pack, and a filter kit. It is commonly called the "Christmas Tree" light string mod, is pre-wired by life support, and requires minimal cockpit setup by the pilot. When ready for NVG operations, the pilot turns off conventional cockpit lighting and activates the LED-modified lighting. In addition, NVGs used in non-compatible lighting aircraft require Glendale-green (or an equivalent filter material) plastic film covers with Velcro backing, black electrical tape, chamois for the AOA indexer, and potentially other filters designed to make the cockpit compatible for NVG operations.

8.2.3.2 Compatible Lighting—NVIS. Compatible cockpit lighting allows aircrews to see cockpit instruments without affecting NVG performance. An added benefit of night vision imaging system (NVIS)-compatible interior and exterior lighting is its improved survivability against adversaries equipped with NVGs.

8.2.4 Exterior Aircraft Lighting. Conventional external lighting from one's own aircraft or other aircraft in formation can degrade NVG performance because of the automatic-gain-control feature of the goggles. By reducing the levels of the exterior lighting for non-NVIS aircraft this limitation is reduced. (See **Figure 8.4**, Standard Switches—Non-NVIS.) Compatible visible and covert/IR external lighting may be installed on the aircraft, allowing aircrews to fly tactical formations while limiting the possibility of visual detection only to adversaries equipped with NVGs. Fully NVIS-modified aircraft use programmable covert/IR strobes in conjunction with NVGs which greatly enhance SA in multi-ship formations and packages while still minimizing the chances of enemy visual detection. (See **Figure 8.5**, Standard Switches—NVIS.)

8.3 Night Vision Goggle Capabilities. Just like with the unaided eye in daylight, NVGs see line of sight (LOS) to the horizon. Additionally, NVGs sense near-IR energy allowing detection of engine heat, missile plumes, and muzzle flashes, which are not seen by the unaided eye. Typically, NVGs allow pilots to see non-compatible aircraft lighting at more than 50 NM, lighted objects beyond 10 NM, and a lit cigarette at about 5 NM. The most significant benefits provided by using NVGs are an increase in pilot SA, a corresponding increase in safety, and a potential decrease in the risk of fratricide. When flying at night without NVGs, pilots must use a variety of non-visual techniques to accomplish tasks they normally accomplish visually during daylight. These techniques include dependence on A/A and terrain following radars (TFR), FLIR pods, A/A TACAN, trail formations, flying minimum safe altitudes (MSA), and using separate altitude blocks. By using NVGs, pilots are able to perform many of their tasks visually instead of using conventional night techniques. Aircraft not equipped with targeting pods (TGP) and FLIRs can operate more effectively at night using NVGs. Advantages can be broken down into seven main categories: cooperation with other thermal imaging devices, visual formation/escort, visual navigation and terrain avoidance, maneuverability, visual identification (VID), threat detection/survivability, and covert close air support (CAS) operations, all of which allow enhanced nighttime tactics.

8.3.1 Cooperation with Thermal Imaging Devices. NVGs and FLIR thermal imaging devices are complementary sensors and can aid mission accomplishment through sensor integration. FLIR technology is based on the fact that all objects warmer than absolute zero emit heat. FLIR can discriminate between objects with a temperature difference of less than 1-degree or of the same temperature if they emit heat at different rates (the rate of emission depends upon composition of individual objects). FLIR sensors detect differences in the thermal properties of these materials and create an image on either a HUD or head-down display (HDD). This process called thermal imaging, results in a monochromatic image for the pilot. FLIRs allow detection, recognition, identification, and classification of targets, scenes, or activities that would otherwise be concealed by darkness. **Table 8.1**, NVG/FLIR Comparison, and **Figure 8.6**, Comparison of NVG and FLIR Technology, show a comparison of NVG and FLIR technology.

Figure 8.4 Standard Switches—Non-NVIS.

Standard Switches—Non NVIS

NAME	MASTER	ANTI-COLL	POSITION	WING/TAIL	FUSELAGE	FORM
"BRT FLASH"	NORM	OFF	FLASH	BRT	BRT	N/A
"BRT STEADY"	NORM	OFF	STDY	BRT	BRT	N/A
"DIM STEADY"	NORM	OFF	STDY	DIM	DIM	N/A
"DIM FLASH"	NORM	OFF	FLASH	DIM	DIM	N/A
"CLOAK"	NORM	OFF	N/A	OFF	DIM	12:00
"DARK CLOAK"	NORM	OFF	N/A	OFF	OFF	12:00
"LIGHTS ON"	NORM	ON	FLASH	BRT	BRT	N/A
"LIGHTS OFF"	OFF	N/A	N/A	N/A	N/A	N/A

Lighting Panel—Non NVIS

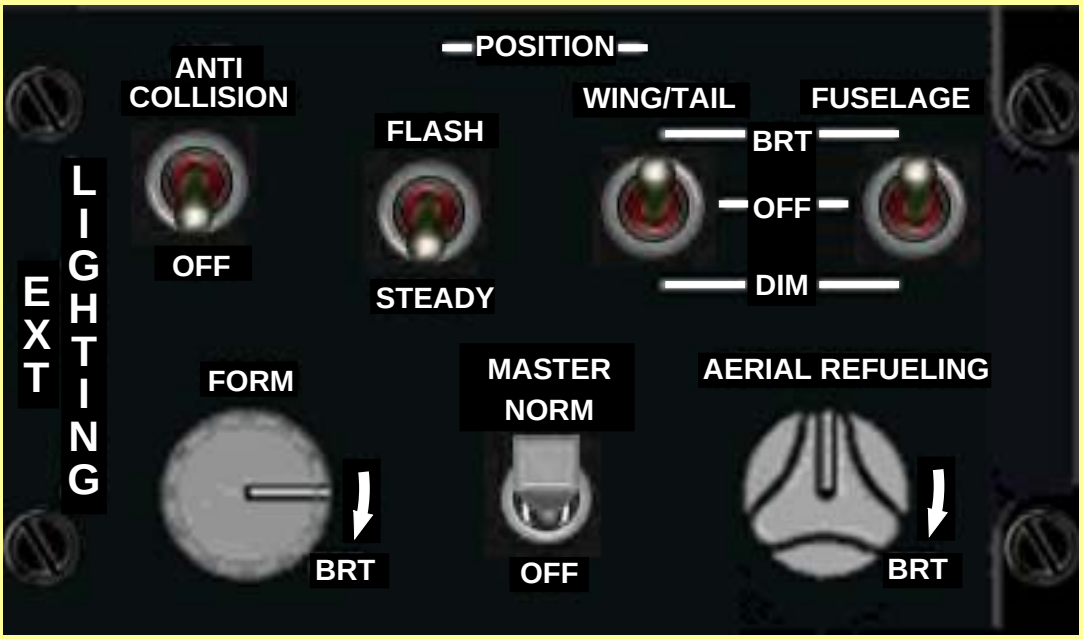


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Figure 8.5 Standard Switches—NVIS.

Standard Switches—NVIS

NAME	MASTER	ANTI-COLL	POSITION	WING/TAIL	FUSELAGE	FORM
"BRT FLASH"	NORM	A/R	FLASH	BRT	BRT	N/A
"BRT STEADY"	NORM	A/R	STDY	BRT	BRT	N/A
"DIM STEADY"	NORM	A/R	STDY	DIM	DIM	N/A
"DIM FLASH"	NORM	A/R	FLASH	DIM	DIM	N/A
"CLOAK"	NORM	A/R	N/A	OFF	DIM	12:00
"DARK CLOAK"	NORM	A/R	N/A	OFF	OFF	12:00
"LIGHTS ON"	NORM	A/R	FLASH	BRT	BRT	N/A
"LIGHTS OFF"	OFF	N/A	N/A	N/A	N/A	N/A
Covert Settings						
"COVERT"	ALL	A/R	A/R	BRT	BRT	N/A
"COVERT STROBE"	A-C	A/R	A/R	BRT	BRT	N/A
"COVERT FORM"	FORM	A/R	A/R	BRT	BRT	N/A

Lighting Panel—NVIS

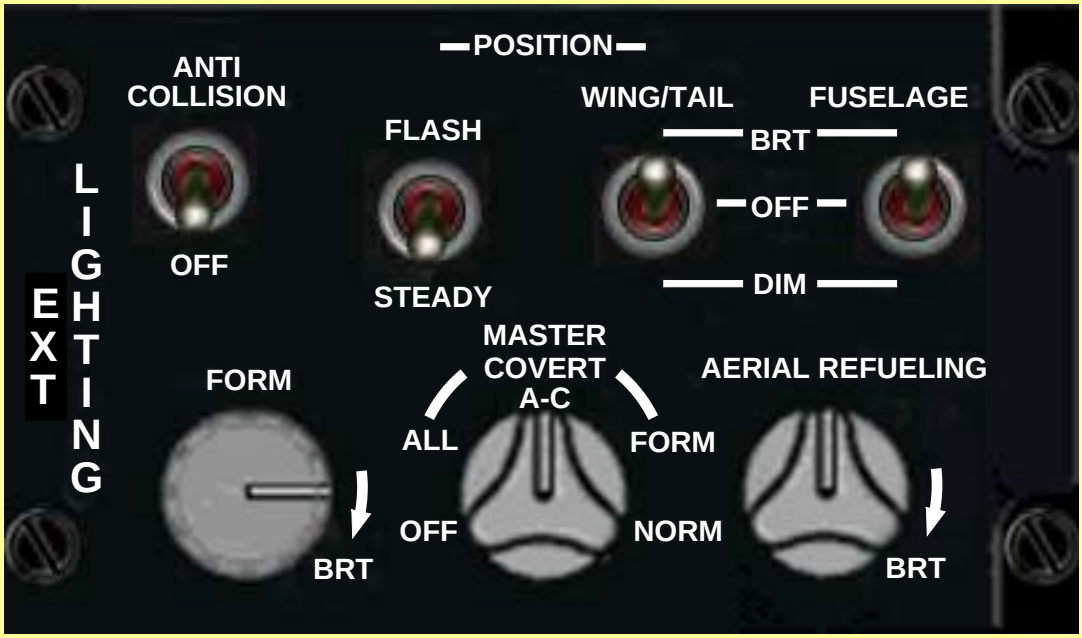

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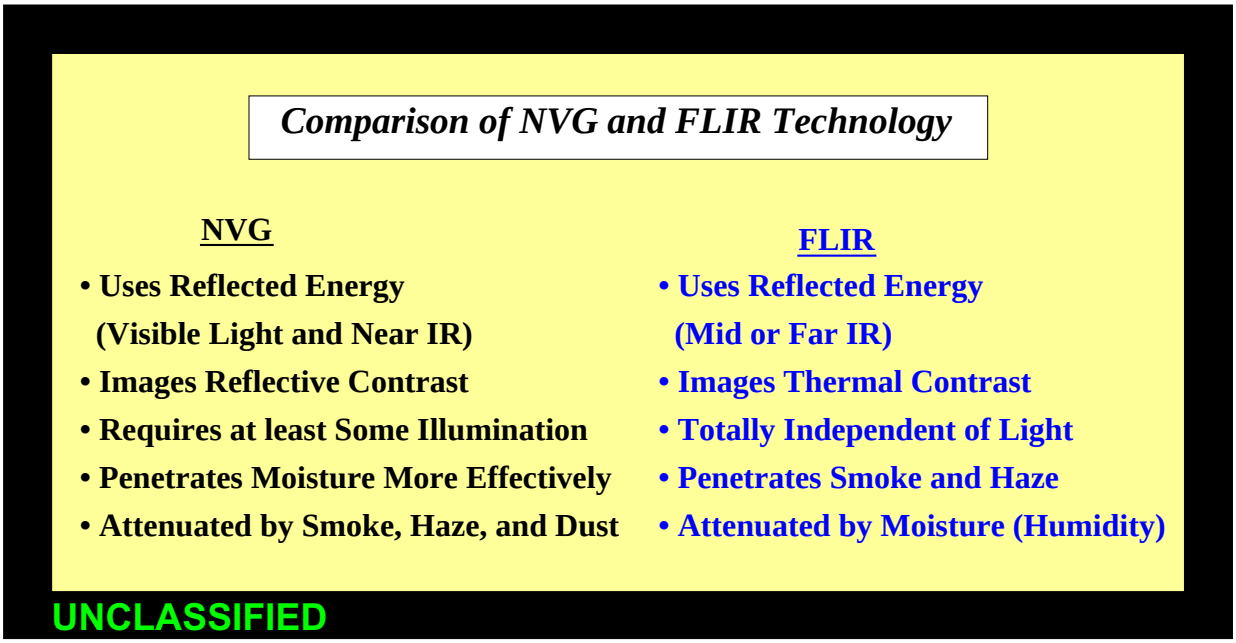
Table 8.1 NVG/FLIR Comparison.

NVG	FLIR
Uses reflective energy	—
Visible light and near IR	Uses emitted energy
Mid or far IR	—
Images reflective contrast	Images thermal contrast
Requires some illumination	Totally independent of light
Penetrates moisture more effectively	Penetrates smoke and haze
Attenuated by smoke, haze, and dust	Attenuated by moisture (humidity)
UNCLASSIFIED	

Figure 8.6 Comparison of NVG and FLIR Technology.



8.3.2 Visual Formation/Escort. In combat, aircraft are normally flown "lights out" to avoid visual detection by enemy A/A and S/A threats. When lights out, pilots must use other than visual means to monitor and deconflict with other aircraft in the flight or package. NVGs allow you to fly visual tactical formations and deconflict each other aircraft while using covert lighting invisible to the naked eye. Visual formations reduce electronic emissions and increase mutual support. Strike packages can be compressed, reducing time required over the objective and exposure to the threat. Aircraft escorting strike, airdrop, or combat search and rescue (CSAR) packages can do so visually, increasing mutual support and simplifying deconfliction.

8.3.3 Visual Navigation and Terrain Avoidance. During high-illumination, NVGs improve SA by allowing pilots to see hazards like rising terrain on either side of the route. In addition, NVGs allow pilots not equipped with low-altitude navigation and targeting infrared night (LANTIRN) systems to visually navigate and avoid terrain at low altitude when required to

avoid threats and weather. Even when low altitude flight is not required, NVGs allow you to augment the INS by visually navigating at medium altitudes.

8.3.4 Maneuverability. Due to fewer visual cues and lower SA at night, pilots generally maneuver their aircraft less aggressively than during daylight. With NVGs, pilots can maneuver more aggressively. This increased maneuverability gives a distinct advantage to fighters attacking or defending against enemy aircraft and increases probability of survival while defending against S/A threats. In addition, aircraft attacking surface targets can employ more flexible attack profiles.

8.3.5 Visual Identification. At night, enemy aircraft will most likely extinguish their exterior lights and may employ emission control (EMCON) tactics under airborne or ground-controlled intercept (GCI) direction. Normal unaided night vision does not permit aircrews to visually acquire or identify such aircraft. NVGs allow pilots to visually scan for other aircraft and are particularly capable of acquiring aircraft equipped with unmodified interior/cockpit lighting. Once an aircraft is seen, NVGs can be used for visual identification (VID) at close range if there is adequate illumination. High illumination from various sources may be available to illuminate the target for a valid ID: heavy cultural lighting, high moon illumination, or artificial illumination from covert/overt flares or spotlights.

8.3.6 Threat Detection/Survivability. Testing has proven NVGs viable for the detection of surface-to-air missiles (SAM) and antiaircraft artillery (AAA). NVGs are also effective in visually detecting enemy aircraft and air-to-air missiles (AAM) in flight. The ability to see at night improves aircraft survivability by increasing a pilot's ability to detect, avoid, and defeat threats.

8.3.7 Covert Close Air Support Operations. Non-NVG units performing CAS require illumination flares to light up the battlefield in order to acquire and engage enemy targets. However, visual-band flares degrade friendly ground troop NVGs and highlight friendly positions to the enemy. By using NVGs, pilots can covertly accomplish their missions, thereby reducing the risk to friendly ground forces.

8.3.8 Night Vision Goggle Planning Considerations. Mission planning begins by determining expected illumination conditions. Light level planning software programs are used to calculate expected light illumination levels. These programs produce sunrise, sunset, moonrise, moonset, moon elevation, and a millilux light level in lumens. The base weather shop can usually provide solar and lunar data High illumination is defined as a minimum light level of 2.2 millilux. A general ROT is that 25 percent moon illumination with greater than 30 degrees elevation produces high illumination. Also, just like flying into the sun, moon elevation is a factor when attempting to ingress or egress toward the moon's azimuth. Be aware, weather has an unpredictable effect on illumination as cloud cover lowers the illumination conditions by an undetermined amount. Pilots should always have a low-illumination contingency option.

8.3.9 Environmental Conditions. Your mission planning must consider environmental conditions and their impact on night vision devices. Additionally, planning should include spot locations (azimuth and elevation) of the sun and moon for critical stages of the mission, such as ingressing the target/objective. Predicted illumination levels should be calculated with the aid of weather personnel, and mission tactics planned accordingly.

8.3.10 Night Vision Goggle Performance Considerations. The following environmental conditions affect NVG performance and must be understood to safely conduct NVG operations.

8.3.10.1 Luminance, Illuminance, Radiance, and Albedo. The two most common terms used when discussing light as it pertains to NVGs are luminance and radiance. Luminance and radiance refer to reflected or emitted light from an object or scene. Illuminance and irradiation refer to the amount of electromagnetic energy striking the object or scene. An example of luminance is the moonlight which is reflected from objects in a given scene. For a fixed-illumination level, the amount of light reflected varies with the reflectivity of the objects. The ratio of luminance (reflected energy) to illumination (energy source) is called albedo, which varies with the composition and condition of the particular object or surface. The albedo, or reflectivity, of objects in a scene varies. This difference allows one to detect an object like a dirt road in a scene. It is important to note that while the ambient light provides the necessary illumination, it is actually the reflected light, or luminance, that NVGs detect from objects and the terrain that allows one to “see.”

8.3.10.2 Weather. Any condition of the atmosphere that absorbs, scatters, or refracts the sky's illumination, either before or after it strikes the terrain, will effectively reduce the usable light available to NVGs. Weather and visibility restrictions all serve to alter illumination, luminance, or both. Recognition of this reduction in the cockpit is sometimes very difficult. The changes are often very subtle reductions in contrast, which are not perceived when viewed through NVGs. The automatic gain control in the intensifier tubes can hide these changes by attempting to provide a constant image in spite of the changing luminance conditions. If cues are perceivable, the aircrew must recognize them and their significance. Common cues to reductions in ambient illumination include loss of celestial and ground lights, loss of the perceivable horizon, reduced contrast, decreased depth perception and distance estimation capability, reduced visual acuity, increased NVG sparkle, scintillation (graininess or “snow” in the scene), and a “halo” effect around light sources. As a general rule, any weather phenomenon that affects vision in daylight will affect NVGs at night. Weather conditions that effect NVG operations include clouds, fog, rain, snow, sand/dust, lightning, and obscurants like haze and smoke.

8.3.11 Illumination Sources. Natural illumination sources include the moon, stars, solar twilight, and other background illumination. There are also artificial illumination sources such as light from urban areas, fires, automobiles, weapons, searchlights, and flares. In areas without cultural lighting, the moon normally provides the highest percentage of natural illumination at night.

8.3.11.1 Sunset and Sunrise. NVG operations can be hampered by zodiacal light (twilight in the western sky for up to 2 hours after sunset). If the mission is flown soon after sunset, profiles should be adjusted to allow west to east operations with zodiacal light at the aircraft's 6 o'clock position. This light can be intense immediately following sunset, and can be sufficient to brightly illuminate the objective with the light from behind. If the mission is flown with the objective located in the same relative direction as the zodiacal light, the ambient light will reduce NVG gain and the objective may not be detected. Similar preplanning is required beginning about 1 hour prior to sunrise.

8.3.11.2 Moon Phase and Moonrise/Moonset Times. Moon phase and elevation determine how much moonlight will be available, while moonrise/moonset times determine when it will be available. The most important operational aspects of moonrise/moonset times concern times when the moon is low in the sky. Moon angles of less than 30 degrees can render the NVGs ineffective when looking in the direction of the low moon. The moon moves across the sky at approximately 15 degrees per hour. This means it will be a factor for 2 hours after moonrise and for 2 hours before moonset.

8.3.11.3 Cultural Effects. Any common light source is visible in NVGs. Flashlights can be seen out to 25 NM, while cigarettes can be seen out to 5 NM in low-ambient lighting conditions. Campfires are IR beacons, which are brilliant on NVGs but can be difficult to see with the naked eye. Red lights on transmission towers are highly visible.

8.3.12 Terrain. Due to changes in climate and lunar cycle, a given terrain scene may look radically different on consecutive nights. Successful NVG operations require an understanding of various terrain characteristics along with the effects of weather and lunar cycles on NVG performance. Terrain features with distinct characteristics when viewed through NVGs include roads, bodies of water, open fields, deserts, forests, snow, and mountains.

8.3.12.1 Featureless Terrain. It is difficult to determine altitude when flying with NVGs over areas of little contrast such as snow fields, water, and desert. NVGs by themselves may not give adequate awareness of height above the ground, and other devices such as radar altimeter, FLIR, or TFR, may be required to conduct safe low-level operations.

8.3.12.2 Shadows and Obstructions. Terrain and other obstacles concealed in the shadows of higher terrain or cloud cover are difficult to see while conducting NVG operations at low altitude. Unlit obstructions like electric power lines, towers, poles, antennas, and dead trees, are particularly hazardous, as they may not be detected.

8.3.13 High-Illumination Conditions.

8.3.13.1 Employment. High illumination allows pilots to identify turn points and targets, especially if they have vertical development and/or background contrast. Medium- and low-altitude attacks using visual reference points are similar to day missions. High illumination generally benefits A/S missions more than A/A, as the high-illumination level can mask airborne light sources that would be visible under low illumination.

8.3.13.2 Lunar Planning. Routes into low-moon angles (less than 30 degrees elevation) or the solar glow of the rising and/or setting sun (within 1 hour of sunrise/sunset) require operating at MSAs or individual comfort level; whichever is higher. Attack axis should be planned at least 90 degrees away from a low moon or solar glow. With a near vertical moon (70 to 90 degrees elevation), terrain features may not be readily apparent. Due to lack of shadows, this featureless terrain may cause a flight hazard.

8.3.14 Low-Illumination Conditions.

8.3.14.1 Preparation and Planning. Low illumination planning must include the same considerations for flying at night with no NVGs (above the MSA). Under low illumination, pilots should not expect to see terrain features, landmarks, or other target area/DMPI lead in features that would normally be seen in the day or high illumination. Route planning and

attacks must be more benign, with radar or TGP updates available. Pilots are typically restricted to above the MSA unless a low checkout has been accomplished and it is high illumination. Low-altitude fly-ups should be planned with a maximum climb angle of 20 degrees (with no expectation of visually acquiring the target unless it is culturally lit) and to limit afterburner use. Medium- and high-altitude missions require the use of on-board sensors (radar, TGP, and FLIR) and an accurate inertial navigation system (INS) or global positioning system (GPS). Planned delivery options should include either system or visual deliveries using continuously computed release point (CCRP), or visual deliveries using continuously computed impact point (CCIP), or dive toss (DTOS) against culturally lit targets.

8.3.14.2 Increasing Illumination. Low-environmental illumination may require artificial illumination to enable mission accomplishment. Relative placement of visual-band illumination flares in relation to targets or other mission objectives is critical, as these flares can gain down, or interfere with, your NVGs. Covert/IR illumination flares allow pilots to use NVGs on dark nights without degrading friendly ground troop NVGs, exposing their positions, or exposing the position of the target and objective.

8.3.15 Night Vision Goggle Limitations. Although NVGs can improve performance at night, they have numerous limitations which you must be familiar with in order to use them safely. NVGs DO NOT turn night into day.

8.3.15.1 Field of View. FOV refers to the total instantaneous area covered by the NVG image. FOV depends on NVG design and type, and ranges from 30 to 40 degrees for current systems. Regardless of the FOV of any particular system, it is considerably less than the eye's normal FOV of 120 degrees by 80 degrees. This lack of good peripheral vision can influence the onset of misperceptions and illusions.

8.3.15.2 Windscreen and Canopy Transparency/Transmissivity. Windscreens, canopies, or other transparencies through which the pilot must look degrade NVG performance. Some transparencies transmit visible wavelengths fairly well, but near-IR wavelengths poorly. Since NVGs use near-IR wavelengths, those canopies would keep much of that energy from reaching the goggle, thus degrading the image of the outside scene. Just because an NVG has a 20/30 capability in the eye lane does not mean it will give you a 20/30 capability from the cockpit.

8.3.15.3 Resolution. Resolution, or visual acuity, refers to the ability of the goggle to present an image that makes clear and distinguishable the separate components of a scene or object. Normal unaided night vision is approximately 20/200. Current NVGs typically have a resolution capability of between 20/25 to 20/40. While not as good as day vision, NVGs represent a significant improvement in night visual acuity.

8.3.15.4 Depth Perception. Depth perception encompasses determining the relative distance of objects in relation to each other. There are two types of depth perception cues: binocular and monocular. Binocular cues are basically a triangulation of retinal points called stereopsis. This provides the 3-dimensional aspect of our vision. With NVGs, stereopsis is still possible, but is limited to distances less than 50 meters. With NVGs, depth perception is judged primarily by using monocular cues. Monocular cues include relative size and height of objects, overlap of objects, convergence of parallel lines, and motion parallax

(closer objects within the FOV moving faster than farther objects). Binocular cues are limited by distance, while monocular cues are limited by degraded acuity and reduced contrast.

8.3.15.5 Distance Estimation. Distance estimation is altered while using NVGs due to a reduction in visual acuity. This results in unlit objects sometimes appearing farther away than they actually are. This effect is primarily a learned subconscious phenomenon, as humans expect objects that are less distinct in detail to be farther away than those which have sharp detail. This can cause problems with overestimating altitudes or distances. The opposite occurs when observing lit objects, which may result in underestimating distances.

8.3.15.6 Reduced Contrast. Reduced contrast manifests itself primarily as reduced visual acuity since low-contrast objects are more difficult to see than those that have a high contrast. A reduction in contrast occurs as the eye is presented a monochromatic image and color contrast cues are lost. Also, a bright light source in the FOV will reduce contrast as the NVG begins to reduce the gain. Because there are individual differences in sensitivity to contrast, there can be differences among pilots of the same flight with regard to what they can and cannot see.

8.3.15.7 Degraded Ability to Detect Meteorological Conditions. One of the most dangerous situations that can be experienced with NVGs is flight into undetected meteorological conditions. The inability of the NVGs to see various areas of moisture can lull you to continue further into IMC, to a point where there is virtually no visual information. This can result in a gradual loss of scene detail, placing the pilot in an area of heavy moisture. In the low-level environment, this can put you into a potential conflict with masked terrain. This late detection of IMC decreases the time available for you to transition from visual flight using NVGs to instrument flight using aircraft instruments. It also reduces the time available to execute a route abort from low altitude, if required. Ultimately, clouds can only be seen in NVGs when there is sufficient illumination to make them visible.

8.3.15.8 Spatial Disorientation. Although NVGs usually improve SA, under certain conditions they can enhance the possibility of spatial disorientation. This is due to the NVGs limited FOV and lack of resolution. It is very important to include the horizon in your NVG cross-check.

8.3.15.9 Overconfidence. After initial NVG training, there is a natural tendency for pilots to become overconfident in their abilities during NVG flight. However, NVGs DO NOT turn night into day. They have very real limitations, and you must exercise caution to avoid becoming complacent.

8.3.15.10 Laser Eye Protection. Other than the physical blockage of laser beams by their body and tubes, NVGs provide no laser eye protection and may not be compatible with current laser eye protection glasses. Use in a laser threat environment and/or in combination with air commander's pointers (ACP) will expose the pilot to potential laser eye damage.

8.4 Night Vision Goggle Employment.

8.4.1 Night Vision Goggle Preflight and Adjustment. Extra time after the briefing must be allowed to accomplish the NVG preflight check. Therefore, accomplish NVG preflight before the flight briefing if possible. Flight testing and operational flying experience has shown this check to be one of the most important steps for a safe NVG flight. The importance of proper goggle alignment, focus, and use of the NVG test lane or Hoffman Tester cannot be over-emphasized. After completing NVG preflight, write down the diopter settings so they may be reset in the cockpit if they accidently get moved. It is difficult to accurately set diopter outside an eye lane or Hoffman Tester. Common malfunctions encountered during preflight of NVGs include battery problems, interpupillary distance (IPD) adjustment problems, one tube not focusing, tubes mis-aligned, and light intensifying element damage which results in large "spots" obstructing your vision. If any of these malfunctions are encountered, another set of NVGs should be obtained from Life Support. Battery failure is the most common malfunction and it is always recommended to fly with fresh batteries and spares.

8.4.2 Ground Operations.

8.4.2.1 Pre-Engine Start. Before preflighting the aircraft of an LED-modified cockpit, ensure the LED string has enough battery power to last the entire flight. Press and hold the battery test button to ensure the power light stays illuminated for 5 seconds. Turn on the light string to verify operation. Each LED module must have at least 50 percent of the LEDs operational. Any missing LEDs should be annotated with a white "X" on the module. If green "finger-lights" are available it is a good technique to use them for reading data from line-up cards and maps. The contents of the NVG kit pose a large FOD hazard and extreme care must be taken not to drop finger-lights and filters inside the cockpit.

8.4.2.2 Post-Engine Start. After engine start, pilots must ensure required external and internal aircraft lights are operational. For LED-modified aircraft, the internal light string must be operational and ALL Velcro must be properly positioned. As a technique, do not setup an LED modified cockpit with Glendale-green filters, and so forth, until sure the aircraft if flight worthy and a spare aircraft is not required. For external lighting requirements, refer to the Federal Aviation Regulations (FAR) and any unit waivers for reduced lighting operations in MOAs.

8.4.2.3 End of Runway. Once in end of runway (EOR) (last chance) and away from as many bright lights as possible, don the NVGs (goggle) and check your NVG focus. When checking the focus, use a star as a reference, and if the star appears fuzzy, use the focus to sharpen it. If the star appears stretched from a point source into a horizontal or vertical line, then the diopter needs to be adjusted. Be very cautious when adjusting either setting on the goggles, as it is easy to adjust them to a setting worse than that achieved with the Hoffman tester or the eye lane. After checking the settings, perform a leak check by scanning the cockpit for any non-compatible light (leaks) and fixing them as required. A good technique is to use the black electrical tape in the NVG kit to cover up any problem light areas.

8.4.2.4 Cockpit Organization. Cockpit organization is essential for safe and effective mission employment. After the NVG focus, stow your NVGs and adjust cockpit lighting as low as practical for takeoff. Pilots should stow NVGs in a convenient place for easy access

when airborne: there is ample room under the armrest to stow the goggles (and goggle case) for takeoff and landing.

8.4.3 Takeoff/En Route. NVGs should not be used during takeoff, landing or during instrument meteorological conditions (IMC) conditions.

8.4.3.1 Goggle Altitude. Once established above 1,500 feet AGL minimum, wings-level or in a slight climb and in the briefed departure formation (radar-assisted trail), flight leads will direct flight members to “GOGGLE.” Wingmen will call “GOGGLED” only after interior lights have been set; the goggles properly focused and are aware of the environmental conditions. Normally, wingmen will goggle first and then flight leads.

8.4.3.2 Exterior Lighting. Once the entire flight is goggled, flights will rejoin to the briefed formation and set their own exterior lights. Each flight member is responsible for requesting changes to the element mate's lights based on environmental conditions. At least one flight member must flash the anti-collision strobe until established in reduced lighting approved airspace. Exterior lighting settings will vary depending on the aircraft lighting modification and unit standards.

8.4.3.3 Goggle Reorientation. Once established in the operating airspace, the flight should accomplish a G-check, ensure all the light filters remain fixed and that the NVGs remain fixed and operate under a higher G-loading. The flight is also responsible for completing a horizon check of the environmental conditions. As a technique, perform a “30-Up and 30-Down” maneuver to check horizon conditions. This also re-familiarizes all members with 30-degree nose-low before seeing this attitude during tactical maneuvering as this type of NVG vertical maneuvering, can be disorienting.

8.4.4 Night Vision Goggles Cross-Check. The NVG cross-check is a combination of using outside references, HUD, and primary flight instruments to maintain overall SA and attitude awareness. Environmental and cultural conditions that provide for a “clean” NVG environment (i.e., high moon illumination, low cultural interference, high albedo/contrast terrain, and low-visible moisture/low absolute humidity) may permit near exclusive use of NVGs for spatial orientation with little reliance on primary flight instrumentation. Over reliance on NVGs and under reliance on primary flight instruments during poor NVG conditions may contribute to loss of spatial orientation or SA. You must evaluate specific flight conditions and determine the appropriate weighting between instrument flight and NVG use for outside references. Recency, currency, and pilot NVG experience all play a dramatic role in determining your ability to quickly recognize what may be insidious changes in illumination conditions. Therefore, it is critical to perform a thorough risk assessment review prior to each sortie when and how NVGs will be used.

8.4.5 Air Refueling. NVGs will not be worn for air refueling operations. De-goggle NLT the pre-contact position. NVGs may be stowed or worn in the up position for air refueling operations. Goggle when refueling is complete and established safely on the tanker's wing.

8.4.6 Night Vision Goggle Recovery.

8.4.6.1 NVG Battle Damage Checks. Accomplish NVG battle damage checks IAW local standards or when damage is suspected. Checks will be done “comm-in.” Wingmen will join to route and set their leader's lights as desired, and perform a battle damage check with

a cross-under similar to daytime. A lead change will be initiated on the radio and then lead will reset lights. After lead has checked the wingman, another lead swap will occur and both aircraft lights will be set as briefed for the recovery.

8.4.6.2 Prior to Landing. Flights will remove and stow goggles at least 5 minutes prior to landing. A flight lead “DE-GOGGLE” call is advisory; each pilot is responsible for removing his goggles prior to landing. Additionally, pilots should de-goggle early if anticipating IMC. It is important to ensure the exterior lights are set to overt and “Lights On” prior to exiting any reduced lighting airspace.

8.4.7 Night Vision Goggle Emergencies.

8.4.7.1 Primary Hazard. The primary hazard is during ejection and concerns both the NVGs interference with the ACES II seat (pitot tube damage) and injury to the pilot due to wind blast effects on the NVGs. Normally, the NVGs will not remain fixed during the ejection.

8.4.7.2 Wind Blast Effects. If the NVGs remain fixed, expect head/neck injuries caused by wind blast. Additional considerations should include parachute and/or riser entanglement increasing injury potential. Attempt to stow or remove the NVGs if ejection is anticipated.

8.4.8 Night Vision Goggle Abnormal Procedures.

8.4.8.1 Loss of Sight. There will be instances of the wingman/element lead going blind due to environmental conditions or limited NVG FOV. Proper NVG scanning helps prevent this condition. When a wingman loses the visual but has a light source and is unsure it is the flight lead, ask for one of the following light signal requests: “VIPER 1, FLASH-CHAFF/BURNER/STROBES/FLARE” The tactical situation and proximity of enemy forces temper all light signal usage. When the wingman regains the visual, maneuver aggressively to regain formation position. If the wingman does not regain the visual, the pilot transmits “Call Sign, BLIND, ANGELS (in hundreds). For example, “VIPER 2, BLIND ANGELS 16.2." The altitude call allows the other flight members to immediately deconflict flight paths by altitude. If the flight lead is visual and can tell the wingman's aspect, the leader gives the clock position and estimated range from the wingman. If the flight lead is unsure of the wingman's aspect, the leader gives own position as bearing and range from the wingman. If the wingman loses SA and is unsure of the location of his flight lead, default to the blind with ANGELS game plan to ensure immediate deconfliction.

8.4.8.2 Battery Replacement. Pilots will initially use the right battery (switch in the UP position). Upon illumination of the flashing battery-low light, switch to the left battery (switch down). For other suspected malfunctions, switch to left battery. Consider changing the lead or informing the rest of the flight during battery replacement due to reduced SA while de-goggled.

8.4.8.3 NVG or Light Failure. Deconfliction and maintaining spatial orientation is the primary consideration. Correcting the NVG failure is secondary. Accomplish the following:

- Request the Lead Position, if practical.
- Transition to instruments and execute “Lost Wingman” procedures.

- Terminate or knock-it-off as appropriate. Direct “Lights On.”
- Enter and maintain correct block with adversaries or other fighters present.
- With deconfliction assured, attempt to identify and solve the problem.
- If NVG or light failure is unrecoverable, proceed with non-NVG plan.

8.4.8.4 NORDO Plan. Go “Lights On” and select the overt setting for NVIS lighting. Following this, proceed with primary/briefed NORDO plan.

8.5 Night Vision Goggle Formations.

8.5.1 Formation Considerations. The current 40-degree NVG FOV and the limited aft view behind 3/9 line requires several formation considerations.

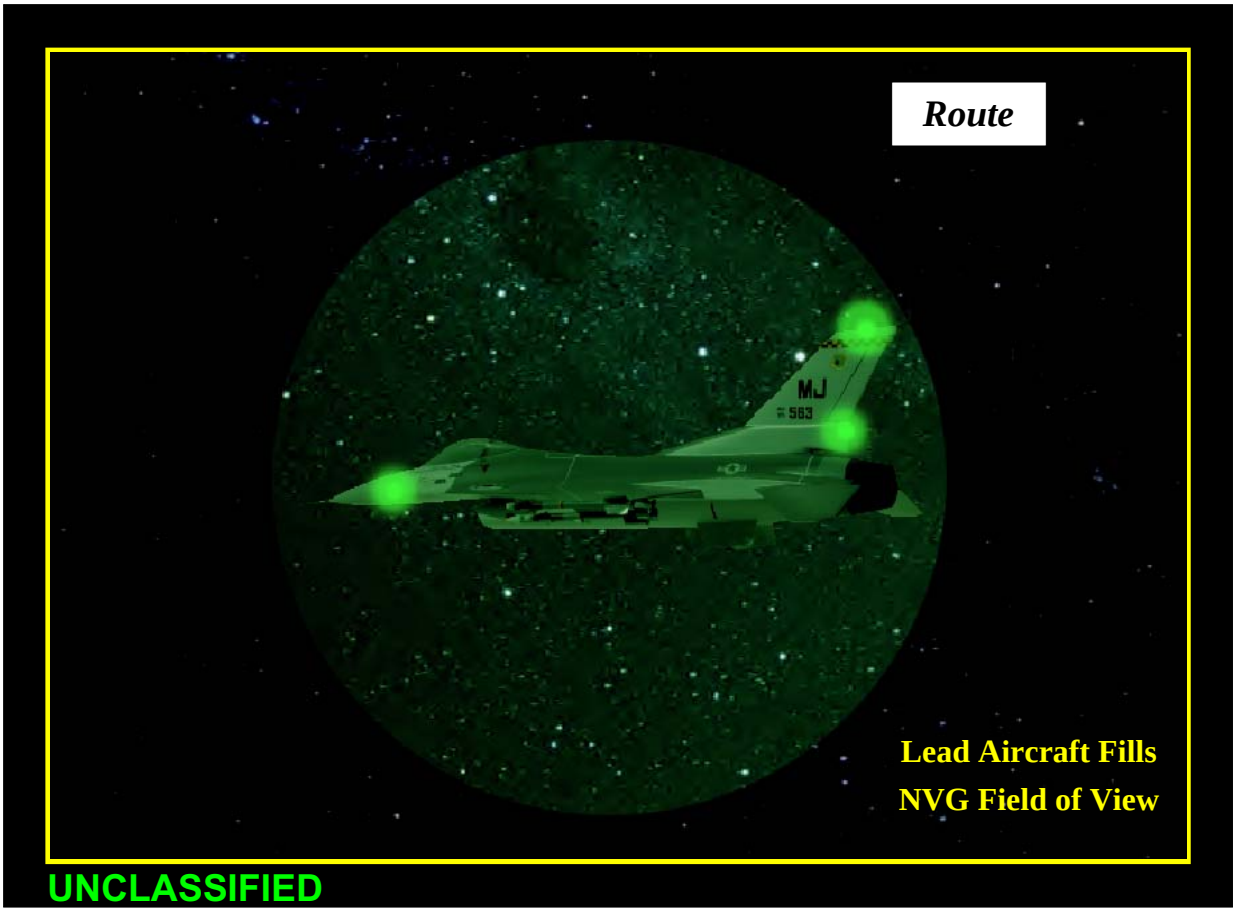
8.5.2 Wingman Priority. The wingman's primary task is to maintain formation position and ensure deconfliction. As NVG experience increases wingmen learn that creating line of sight (LOS) by maneuvering the aircraft is a good technique to ensure deconfliction.

8.5.3 Performance Characteristics. All flight members must be intimately familiar with the operation and performance characteristics of the external light scheme. Wingmen must have the option to adjust the flight lead's external light settings. More than one adjustment may be required as illumination conditions change during flight. If the entire formation is NVIS-modified, the optimum external light setup will be dictated by tactical and environmental considerations. If covert lighting is not available, adjust the normal exterior lights to the lowest practical intensity that allows formation station keeping without going blind.

8.5.4 Tactical Formation and Turns. When maneuvering tactical formations at night, all flight members should generally strive for level turns with Mil power and G-loading to maintain airspeed. Flight members will have difficulty accomplishing other tasks, such as radio changes, until turns are completed. Altitude stacks of any magnitude are difficult to maintain due to the limited FOV of the NVGs. Flight members can stack above or below the leader to maintain visual when cultural lights or stars become a problem. As NVG proficiency increases, all formation parameters are easier to maintain. Due to the limited NVG FOV, night line abreast (LAB) formations require comm-in turns (with headings) to ensure positive flight path deconfliction and adherence to briefed airspeed.

8.5.5 Route. This position is similar to daytime Route, but no closer than the range at which the entire lead aircraft is visible in the NVG FOV. (See **Figure 8.7**, Route.)

Figure 8.7 Route.



8.5.6 Fighting Wing. Similar to daytime, the wingman's position is 30 to 60 degrees aft of leader's 3/9 line and 500 to 3,000 feet. Wingman remains fluid to keep the leader in NVG FOV during turns and is cleared to cross the leader's 6 o'clock position as required. Wingman are responsible for flight path deconfliction. Inside 3,000 feet, individual aircraft lights are discernible and can be used as a visual cue. (See **Figure 8.8**, Fighting Wing.)

8.5.7 Wedge. Similar to daytime, this formation position is used for more extreme tactical maneuvering. The wingman positions 30 to 60 degrees aft of leader's 3/9 line and 3,000 to 6,000 feet. Wingman remains fluid, is cleared to cross the leaders 6 o'clock position, and is responsible for flight path deconfliction. Outside 6,000 feet, individual aircraft lights are more difficult to see and the A/A TACAN is more helpful for proper spacing. (See **Figure 8.9**, Wedge.)

Figure 8.8 Fighting Wing.

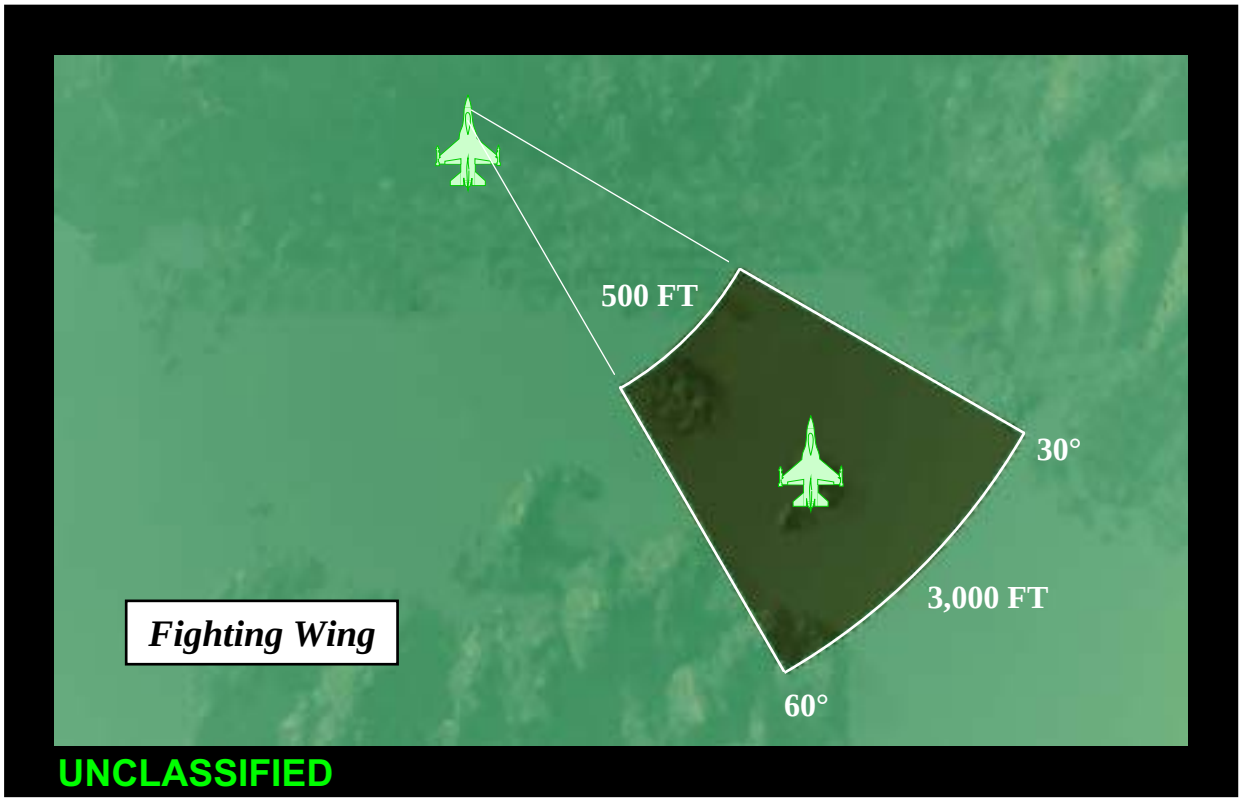
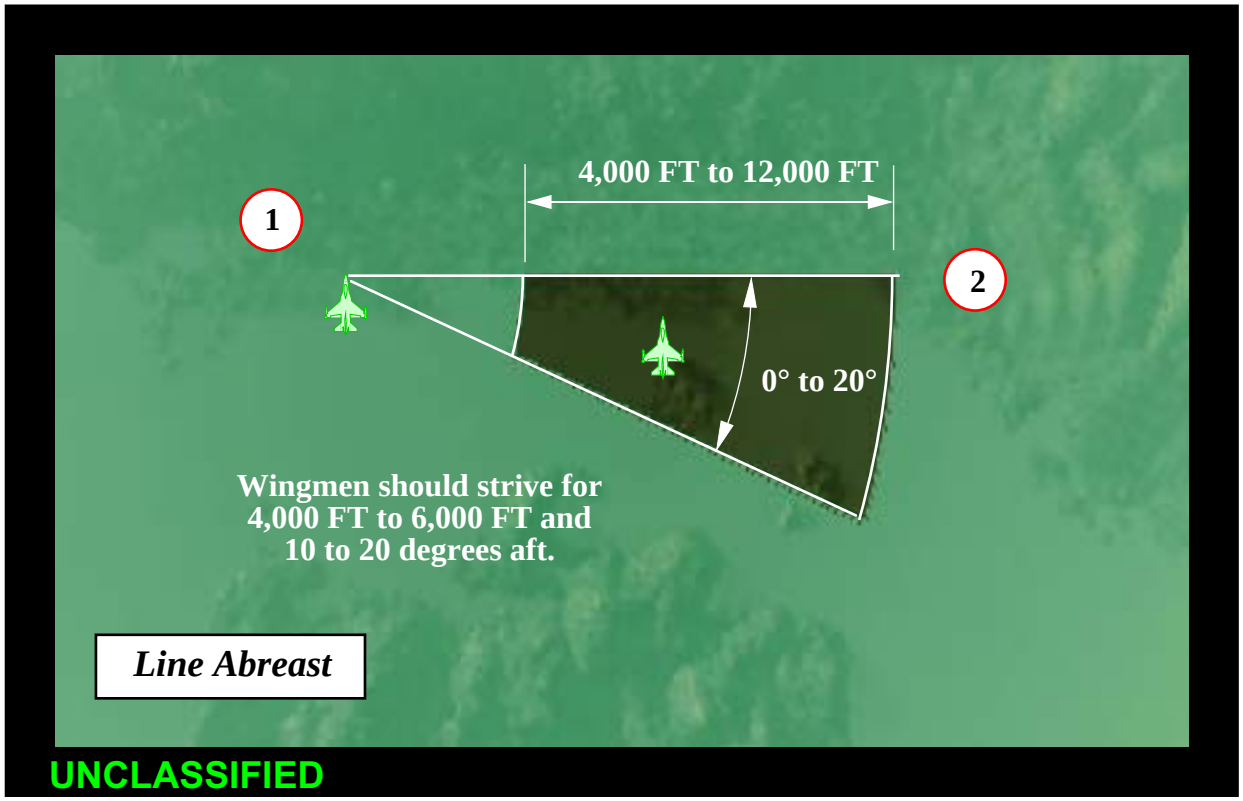


Figure 8.9 Wedge.

8.5.8 Line Abreast. Wingman flies 0 to 20 degrees aft of leader's 3/9 line and 4,000 to 12,000 feet out. The preferred position is to fly as close to LAB as possible while still maintaining a good NVG cross-check. This position makes it easier for the flight lead to keep track of the wingman. The wingman should strive for 6,000 to 9,000 feet, not for the wingman's visual, but allowing the flight lead to check the wingman without having to search through many stars and/or cultural lights. As task level increases or maneuvering becomes more dynamic, the tendency is to fall aft. When the maneuvering settles down, the wingman should use power, including afterburner if required, and geometry to regain the LAB position. Turns are performed similar to daytime LAB formations with comm-in radio calls. (See **Figure 8.10**, Line Abreast.)

Figure 8.10 Line Abreast.

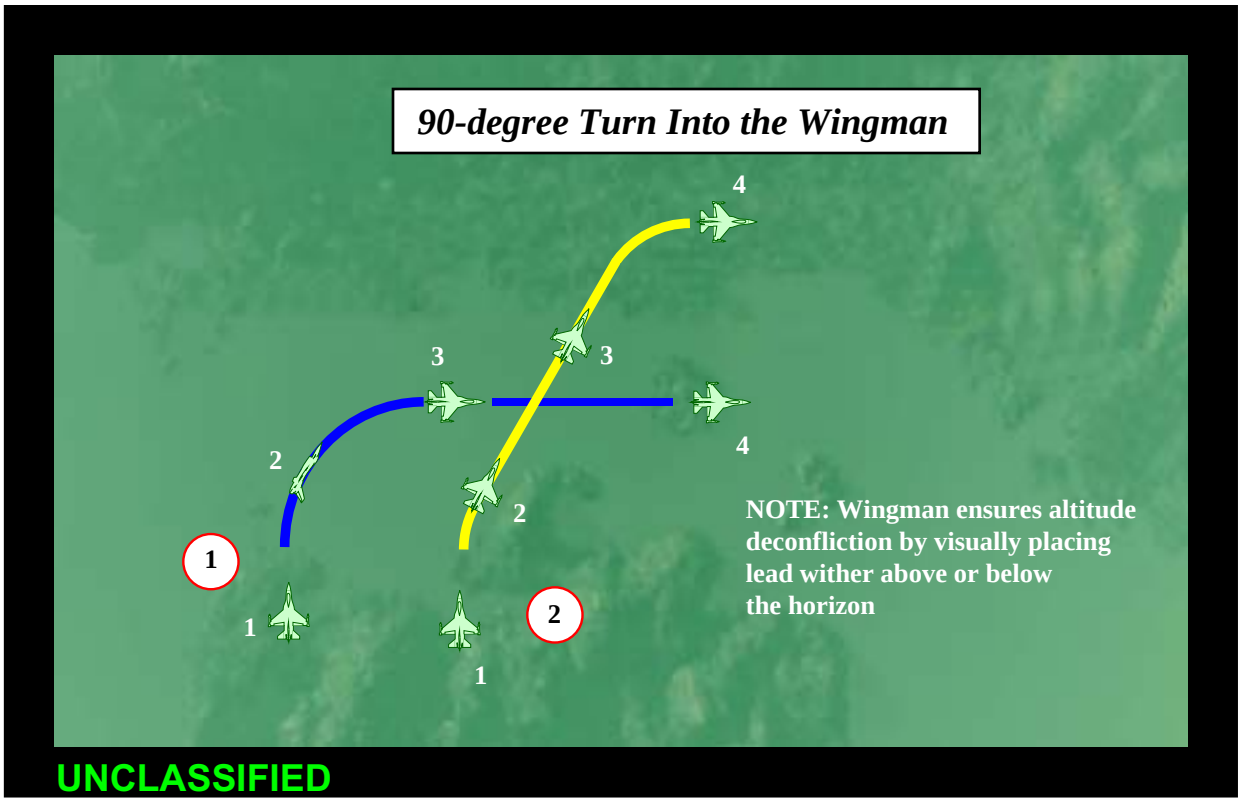


8.5.9 Line Abreast Formation Contracts. Flight lead calls turn direction and roll out heading ±10 degrees, holds pre-briefed airspeed ±20 knots, and calls updates with new parameters if required. Lead uses Mil power and G as required to hold airspeed and altitude. Wingmen attempt to match leads turn and are responsible for flight path deconfliction. Check turns and wing flashes by the flight lead will be difficult for the wingman to notice. Directive radio calls are the most positive method to initiate a turn.

8.5.9.1 LAB Fluid Turn. See **Figure 8.11**, 90-Degree Turn into the Wingman, for a Fluid Turn example. The wingman ensures altitude deconfliction by visually placing the flight lead above or below the horizon (while keeping the horizon in sight) and flies a normal tactical turn. Once rolled out, the wingman uses the light references and A/A TACAN to cor-

rect any spacing deviations. Radio calls referencing the turn and roll-out headings are helpful for the wingman. For example, “VIPER 1, 90 LEFT, REFERENCE 240."

Figure 8.11 90-Degree Turn Into the Wingman.



8.5.9.2 LAB l80-Degree Turn. See **Figure 8.12**, 180-Degree Turns, for an example. The wingman ensures altitude deconfliction by visually placing the flight lead above or below the horizon (while keeping the horizon in sight). For a 180-Degree Hook Away, the wingman must delay the turn to come out line abreast if starting the maneuver slightly swept aft. For a 180-Hook Into, the wingman immediately checks 45 degrees away from the flight lead and delays the turn (typically 5 seconds) until the flight lead is difficult to see. The wingman then completes the turn and kicks the flight lead across the tail to come out line abreast. The flight lead must temporarily ensure deconfliction halfway through the turn as the wingman loses the visual momentarily. Once rolled out, the wingman uses the light references and A/A TACAN to correct any spacing deviations. If the visual is lost upon roll out, expect a FLASH call or immediately execute the BLIND deconfliction plan.

8.5.10 Four-Ship Offset Box. The wingmen fly LAB. The trailing element lead flies 2 to 4 NM in trail of the lead element. The engine light from lead makes it easy for the aft element to remain visual with the lead element. Since range estimation can be difficult, A/A TACAN should be used between element leads. If A/A TACAN is not available, the radar can be used for station keeping. As a technique, wingmen fly tight two-ship LAB position (inside 6,000 feet) to ensure flight paths do not conflict with the other element. (See **Figure 8.13**, Four-Ship Offset Box.)

Figure 8.12 180-Degree Turns.

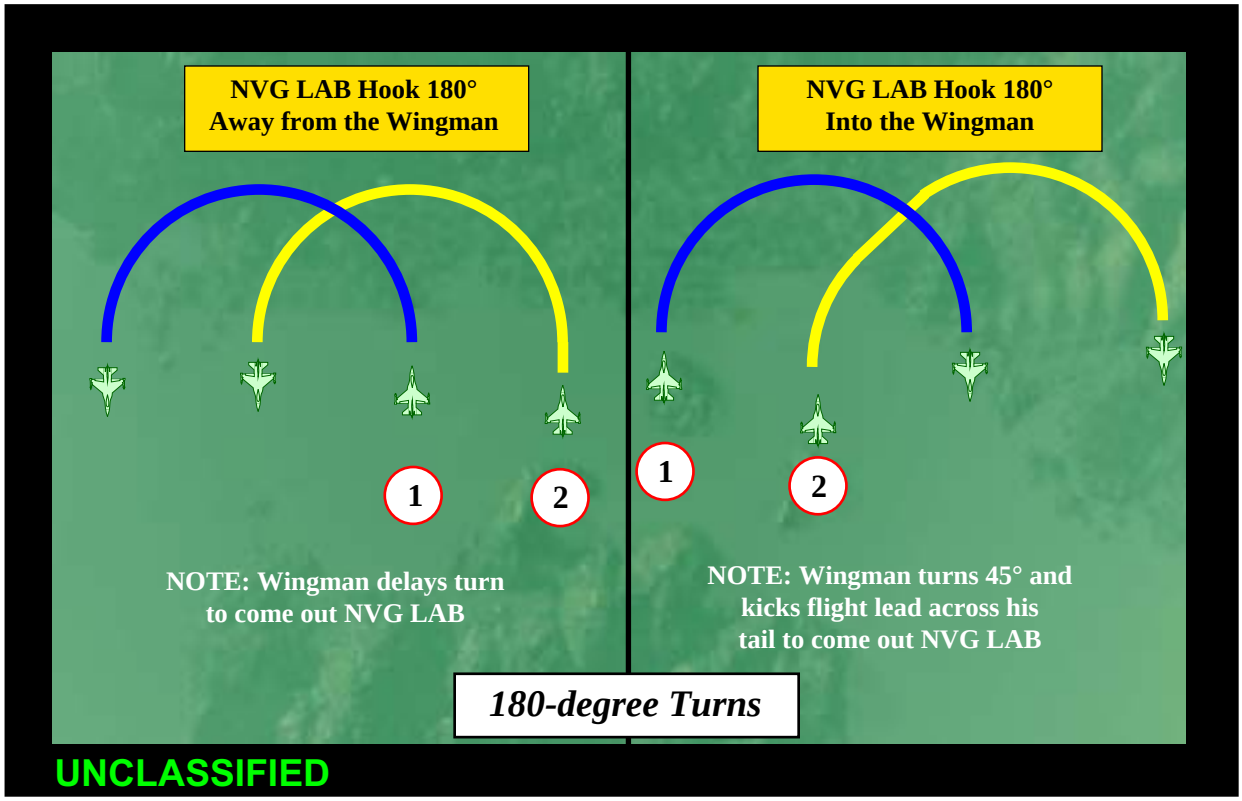
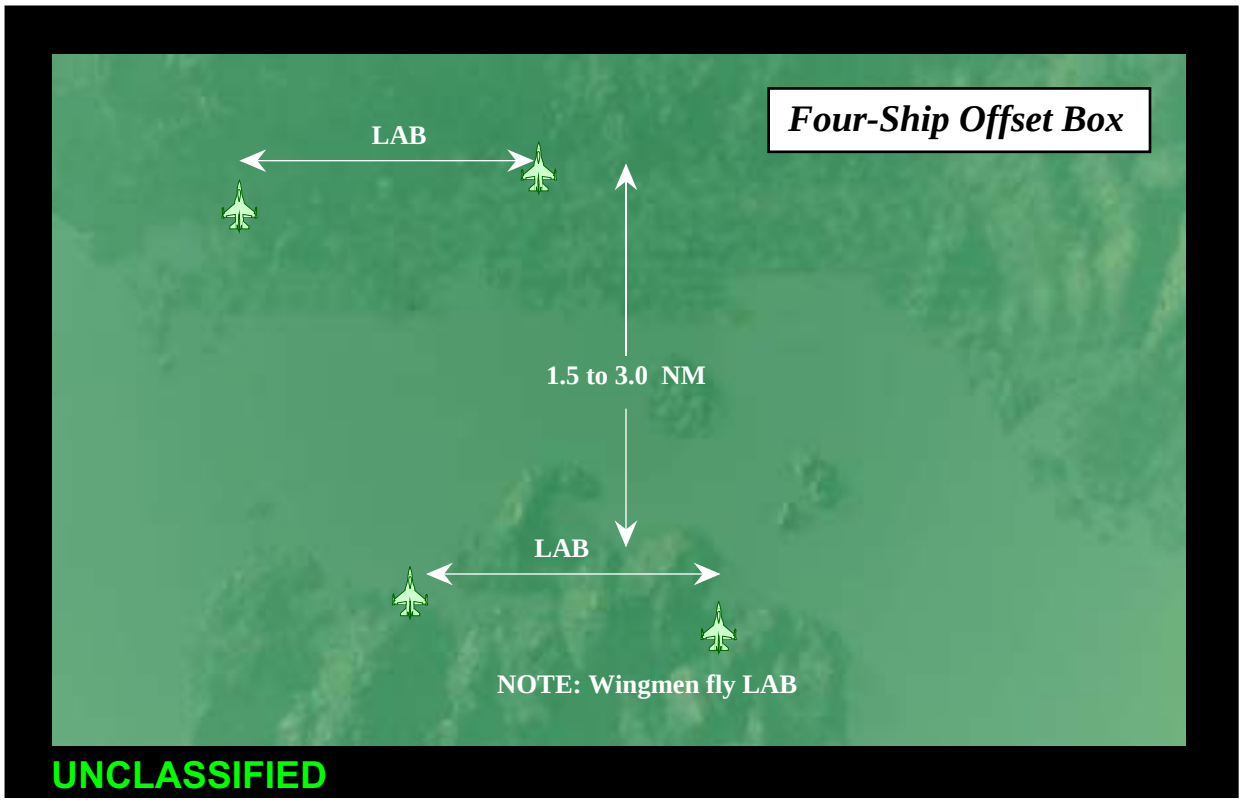
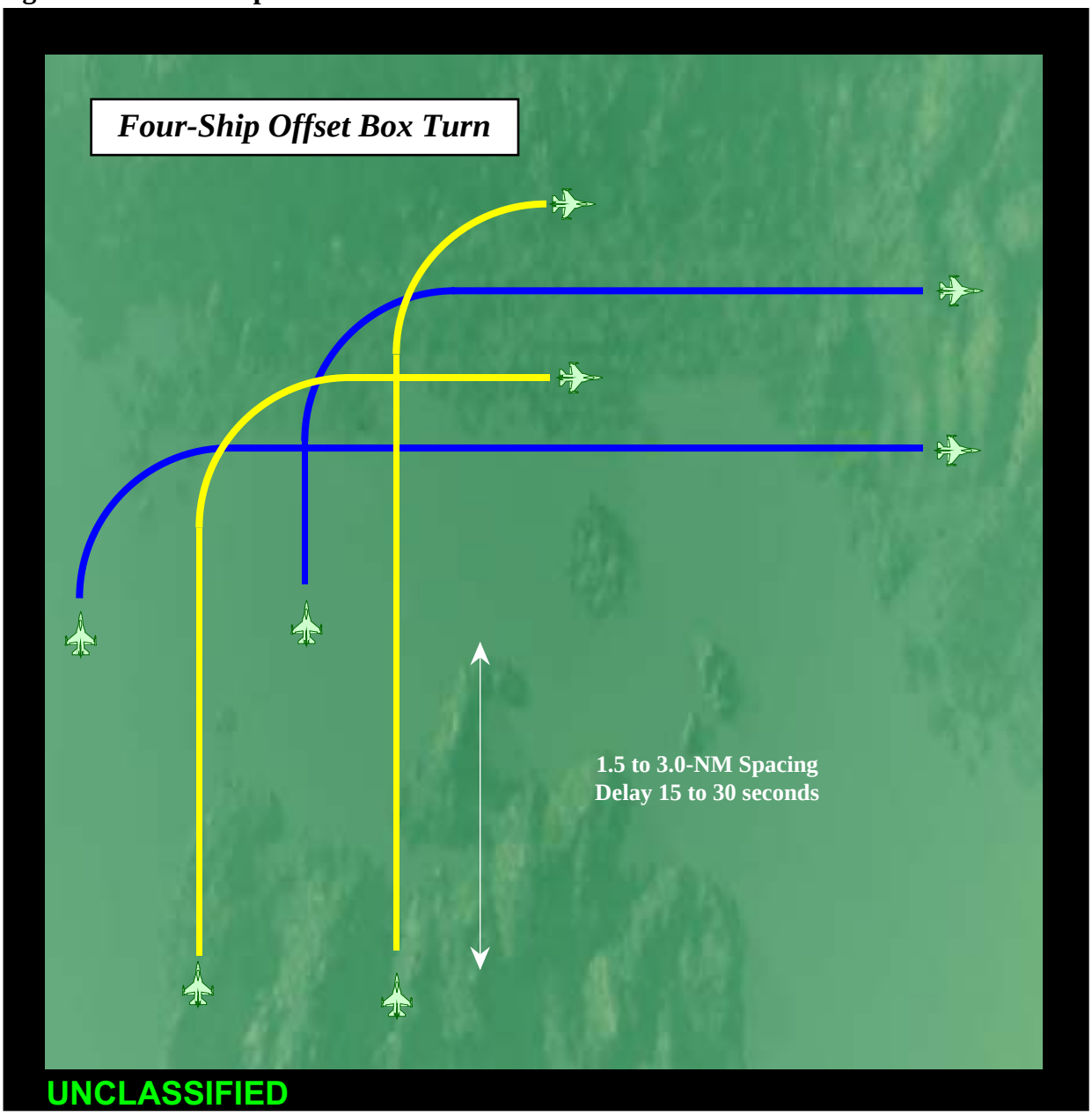


Figure 8.13 Four-Ship Offset Box.



8.5.11 Four-Ship Offset Box Turns. Each element makes a standard turn with the trailing element delaying approximately 15 to 30 seconds to allow for the 2 to 4 NM spacing behind the lead element. (See **Figure 8.14**, Four-Ship Offset Box Turn.)

Figure 8.14 Four-Ship Offset Box Turn.



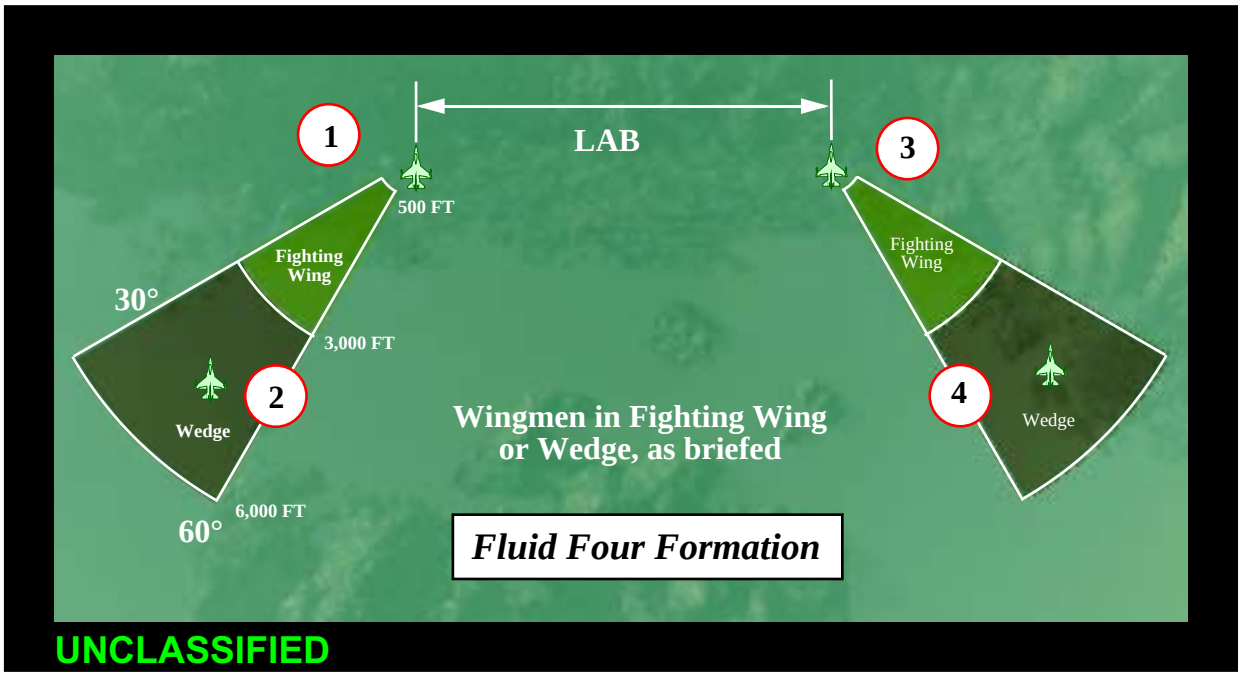
8.5.12 Fluid Four. Flight leads fly LAB and wingmen fly Fighting Wing or WEDGE, as briefed. (See **paragraph 8.5.6**, Fighting Wing.) The formation turns are the same as two-ship LAB between Number One and Number Three. Both wingmen maintain a tight, fighting wing position during the turns to prevent conflict with the other element. This formation can be useful for long, straight portions of flight and may be used to maintain position in certain A/A tactics. (See **Figure 8.15**, Fluid Four Formation.)

8.5.13 Night Vision Goggles Fluid Four Turns. All Fluid Four turns are performed as tactical turns between Number One and Number Three. As a technique it is easier to manage if Number Three is briefed to always go low or high. Wingmen can then fly lower/higher than their flight lead, providing more positive deconfliction as both elements cross flight paths during turns. Squadron standards should incorporate an NVG deconfliction plan as well as a standard exterior light plan for four-ship operations.

8.5.14 Lead Changes. The increase in wingman task loading during nighttime employment can require more lead changes. The flight lead's decision to pass the lead to the wingman is dependent on the tactical situation and the wingman's proficiency.

8.5.14.1 Flight Lead has a Visual on Wingman. The flight lead calls “CALL SIGN, LEAD LEFT/RIGHT” and expects a corresponding acknowledgment from the affected flight member. This relieves the wingman of deconfliction and formation responsibilities.

Figure 8.15 Fluid Four Formation.



8.5.14.2 Flight Lead is Blind on Wingman. The flight lead calls “CALL SIGN, BLIND, STANDBY LEAD LEFT/RIGHT.” This call is a request for the wingman to respond with position in relation to lead and be prepared to take the lead when the flight lead regains a visual. When the flight lead regains the visual, the lead will be passed as discussed in **paragraph 3.6.8.**, Lead Changes.

8.6 The LANTIRN System.

8.6.1 LANTIRN Description. The low-altitude navigation and targeting infrared for night (LANTIRN) system is a self-contained dual-pod system that provides the F-16 with a day/night/under-the-weather, low-level navigation, and precision air-to-surface weapons delivery capability. The terrain following radar (TFR) provides ground clearances for limited weather penetration capability during ingress and egress. F-16 LANTIRN aircraft can be employed

across the entire mission spectrum. The primary focus of this chapter is night, medium altitude, and laser-guided bomb (LGB) employment. See **paragraph 8.13** LANTIRN Employment for a discussion of low altitude specifics. The major areas covered are general LANTIRN mission planning considerations, night LANTIRN ground operations, cruise/en route sensor optimization, and LANTIRN attack planning considerations. LANTIRN considerations are addressed at the end of this chapter. Refer to AEM and appropriate Air Force instructions for further guidance.

8.6.2 LANTIRN Operations. LANTIRN operations consist of both the navigation pod (NVP) and targeting pod (TGP) unless specifically noted. While non-TFR operations can be conducted at or above the minimum safe altitude (MSA), the use of the TGP at night is restricted to use above 5,000 feet AGL for Category I pilots. During daytime operations, there is no altitude restriction for TGP use. Refer to appropriate instructions for TGP restrictions for Category II and III qualifications.

8.7 LANTIRN Mission Planning Considerations. A discussion of the general factors to be considered during the mission planning process is contained in **Chapter 5**, "Air-to-Surface." This section will discuss the mission planning considerations specific to F-16 LANTIRN missions.

8.7.1 Mission Preparation. Special planning considerations are driven primarily by the physics of the IR versus the visual light spectrum, and the limited field of view (FOV) of the LANTIRN system compared to the human eye. IR imagery is fully discussed in the MPM

8.7.2 Field of View Limitations. The NVP FOV (28 degrees horizontal x 21 degrees vertical) is adequate for navigation and target attack if the aircraft is positioned to center this FOV on turnpoints, IPs, and targets. The probability of successfully identifying a point drops off significantly if the point falls outside of the HUD FOV. To have a high probability of success, the system point of interest (SPI) (driven by inertial navigation system [INS], global positioning system [GPS], or sensor cueing) must be accurate within 0.2 to 0.3 NM. In the absence of GPS or DTS, frequent INS updates and altitude calibration (ACAL) are necessary to maintain system accuracy. In most cases, the TGP adequately compensates for this limitation in the NVP FOV.

8.7.3 LANTIRN Turnpoint Selection. In most cases, good visual turnpoints make good forward-looking infrared (FLIR) turnpoints. The two ingredients of valid FLIR turnpoints are IR contrast and vertical development. It is best to have both, but as a rule, IR contrast is the most important. Accuracy of coordinates is critical in mission planning. Ideally, the pilot would have high confidence in the coordinate accuracy of each point on the route, so that if the INS started drifting, the pilot could update the system solution at any time. Because of the time it takes to derive mensurated coordinates using systems like the Analytical Photogrammetric Positioning System (APPS), this will require a substantial amount of pre-planning by units in their expected area of employment if they are to be responsive to short-notice tasking. The integration of FalconView into current mission planning software, as well as systems such as DewDrop, allows planners to easily achieve the desired level of accuracy for steerpoint data. While not technically mensurated, these systems can achieve accuracy to within 5 meters or less.

8.7.3.1 As a general rule, try to ensure that a readily identifiable LANTIRN turnpoint is along the ingress route at least every 10 minutes of flight. A precise update is needed if the system is off by more than 0.1 to 0.3 NM. GPS and/or DTS, especially at lower altitude, is mission critical. Without it, pilot work load is greatly increased. Ensure that a radar significant turnpoint or offset aimpoint (OAP) is available somewhere along the route (where cockpit tasking is low), and at the IP (for a "last chance" update, prior to weapons employment). This provides an acceptable opportunity to verify and correct the navigation solution if the TGP is inoperative or the steerpoint is obscured by weather.

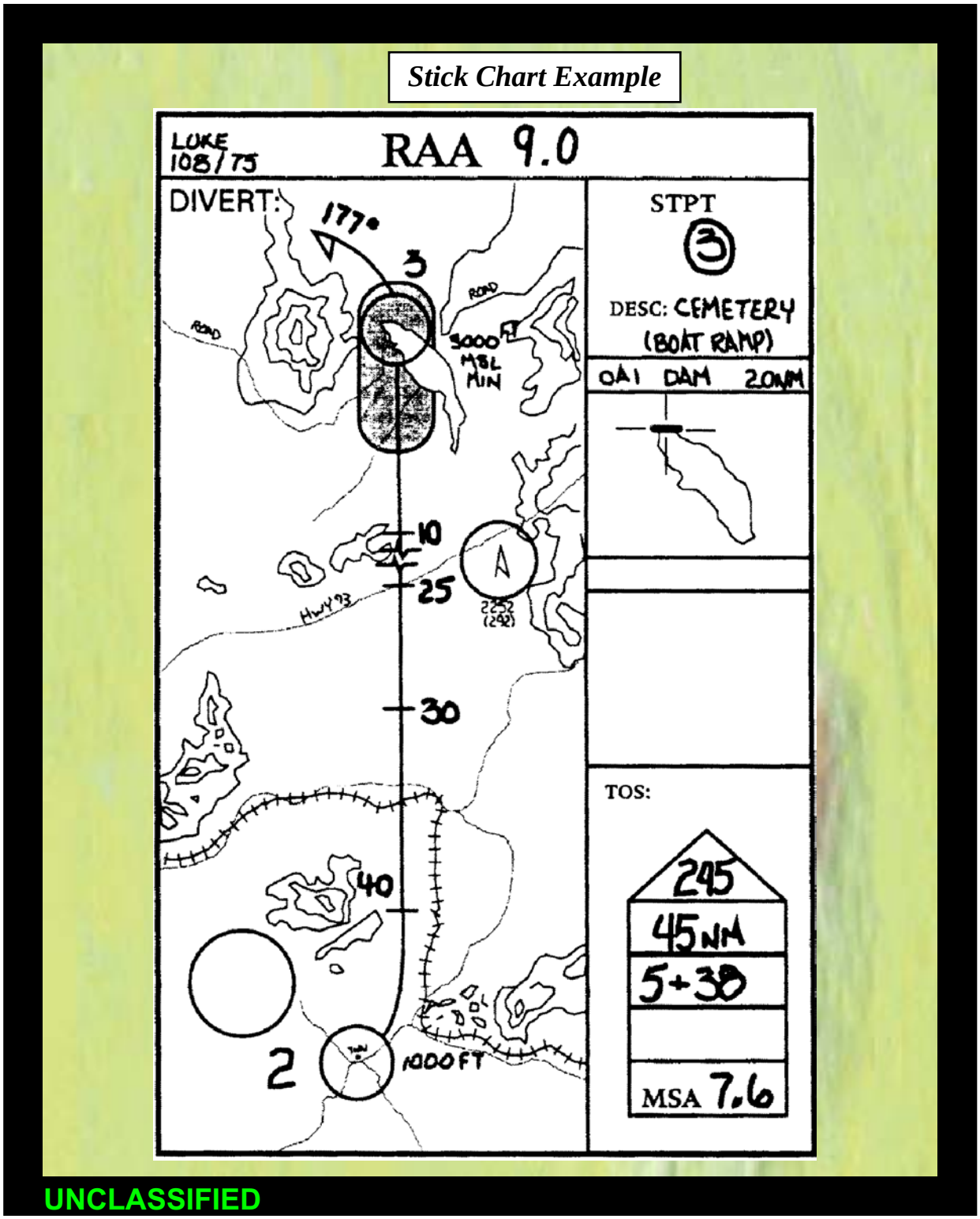
8.7.3.2 Navigating using a typical visual flight reference (VFR) map becomes unmanageable at night with lower cockpit lighting. Stick charts are used as a refresher to route study. Stick charts do not remove the, requirements to carry a VFR map. Development of a stick chart is an individual process to aid in mission study and in-flight reference. Each pilot has a different idea of what is significant for each leg of the route. However, the minimum items normally included on the map are times, distances, headings, attack parameters, route abort altitude (RAA), and MSA. Optional data on the stick chart includes significant points, obstacles, and any required cockpit tasks or useful information. **Figure 8.16**, Stick Chart Example, shows a typical hand-drawn stick figure map.

8.7.3.3 LANTIRN missions require extensive use of the slew controller in the A/G mode. The reliance on radar significant turnpoints, use of the snap look function of the NVP FLIR, and TGP slewing have the potential to corrupt the cursor deltas. Therefore, with a high-system accuracy (HIGH/HIGH), it is important to cursor zero (CZ) often. In most cases, with a HIGH/HIGH, it is advisable not to input any slews into the system if the turnpoint can be identified in the FOV of the sensor. If slews are input and a high system accuracy can be verified, the habit pattern of TMS AFT, CZ, and wide field of view (WFOV) (often called the TGP CAPS) should be continued along the route to subsequent steerpoints.

8.7.3.4 Given INS system accuracy without automatic GPS/DTS updates (0.8 NM per hour specification), an INS performing at factory specifications will require updates approximately every 15 minutes. Performing an enhanced interrupted alignment (EIA) on a Ring Laser Gyro (RLG)-equipped F-16 can increase this accuracy to 0.5 NM per hour. You should do an EIA on every mission if conditions allow. RLGs with eight good EIAs stored in memory bias could be accurate to 0.2 to 0.3 NM per hour. Additionally, the accuracy of the system altitude will affect weapons delivery calculations and TGP vertical pointing angles. Both the system altitude and the INS present position should be kept as accurate as possible; however, only perform "fixes" if system inaccuracy can be verified.

8.7.4 Weather Support. To help interpret the IR scene, LANTIRN pilots require IR information, such as absolute humidity, and Delta T values, in addition to conventional weather data. The weather service has developed a tactical decision aid (TDA) to provide this support.

Figure 8.16 Stick Chart Example.



8.7.4.1 To compute a TDA, the weather forecaster must know the target location and description, time over target (TOT), acquisition and weapon release altitude, expected attack axis, and the background characteristics of the target. This information is provided

by the pilot or by intelligence personnel. During contingency operations, a planning forecast of IR conditions within given geographical areas during specific time periods will be available to assist wing and squadron mission planners. This forecast would include expected acquisition and lock-on ranges, thermal contrast, and the polarity of previously agreed upon targets.

8.7.4.2 TDA information should include the following:

- Maximum TGP/AGM-65D/G acquisition range at given altitude.
- Maximum TGP/AGM-65D/G lock-on range at given altitude.
- Maximum laser designation and detection range.
- Maximum LGB seeker detection range.
- IR polarity (target hotter or colder than background) at acquisition/lock-on.
- Apparent thermal contrast (degree to which the target is distinguishable from background) at acquisition range.
- Optimum attack axis for maximum range acquisition and lock-on.

8.7.5 Environmental Considerations.

8.7.5.1 Weather. Weather has a great effect on the IR scene, as well as IR seeker performance. Clear skies, precipitation, clouds, wind, and previous weather affect FLIR detection ranges and laser performance.

8.7.5.2 Clear Skies. At night, rapid radiation cooling increases thermal contrast. Targets and backgrounds with low-thermal inertia cool rapidly at night. Those with high-thermal inertia retain much of the heat gained during the day.

8.7.5.3 Precipitation. Water vapor in the form of rain, snow, clouds, and fog, absorbs IR radiation and scatters thermal energy, thereby, reducing acquisition range. Rain and snow reduce the transmission of IR energy and decrease apparent Delta T. Delta T gradually decreases as precipitation continues to fall. Falling precipitation restricts IR detection more severely than that which has already fallen. Solar and friction heated target features suffer the most heat loss. Friction heat loss is caused by water and mud accumulating on tracks and wheels. Heated areas stand out more clearly against cool and washed-out backgrounds. Rain affects horizontal surfaces more than vertical surfaces. The types of material in the target area will magnify rain effects. Porous materials soak up water and take longer to dry than nonporous materials. At low viewing angles, snow reflects the sky temperature and appears cold on the display. Under clouded skies, at lower altitudes, snow reflects warm clouds, which emit absorbed solar radiation. Snow appears warm under this condition. Previous weather can have a tremendous impact on thermal contrast and must be considered in mission planning. A recent rain or snow shower can wash out the thermal contrast of the target and background.

8.7.5.4 Clouds. Clouds directly affect LANTIRN operations since as previously discussed, they can block IR energy. Cloud-free line of sight (LOS) is required to see the target. When using the TGP, LOS must be maintained or the TGP will either break lock or transfer lock to a cloud. Overcast weather effects the IR visibility beneath by reducing temperature contrasts. During a LANTIRN delivery, if clouds become a factor (obscuring

the target or driving the TGP into rates), a good technique is to TMS AFT, CZ, and WFOV (TGP CAPS) to return the TGP to the correct steerpoint.

8.7.5.5 Wind. Wind reduces the Delta T between the target and background. The higher the wind speed, the less the Delta T. Targets and backgrounds with low-thermal inertia are more sensitive to wind than those with high-thermal inertia. The greatest change in temperature occurs when wind speed increases from 0 to 5 knots. Wind also affects LGB delivery and trajectory, during the terminal phase. For detailed information on wind effects on the LGB, reference the AEM

8.7.6 Mission Materials. Cockpit management is a critical part of flying the LANTIRN mission. Pilots must be very familiar with their planned route prior to flying a night LANTIRN mission. Reduced-scale copy (shrunk down on the photocopier) mission materials are difficult to read at night and require additional heads down time. Ensure all copies of mission products are legible and minimize the number of mission products to only those required to accomplish the mission. The following mission materials are considered to be mission critical: mission data card, route map, attack profile, and target photographs (one big-to-small and one close-up of the desired means point of impact [DMPI]).

8.7.7 Targeting. With the LANTIRN system, plan missions against targets that are geographically and IR significant. LANTIRN depends on thermal contrast between the target and background, as opposed to visual contrast, for target acquisition. In general, a high Delta T (defined as the target IR signature is significantly different than that of its background and shows up clearly in an IR sensor) target can be acquired at longer ranges and with more ease than a target with a low Delta T. The probability of mission success is reduced when choosing a standoff delivery against a target with both low transmissivity and Delta T. Weapons used during day operations are equally effective for night operations; however, FLIR limitations and their impact on accuracy (resolution and boresight errors) must be considered when choosing a munition. PGMs should be considered a higher priority than general purpose (GP) bombs for the LANTIRN mission when the TGP is available. For a detailed LANTIRN weaponeering discussion, reference the AEM

8.8 LANTIRN Ground Operations. The night LANTIRN preflight presents some interesting challenges. Due to the requirement to use a flashlight and spend more time looking at each preflight item, it is a slower process. Preflight of the TGP should ensure that the laser is set to either COMBAT or TRAINING, as required. With actual LGBs, ensure the laser code is properly set on both the guidance kit on the bomb and in the UFC. Check the left and right hardpoint correction coefficients in the aircraft forms and verify the correct data is input in the FCC.

8.8.1 After Start. Ground operations and checklist procedures are essentially the same as daytime operations. After the SEC and EPU checks, turn on all avionics and sensor power. Once the left hardpoint is powered on, select STBY on the FLIR MFD page to begin the time-in process. Reduce lighting as much as practical as the eyes start to adjust to the night lighting. However, cockpit lighting during a LANTIRN mission will still be considerable due to the bright video displays of the FLIR, TGP, and Maverick. The key is take the time to set the desired brightness during ground operations to prevent distraction from a bright MFD once airborne.

8.8.2 Function Checks and Setup. Function checks verify initial sensor operation. Function checks include sensor built-in test (BIT) checks and sensor operation checks.

8.8.2.1 BIT Checks. During the time-in process, all sensors perform a start-up BIT. (**Table 8.2**, BIT Checks.) Additionally, pilot initiated BIT checks should be performed to enhance the start-up BIT. The FLIR and TGP should be BIT checked on every night sortie, and the radar altimeter (RALT) and TFR should be BIT checked if planning to fly low altitude using the TFR. BITs can be accomplished as soon as the "not timed out" messages are out of the MFD displays.

Table 8.2 BIT Checks.

Display	Time	Description
FLIR	15 to 30 seconds	After FLIR BIT selection on the TEST page, go back to the FLIR page to ensure the BIT takes place. This can be verified by BIT in place of STBY in the upper left-hand of the MFD. During the FLIR BIT you will see an IR picture and then the MFD will flash.
TGP	80 seconds	Prior to initiating the BIT, unstow the TGP. Ensure the laser is armed in order to verify proper laser function. At completion of the BIT, stow the TGP and safe the laser. **NOTE:** The laser will only fire in the training mode during the BIT check regardless of the actual setting on the TGP itself. Focusing the TGP on the ground is good for an initial hack to get the TGP focus close, but should never be the final focus attempt. Always plan to accomplish an airborne TGP focus on steerpoints prior to the FLOT/FEBA.
RALT	3 to 5 seconds	The display on the test page will go from 0 to 300. When the RALT de-highlights, the BIT is complete.
TFR	1 minute	Like the FLIR BIT, after BIT selection go to the TFR page and confirm BIT in the upper left-hand of the MFD.
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8.8.2.2 Sensor Operation Check/Setup. See **Table 8.3**, Sensor Operation Check/Setup, for detailed information.

8.8.2.3 Systems Setup. After tuning and boresighting the various pods and systems, ensure all systems are appropriately set up for the mission. Do not forget to set the desired laser code and laser start time in the UFC. MFD setup is an important habit pattern to develop. The primary logic in setting up the MFDs is to keep MFD pages in the same position as much as possible. The following medium-altitude MFD setup optimizes standard setup and allows hands-on operation during time-critical periods. This technique is geared toward LGB employment, but also lends itself to Maverick employment. (See **Table 8.4**, MFD Setup.)

Table 8.3 Sensor Operation Check/Setup.

Display	Description
FLIR	The FLIR must be checked for proper operation prior to flight. The BIT checks the actual NVP FLIR itself, but its' operation must be verified in both the MFD and the HUD. Ensure FLIR video is present in both the MFD and the HUD. Accomplish initial FLIR tuning IAW the Dash 34. Once initial tuning is complete, set the FLIR polarity as desired. In most cases, it is advisable to set the polarity to white hot (WHOT) to view hot objects as white. This will assist in achieving a FLIR boresight, since most objects at night that are visible with the naked eye tend to be heated objects (lights, the tower, and another aircraft's exhaust plume). It also matches most IR Maverick displays. Once airborne, adjust the brightness and contrast for comfort and terrain resolution. Adjust the Level and Gain as required to fine-tune the FLIR. In most cases, running with the FLIR in AUTO provides sufficient Gain and Level to accomplish the mission. In higher humidity environments, and for continuously computed impact point (CCIP) deliveries at night, it is important to achieve the best Gain/Level adjustment to ensure target features are identifiable in the FLIR image.
FLIR BSGT	Accomplish IAW the Dash 34. Often the FLIR can be boresighted on the ground if sufficient visual references are available to compare with the FLIR image. Parallax errors for images close to the F-16 tend to decrease the effectiveness of the ground boresight (only in the horizontal axis). As a general rule of thumb for objects greater than 6,000 feet, a ground boresight provides sufficient accuracy to transition to in-flight FLIR use. The most accurate FLIR boresight is an airborne boresight. An airborne boresight is accomplished by selecting BSGT on the FLIR MFD page and slewing the hot spot of the preceding aircraft so it is just slightly below the tail light (with the aircraft centered in the HUD while in straight and level flight). Select the boresight function with the symbology in the area of the HUD where the expected bombing solution occurs. A boresight can also be accomplished on objects on the ground, however, sufficient visual references must be available to ensure an accurate boresight.
TGP	TGP operation can be verified by entering the A/G master mode and selecting DTOS. Verify the TGP slaves to the DTOS container and the SOI changes to TGP when you DMS AFT. Once the sensor of interest (SOI) is in the TGP, verify proper operation of the polarity and FOV functions. In many cases, operating the TGP in AUTO will provide sufficient scene detail to identify turnpoints and the target. However, since the quality of the FLIR image is very much a function of absolute humidity, the FLIR image can be improved by manually adjusting the Gain (and sometimes Level), as well as adjusting the brightness and contrast. Once airborne, select a steerpoint to optimize the TGP FLIR image. Focusing the TGP on the ground is not recommended. Accomplish a TGP focus while airborne.
MAV BSGT	The Maverick boresight is exactly the same as daytime operations. At night, however, sufficient visual references must be available to ensure the TD container in the HUD matches the IR image in the Maverick. Point track the TGP on an object to verify missile boresight correlation operation. If required, change the SOI to the MAV and manually slew and track the same object prior to pressing the BSGT OSB on the WPN page. Verify operation/ boresight of both missiles, if applicable. Prior to turning MAV power OFF, set the desired polarity (HOC/COH/AREA) and FOV. MAV must be timed in and the Ground Jettison switch must be in ENABLE to view Maverick video prior to accomplishing a boresight.
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Table 8.4 MFD Setup.

Master Mode	Left MFD			Right MFD		
NAV	FCR(1)	TGP(2)	FLIR	SMS	TEST(2)	HSD(1)
A/A	FCR(1)			SMS	TGP	HSD(1)
A/G	FCR	TGP(1)		SMS(1)	WPN(2)	HSD

NOTES:

(1) Displayed front page of the MFD (i.e., page showing on MFD).

(2) May be the displayed front page, depending on the phase of the mission.

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8.8.2.4 Consistency and Sensor of Interest (SOI) Management. The reasoning behind this setup is to always have the sensors in the same spot on the MFD rotary as much as possible (habit patterns). In addition, this consistency allows the brightness and contrast of MFD pages to be optimized for each specific sensor. Also, minimizing the number of actual pages on the MFDs reduces the possibility of self-induced SOI errors and the requirement to DMS left/right. For A/G operations, with horizontal situation display (HSD) and weapon (WPN) moved to the right MFD, the SOI automatically initializes to the TGP in the left (primary cueing sensor). This also allows hands-on SMS corrections without having to take your hand off the stick. When the ground map (GM) radar is desired, DMS left, then transfer the SOI to the radar (DMS AFT). For AGM-65D/G operations, WPN on the right MFD also allows the pilot to view both sensors (TGP and MAV) simultaneously and affords the capability to monitor missile boresight correlation. Since the FLIR is usually displayed in the HUD, there is no reason for the FLIR to be on any MFD, other than when in the NAV Mode (same philosophy for the TEST page). For A/A operations, once the SMS is set-up appropriately, there is no requirement for the SMS to be displayed. Any A/A SMS change requirements are usually indicated visually in the head-up display (HUD) (i.e., wrong missile is selected).

- Delete WPN from A/G master mode MFD page if a Maverick is not carried.
- In NAV and A/G master modes, use the A/G mode of the TGP.
- Administrative MFD pages such as data transfer equipment (DTE), TEST, and flight control system (FLCS) can be placed in open slots at pilot preference. However, it is recommended that they not be located in either A/A or A/G master modes where they may force an extra DMS left or right to get to a more important MFD page.
- The specific order on each MFD is not as important as priority. Ensure that one DMS left or right moves from the primary option on that MFD to the secondary option. Obviously if there are only two options on the MFD, there is not a problem.
- For low-altitude TFR operations, put the TFR MFD page where it can be monitored to the maximum extent possible.
- The FLIR page may be blanked after required FLIR tuning and boresighting are complete.

8.9 LANTIRN En Route Considerations. En route tasks are no less important for a night mission than for day. All the same day considerations apply during the night; however, they are complicated by an inability to "look outside the cockpit" and the lack of true visual mutual support (unless NVGs are employed). The en route tasks fall under three general categories: Navigation, marshaling/holding, and ingress/egress.

8.9.1 Navigation. Navigation is more difficult at night and requires a greater dependence on an accurate system solution. Additionally, night formation contracts are extremely important, since trailing flight members are relying entirely on aircraft systems for station keeping. Altitude, heading, and airspeed contracts must be thoroughly briefed and understood in order to ensure mutual support and deconfliction.

8.9.1.1 System Updates. In order to achieve successful mission results at night, each flight member must monitor and correct individual system performance. During the mission planning process, enough steerpoints should be selected prior to the actual "Push" point in order to allow all flight members the opportunity to accomplish required navigation system updates, weapons checks (including laser check), and TGP tuning and focusing.

8.9.1.2 Sensor Tuning. In order to ensure the ability to find and destroy the target, cueing sensors must be tuned optimally. For TGP operations, select a steerpoint that adequately resembles the target. Plan on focusing the TGP in WIDE, and NARO. The TGP has two sets of lenses (one for WIDE and one for NARO/EXP), so both must be focused. Starting at a point where target acquisition in WFOV is anticipated, AREA track the steerpoint and turn on the "grey scales" in the TGP. Now use the slew button on the throttle to adjust the focus of the TGP. Change to NARO at a point approaching release slant range and focus the NARO lens. Since EXP uses the same lens as NARO, the final focus should be in either NARO or EXP based upon which model will be used during the terminal lase. Generally, focus the TGP in WIDE from 12 to 10 NM, an NARO at 7.5 NM. Subsequent steerpoints should be used to continue to fine-tune the Gain/Level requirements and focus of the TGP. Ensure the grey scales are off when focusing is complete. With a high system accuracy, TMS AFT, CZ, WFOV (TGP CAPS) to reduce the possibility of self-induced system errors. For fire control radar (FCR) operations, set the Gain/Level to provide optimum target/offset resolution and still allow accurate cursor positioning. Adjust the brightness to comfort.

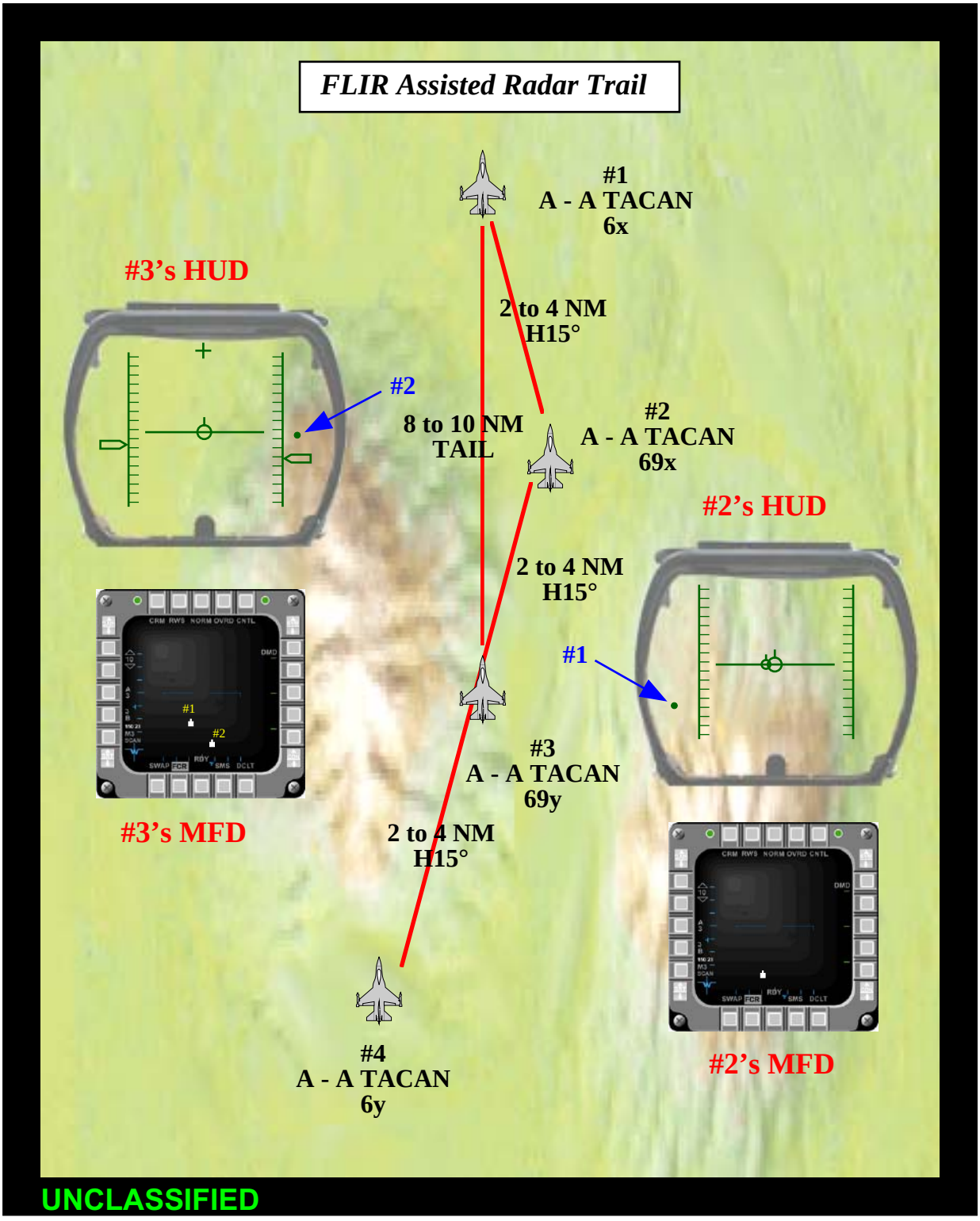
8.9.1.3 MFD Tuning. It is critically important that the pilot not only tune the internal TGP (auto versus manual gains), but also tune the MFD itself. Call up the TGP gray scale and use the MFD brightness and contrast rocker switches to ensure the MFD is displaying all shades of green in the scale and adjust the picture to enhance target area acquisition.

8.9.1.4 Formations (Non-NVG-equipped). Generally, en route admin formations should be relatively fluid, requiring minimum station keeping efforts, yet still provide acceptable mutual support. A technique is to fly a FLIR Assisted Radar Trail formation to keep wingmen close and still allow IR deconfliction by the trailing element. (See **Figure 8.17**, FLIR Assisted Radar Trail.) Spacing between flight leads and wingmen of 2 to 4 NM and offset up to 15 degrees (horizontal offset in the FLIR) allows adequate opportunity to accomplish navigation tasks and still allow time to monitor and correct spacing errors. Typically, night A/A TACAN plans tie elements together (Number One to Number Two and Number Three

to Number Four). Thus, wingmen have both the A/A TACAN and their radar to monitor range, while keeping visual using the FLIR. Positioning the preceding flight member just outside of the altitude or velocity scale in the HUD gives the desired horizontal offset. The trailing element lead can use the FLIR to monitor the preceding aircraft and maintain spacing by keeping the lead aircraft 8 to 10 NM on the radar. Altitude deconfliction is especially critical while flying in close proximity to other aircraft at night. While altitude deconfliction is not required if a pilot is "FLIR visual," sanctuary altitudes must be briefed to ensure deconfliction when flight members are not visual. A technique is to use 1,000 feet of separation (within the block) between flight members and stack high to low as a default deconfliction method. This allows trailing flight members to keep aircraft in front of them above the ground clutter. For example, if cruising in the 20,000- to 24,000-foot block, Number One would default to 24,000 feet, Number Two to 23,000 feet, Number Three to 22,000 feet, and Number Four to 21,000 feet. Flying the correct contracts in airspeed and turns are critical to staying in FLIR Trail formation. The radar and A/A TACAN are primary references to keeping "FLIR visual." If the formation deviates outside briefed ranges, make a "STRIPPED NEAR" or "STRIPPED FAR" call as appropriate. The FLIR visual is often lost during turns and at other momentary times, but should be quickly regained after completing the turn. If the A/A TACAN and radar do not agree in range and the preceding aircraft is not visible in the FLIR, transmit "BLIND" with altitude and immediately deconflict aircraft. Regaining a safe FLIR Trail now becomes a top priority.

8.9.2 Marshaling/Holding. Typically, any plan with specific TOT contracts will require some form of force marshaling or holding. Marshal/hold points may be geographically and/or vertically deconflicted. Strict adherence to briefed contracts is critical, especially at night, to avoid conflicts within and between flights. For ease of maneuvering, maintaining the 2 to 4 NM Trail formation among all flight members allows the opportunity to keep the flight together as long as possible and minimizes deconfliction issues. Turns are generally comm-in on the discrete frequency. Blind deconfliction contracts must be adhered to since 180-degree turns at each end of the circuit will take preceding aircraft out of the HUD FLIR FOV until the turn is completed. The change to the ingress formation can be accomplished via either circuit timing extension or airspeed differentials to open the range between elements (if required). Aggressive maneuvering to open spacing should be avoided to reduce the possibility of wingmen losing FLIR visual and SA, as well as the possibility of spatial disorientation. When selecting a marshal/hold point, consider selecting a point which will allow a system update and sensor tuning in case the flight was forced to proceed directly to the hold point with no opportunity to accomplish the previously mentioned system/sensor tasks.

Figure 8.17 FLIR Assisted Radar Trail.



8.9.3 Ingress and Egress. Ingress and egress tactical considerations are exactly the same as in the day. Weather, threat layout, package composition/routing, support assets, and weaponeering are still the driving factors affecting the ingress and egress phase. The ingress and

egress at night are complicated by the fact a non-NVG-equipped pilot is literally blind except through the narrow field of view (FOV) capability of the FLIR. Use of the radar and A/A TACAN is critical to maintain SA on the events occurring around and within the flight. Communication and maneuvering contracts are even more important at night than in the day. Threat reactions require disciplined communication and contract execution in order to maintain positional SA within the flight. Refer to the AEM for a detailed description of night threat reaction considerations. One of the most important considerations for night threat reactions is a well-thought-out blind/separated flight reform plan.

8.10 LANTIRN Attack Mission Planning Considerations.

8.10.1 Assumptions. In most cases, the TGP will be the primary cueing sensor for all A/S weapons, due to the capability to precisely cue steering commands and the increased accuracy of laser ranging. The GM radar, while arguably a viable tool, is a backup capability and its' utility will be a function of the weapon being employed and/or the capability to directly aim at the target. For system deliveries using radar cueing, two radar significant offset aimpoints (OAP) near the target usually offer the greatest chance for success. Ideally, one OAP should be long of the target and one short of the target. Each should be offset from the ingress axis (to allow DBS) and they should lie on opposite sides of the ingress axis. This provides maximum flexibility in a radar jamming environment. Additionally, though generally ROE dependant, delivering unguided ordnance with a full-up system (HIGH/HIGH) and mensurated coordinates may be preferred over system deliveries using the radar for cueing.

8.10.2 Unguided Weapon Operations. Flying at medium altitude significantly reduces workload and may increase target acquisition range. The NVP, used by itself, has less potential for medium-altitude employment. The FLIR video on the HUD has lower resolution than the TGP display and the problem is compounded by longer slant ranges. For example, the slant range at which the center of the HUD FOV intersects the ground is 0.3 NM at 200 feet and 34 NM at 20,000 feet. The bottom of the HUD FOV (closest point) intersects at 0.1 NM and 12.0 NM, respectively. Recognition of only very large, thermally significant targets will occur at long slant ranges. However, medium altitude slant ranges are reduced significantly after roll-in for a dive delivery (3.3 NM from 30 degrees dive at 10,000 feet AGL), and the HUD can then be used to accomplish target acquisition and weapon delivery. Laser ranging using the TGP can help increase the accuracy of standoff deliveries such as loft as well as traditional level or diving deliveries.

8.10.2.1 Employment Considerations. Other considerations for medium-altitude unguided weapon employment are FLIR boresight, FLIR visibility, and winds. If TGP-equipped, the TGP can aid in DMPI acquisition and range update with both passive and laser ranging. GPS/DTS enhances system and weapons delivery accuracy.

8.10.2.1.1 FLIR Boresight. If performing a FLIR-assisted delivery (i.e., no TGP available), check the FLIR boresight during holding or ingress. Since the FLIR is normally boresighted to the top of the HUD on the ground, a FLIR boresight error may be noticed while airborne. The flight lead can establish a straight and level leg for flight members to perform a FLIR boresight update on the preceding aircraft.

8.10.2.1.2 Sensor Bombing. Due to increased slant ranges and a combination of aircraft boresight errors, FLIR boresight errors, and small target size in the FLIR, a TGP, GPS, or fixed target track (FTT)-aided continuously computed release point (CCRP) delivery is more accurate than a CCIP FLIR delivery from medium altitude. To increase accuracy with CCRP, perform a ramp-down delivery to a 15 to 30 degree dive decreasing the slant range at release. The GMT/GMTT radar mode using a CCRP delivery is very effective from medium altitude when area munitions are used. For moving targets, the GMTT mode will provide lead steering based on the target's speed and direction of travel, while the CCIP mode requires the pilot to determine an appropriate lead point.

8.10.2.1.3 Common Errors. A common error during medium-altitude level CCRP deliveries is not anticipating the release point resulting in a late pickle, since the release point will be much further from the target at medium altitude. Cease all updates 2 NM prior to this point so there is time to center up the steering prior to release. If the actual flight level winds are predicted to be high, plan the attack to minimize crosswind effects. Allowing significant crosswinds to blow the F-16 off CCRP steering can prevent a release if the FCC computes the bombs will miss the target by more than 5,000 feet laterally. Consider using drift cut-out during strong winds at release altitude to help get on steering. If possible, plan to attack with a tailwind to increase ground speed (GS). This will decrease exposure time to threats and minimize crosswind effects.

8.10.2.1.4 Delivery Parameters. For CCIP deliveries, maintain a stable G to stabilize the weapon solution. After pickle, continue to follow the vertical steering until bomb release. Do not exceed ops limits or stores release G. Target egress considerations are identical to other deliveries. With the reduced weight, climb to a higher altitude on egress for threat and fuel considerations, if possible.

8.10.2.2 Targeting Pod Pacing. Delivery of conventional ballistic bombs and cluster munitions at medium altitude is enhanced and simplified with the addition of the TGP. A CCRP solution may be obtained through point or area track of the target. In a fluid environment (targets in area, but precise coordinates unknown), Doppler beam sharpening (DBS) may provide initial target locations. Transition to the targeting pod at 10 to 12 NM and observe the area. Point or area track the target depending on target IR properties. Verify target environment through the FLIR and center steering. If the laser is armed, it fires when the pickle button is depressed and the bomb solution is updated using laser ranging to target. Using the trigger to update laser ranging is preferred since lasing with the pickle button can result in an early release if clouds become a factor. Due to previously mentioned FLIR inaccuracies, a TGP delivery is superior to a FLIR/CCIP accuracy from medium altitude (especially for HARB). However, aircraft boresight and accuracy of right hardpoint coefficients significantly affect the accuracy of ballistic TGP deliveries. Ballistic TGP deliveries tend to drop long and left of the desired target. To reduce the effect of these hardpoint inaccuracies, area track the target, squeeze the trigger for laser ranging to update system solutions, then break lock with the TGP prior to roll-in and release on steering. This technique is only valid with an accurate system altitude. With a system altitude error, maintain the TGP lock and continue to update with laser ranging.

8.10.3 Laser-Guided Bomb Operations. LGBs are freefall weapons equipped with a bolt-on guidance kit. The F-16 delivered Paveway weapons include the GBU-12 (MK 82), GBU-10 (MK 84 and BLU-109), and GBU-24 (BLU-109 and MK 84) weapons. The F-16 has the capability to self-designate targets, as well as Buddy Lase for other aircraft. Buddy Lase capabilities are also available from other sources such as Army Attack Scout helicopters and Navy/Marine attack aircraft. Special forces ground teams also have a lasing capability.

8.10.3.1 Weapons Selection. If the decision is made to use LGBs, they need to be provided with the best possible solution concerning target acquisition and bomb energy. Plan attacks to provide sufficient energy (dive, medium-altitude level, or high-angle deliveries) to maintain adequate endgame maneuverability.

8.10.3.1.1 The GBU-24 Paveway III offers increased delivery accuracy, an expanded delivery envelope due to proportional guidance, and increased penetration capability due to trajectory shaping.

8.10.3.1.2 GBU-24s cannot be employed ballistically; they must acquire a laser spot in order to hit the target. If the GBU-24 never sees the laser spot during altitude-hold/midcourse guidance modes, it will impact well long (approximately 9,000 to 12,000 feet) of the target. If the GBU-24 fails to see the laser spot in any other mode, it may impact long or short of the target.

8.10.3.2 Target Selection. A point target, which requires a direct hit for target destruction (e.g., bridge, command post, hardened site, or aircraft shelter doors), is a good LGB target. The following considerations are essential in determining LGB use. It is critical to mission success that intel provides pilots with the most current, detailed target photographs and mensurated coordinates. Exact DMPI selection and final guidance is done with either NARO or EXP FOV of the TGP. This small field of regard necessitates good coordinates and the ability to do extended target study prior to flying the mission.

8.10.3.3 Aimpoint Considerations. Actual aimpoints will be driven by target vulnerability, reflectivity, visibility, wind, target motion, vertical development, and tactical employment considerations. The weapon must have an unrestricted LOS to the laser spot once guidance begins.

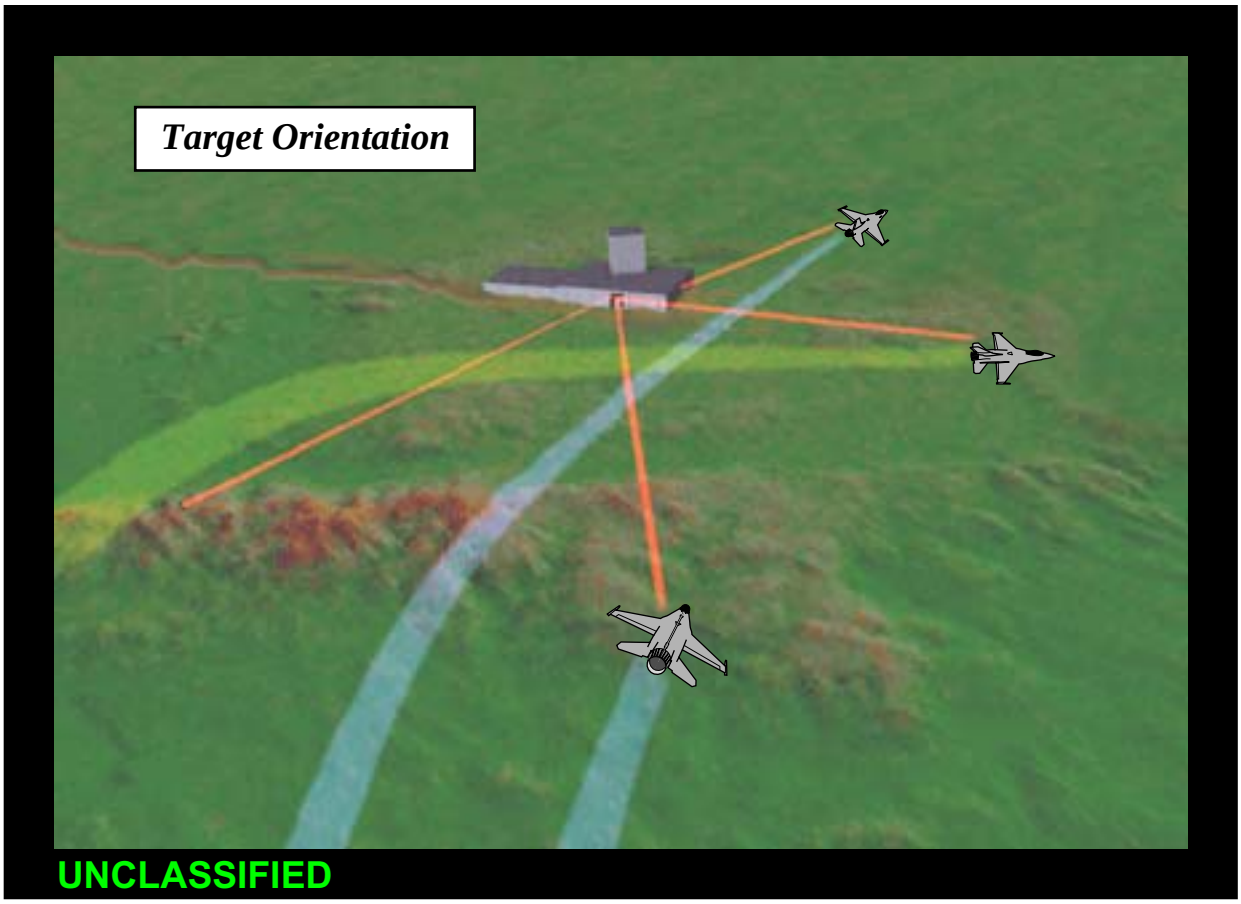
8.10.3.4 Target Reflectivity. Surfaces which exhibit specular (mirror-like) reflectivity (i.e., a smooth water surface, aluminum, or polished steel) are not suitable for laser designation.

8.10.3.5 Impact Angle. For steel or concrete targets, greater than a 70-degree (perpendicular to the target) impact angle will decrease the risk of broaching/ricocheting and increase the probability of success. For dirt covered targets, greater than a 40-degree impact angle will increase the probability of success.

8.10.3.6 Target Orientation. If the target has vertical development, determine the orientation of the sides. Choose an attack axis that allows constant lasing on the side facing the weapon's flight path to avoid podium effect. (See **Figure 8.18** Target Orientation.) Podium effect is the movement of the laser spot from one face of a target to another and can occur if the designator aircraft passes over or around the side of the target. Worst case, the designator may be lasing a target face the weapon cannot see. Select delivery options and attack

axis which ensure the laser spot will remain stationary during bomb time of fall (TOF). This is especially critical with the GBU-24's long TOF. (See **Figure 8.19**, Podium Effect.)

Figure 8.18 Target Orientation.



8.10.3.7 Obstructions to Visibility. Both the designator and weapon require an unobstructed LOS to the target during weapon TOF. Interference may be atmospheric (e.g., dust, smoke, haze, and clouds) or ground-based (e.g., trees, terrain, and buildings).

8.10.3.8 Cloud Base. Cloud bases are a major factor in determining the type of delivery. With the GBU-12, low-level deliveries are possible with ceilings as low as 1,000 feet AGL; however, 3,000 feet AGL is a more practical number. Standoff loft deliveries may be accomplished under relatively low ceilings, as long as pilots plan for at least 8 seconds TOF from laser-spot acquisition to impact. Patchy clouds in the target area can also cause the designator and the LGB to lose track. Minimum altitude for GBU-10 level releases should be 5,000 feet AGL, based on LGB maneuverability and impact angle.

8.10.3.9 Ground Obstructions. Low-altitude designator pilots must plan designation maneuvers to avoid ground obstructions or fly at an altitude that allows LOS over the obstruction.

8.10.3.10 Upwind Laser Aimpoint Correction. Give consideration to winds on the surface as well as release altitude. A/G weapon testing data emphasize that pilots should consider and apply surface wind corrections. Whenever possible, plan an axis of attack that will

give a tailwind. If restrictions preclude this, take the average headwind and crosswind component from best available wind data (usually forecast) from ground level to 4,000 feet AGL at the target and aim upwind from the normal no wind aimpoint. The upwind aimpoint corrections should only be applied to targets that are large enough to maintain the laser spot on the target. The laser aimpoint should never be positioned off target even if the aimpoint correction exceeds target dimensions. The correction factor for GBU-12s is always upwind 1-foot per knot. The GBU-10 correction factor changes as wind speed increases. For GBU-10s, if the wind component is less than 20 knots, move the laser aimpoint upwind 1-foot per knot for a head wind (horizontal target only) or crosswind component. If the wind component is greater than or equal to 20 knots, move the laser aimpoint upwind 2 feet per knot. Due to increased performance, spot correction is generally not required for Paveway III weapons. In any case, never move the laser spot completely off of the target!

8.10.4 Multi-Laser Environment. Paveway II and III weapons were developed with pulse repetition frequency (PRF) coding to allow operations in a multi-laser environment while minimizing laser interference. PRF coding provides the ability to select the PRF the weapon will use for guidance. Therefore, PRF codes should be deconflicted between flight members.

8.10.4.1 If employing weapons using the same code and planning two separate targets, the aimpoints must be separated by enough distance to ensure only the desired spot is within the LGB FOV. **Figure 8.20**, Weapons Acquisition Footprint, shows the shape of the FOV of a Paveway II footprint on the ground for a 30-degree dive angle and 16,000-foot slant range (the Paveway II nominal acquisition range).

8.10.4.2 If two identically coded laser spots exist within the target area, there is no accurate way to predict which of the lasers the weapon will guide on. If two weapons are released from a parallel heading, their acquisition footprints must be deconflicted by distance to ensure proper targeting. As a ROT, 6,000 feet will provide adequate footprint separation so the desired target will be within each weapon's FOV. If the distance is less, the acquisition areas will overlap and it is possible that guidance will be to the wrong laser spot. Thus, if the aircraft headings converge, these targets must have greater separation so the acquisition footprints do not overlap. The primary method for deconfliction in the same target area should be different PRF codes.

8.10.4.3 As the dive or loft angle decreases, the length of the footprint increases and so does the minimum required distance between targets. The allowable tolerance on the weapon's FOV, delivery system dispersion, actual range at acquisition, final attack geometry, and timing of the delivery are all variables that must be considered when deriving the distance between targets. For Paveway II attacks with parallel headings, a minimum of 6,000 feet between targets is required. For headings that converge at 45 degrees, allow 6,600 feet; and for 90 degrees opposing attack axes, allow 8,200 feet. If the targets are closer, then separately coded weapons should be used.

Figure 8.19 Podium Effect.

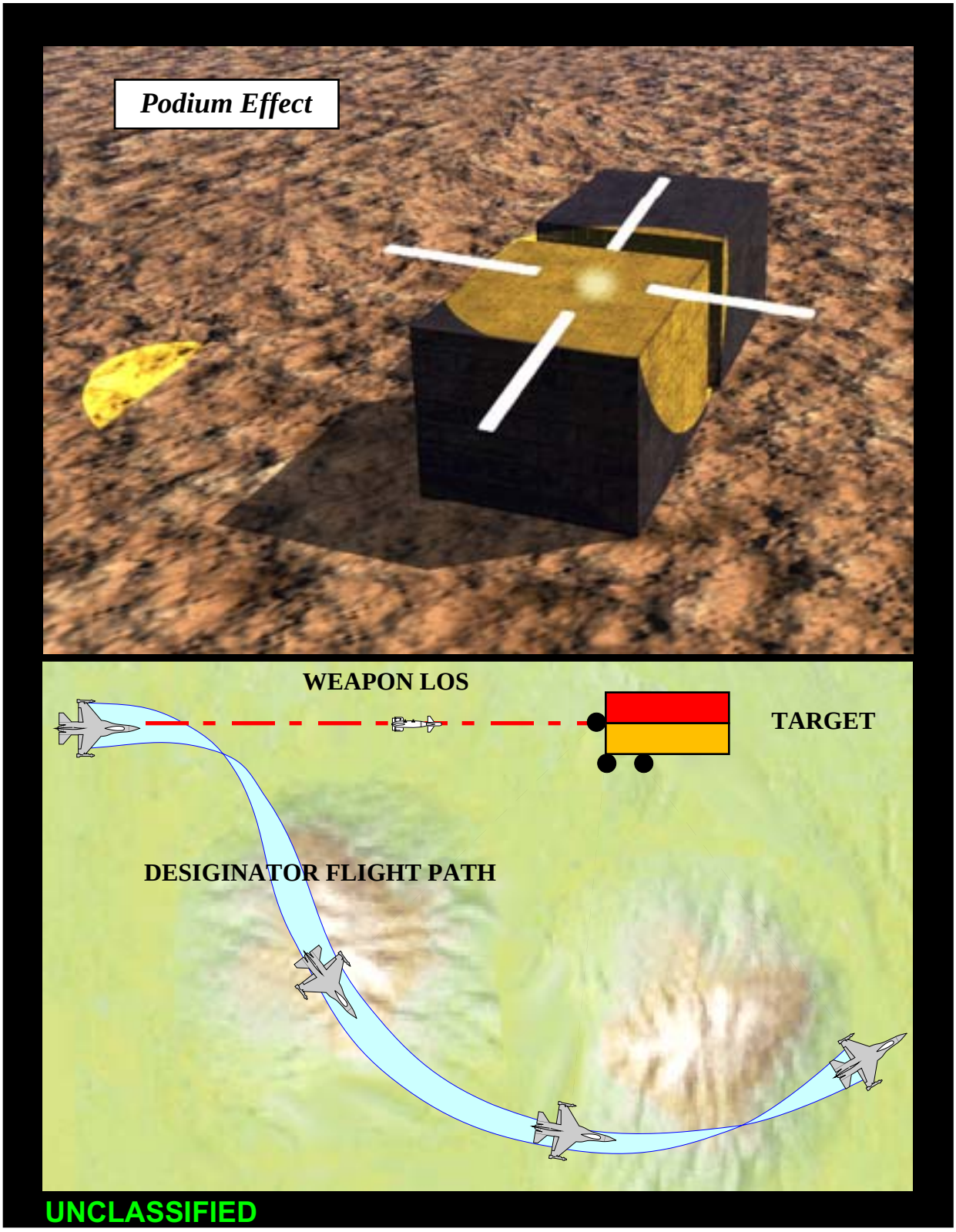
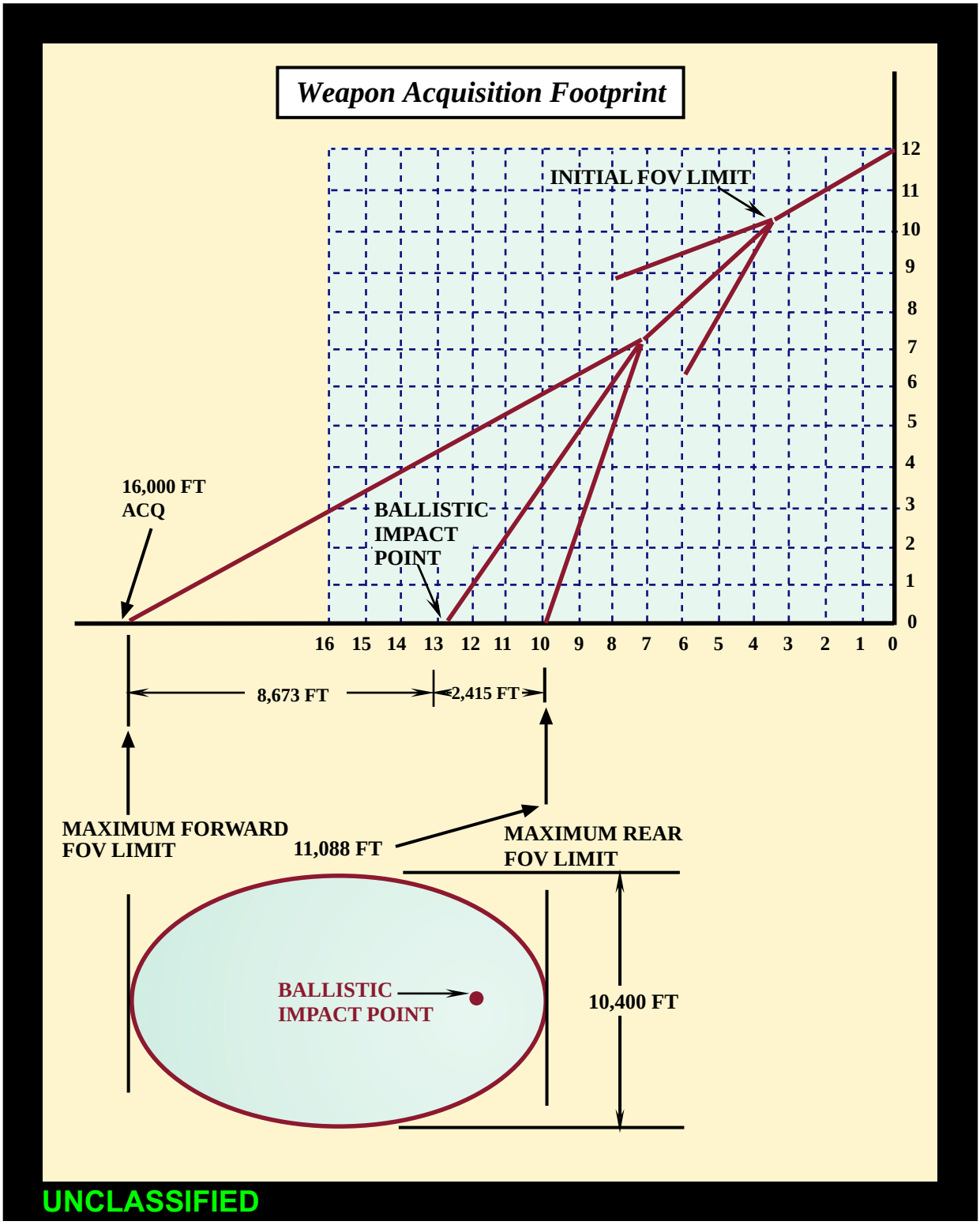


Figure 8.20 Weapons Acquisition Footprint.



8.10.5 Laser-Guided Bomb Enhancement Techniques. The capability of LGBs to guide to a direct hit depends on a number of variables. The most crucial variable is the weapon's airspeed during its guided flight, particularly during low-altitude employment. LGB airspeed is a function of release angle, release airspeed, density altitude, and position at weapon acquisition. The following techniques increase the $PH_{(HIT)}$.

8.10.5.1 Release Airspeed. Use a release airspeed as high as release limits and aircraft capability allow, especially at lower altitudes and with GBU-10s. This gives the LGB maximum energy at acquisition and maximum maneuverability during guided flight. Paveway II weapons dissipate large amounts of energy while guiding. Therefore, the longer the guidance time, the more energy lost. Giving the bomb enough energy to generate 2 Gs during the last seconds of flight is required for success. Airspeed is also a major factor in release range of a GBU-24 providing a longer standoff capability.

8.10.5.2 Vertical Development. Elevating the laser spot on a vertically developed target will increase the probability of the weapon impacting the target. If a ground-level target is designated, a short weapon impact may result due to the flight characteristics of LGBs.

8.10.5.3 Paveway II Designation. Delayed lasing is desired for GBU-10s and required for low-angle loft of Paveway II LGBs. If the target is continuously lased, the LGB attempts to fly directly to the laser spot and flies below the required ballistic trajectory. Minimum loft angles of 25 degrees (GBU-12) or 30 degrees (GBU-10) will ensure bomb apex occurs prior to laser spot acquisition. With less than 30 degrees of dive, the bomb will lose energy during guidance. The result is the LGB tends to impact short for shallow-angle deliveries. To minimize this problem, the laser should be active only during the last 8 seconds of the weapon's TOF. More than 8 seconds of laser guidance dissipates large amounts of weapon energy, resulting in degraded performance.

8.10.5.4 Paveway III Designation. Paveway III weapons are maximized for standoff deliveries with continuous lasing. Continuous lasing will allow the weapon to fly its best energy conserving and maximum range profile. In some atmospheric conditions, the GBU-24 may not be able to acquire the laser energy at extended ranges. In these cases, the release range needs to be adjusted to account for delayed lase profiles. The TGP will allow this technique at medium altitude.

8.10.5.5 Slant Range versus Graze Angle. At long slant ranges or low-graze angles, the laser spot will disperse in an oval pattern on a flat surface. However, even from a 30,000-foot slant range 500 feet above the target, any vertical development will provide a “hot spot” of laser energy and allow weapon guidance.

8.10.5.6 Mission Planning. Current photographs and detailed maps must be used in mission planning. This is especially critical to buddy-lasing when the designator and bomber must be certain of the correct target without radio communication. Planners must account for obstructions to LOS that will dictate the altitude required for the designation maneuver. Cloud cover determines what type of delivery is available to the pilot. Obstructions to visibility (i.e., smoke and dust from ordnance in the target area) must not interfere with either the designator or LGB LOS. Therefore, for an attack with multiple LGBs, it is essential that the pilot consider wind effects on smoke and debris in the target area. For further considerations, reference the AEM.

8.11 Non-Visual Attack Formations. At night and without the aid of NVGs, LGBs are employed from the FLIR Assisted Radar Trail Formation. For specific attack options with Paveway II and III, refer to the AEM.

8.12 Visual Formation Options—Day and Night Vision Goggle. Being able to fly a visual formation has many benefits over flying FLIR Trail. A line abreast formation allows simultaneous impacts and the destruction of multiple DMPIs that would normally be obscured in the TGP by flying a FLIR Trail formation. Two-ship wingman deconfliction responsibilities depend on the direction of the action and lase leg. In a line abreast formation, if the flight lead actions away from the wingman it is easier to deconflict as the wingman falls into a temporary trail formation during the lase leg. Another technique is to vary the action heading of all flight members to help with the deconfliction problem. Actioning into the wingman is slightly more difficult but still manageable. Allowing the wingman to over-check the flight lead is one technique, or letting the wingman cross flight paths similar to a 45-degree checkturn is another technique. Four-ship LGB formations are employable from either offset box or fluid four. Offset box is typically flown with the wingmen on the outside of the action direction. Fluid four is more difficult unless each element actions in the opposite direction or each flight member has a different number of degrees to action. For further information, refer to the AEM

8.13 LANTIRN Employment. Specific mission planning and employment considerations that are specific to the low-altitude environment are discussed in this section.

8.13.1 Mission Planning. Planning for night LANTIRN ingress and employment is significantly different from daytime planning. This is primarily due to reduced cockpit lighting and system limitations.

8.13.1.1 Turn Radius/Limited Turn Capability. When flight with LANTIRN at low altitude is conducted within terrain following (TF) limits, turn radii increase dramatically over typical daytime navigation turns. Plan turns using 45 degrees of bank to ensure they can be accomplished within TF limits. Turns into terrain will further limit turn capability. The turn radius must also be used when drawing your map to aid in route study of where the aircraft is actually going to fly. For turns where large heading changes are required, it may be desirable to plan to lead the turn in order to roll out in more favorable terrain. If overflight of the steerpoint is desired, offset from the inbound track opposite the direction of turn. Intermediate steerpoints may be required solely to reduce turns at important points such as the IP.

8.13.1.2 Start-Route/Letdown Point. Plan to complete all cockpit tasks before descent at the start route point. Consider using altitude deconfliction until past the start route point. Whenever possible, enter the low-level regime over an easily identifiable point. Flat terrain allows a smoother transition to low altitude.

8.13.1.3 Steerpoint Selection. For low-altitude operations, avoid excessively long legs. If circumstances dictate longer than 10-minute legs, consider a midpoint position/altitude update point (OAP).

8.13.2 In-Flight Operations. Using the FLIR/TFR during flight can greatly improve overall SA, but confidence in the system must be reinforced by in-flight checks and in-depth systems knowledge.

8.13.2.1 TFR In-Flight Check. Prior to initiating TFR flight, it is imperative to check the operation and integration of the TFR, radar altimeter, and digital FCS. This check is accomplished IAW the Dash 34 and in an area of known elevation and relatively flat terrain. After a night takeoff, and the aircraft is cleaned up, do not forget to turn the HUD FLIR up so checks are not done in a black hole. The TFR check can be very task intensive depending on airspace limitations, and currency. Make sure you are mentally prepared. Do not continue TF operations until assured of correct system operation. **Table 8.5**, RATSIMPL Cockpit Check, may be useful to complete the TF check and prepare for the next phase of flight.

Table 8.5 RATSIMPL Cockpit Check.

R—Radar altimeter—on and operating after SWIM check
A—ALOW—900 feet set
T—TACAN—REC
S—SCP—1,000 feet set
I —IFF—as required
M—Missile—cool
P—Pod—unstow TGP
L—Laser arm—as required
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8.13.2.2 En Route Cruise. If the mission includes air refueling or a medium-altitude cruise segment prior to low-level letdown, put the TFR in STBY or Blended. Putting the TFR in STBY will allow you to fly formation without getting fly-ups and at slower airspeeds without the flashing limits symbology. Flying with flashing limits is a bad habit pattern to establish because it may desensitize you to the warning. The Blended mode may also be useful. It is selected by turning the autopilot on with the TFR in any mode other than STBY. If altitude hold is used Blended will maintain the aircraft altitude while still giving you TF fly-up protection. Be aware that even if the AMS switch was in AUTO TF when you selected the autopilot function, the AMS will revert to MAN TF when you come out of Blended by deselecting the autopilot. If you exit the Blended mode by depressing the AMS switch, the autopilot will disengage and the system enters AUTO TF. AUTO TF combined with rough terrain or a little turbulence can be an excellent foreign object damage (FOD) generator. This is your last chance to arrange your cockpit prior to the ingress phase. Make sure you are strapped in tight and that maps, charts, and lineup cards are secured and in a usable order. Remember at night things will be harder to read. Consider writing bigger and darker and using different colors than you may be used to on day missions.

8.13.2.3 TFR Modes of Operation. The TFR has six modes of operation from which you can choose: NORM, LPI, STBY, WX, ECCM, or VLC. (See **Table 8.6**, TFR Operation Modes.) Choosing the appropriate mode varies from mission to mission based on the weather, terrain, and threat environment. Knowing the basics of each mode helps you choose the best mode for mission execution.

Table 8.6 TFR Operation Modes.

TFR Mode	Description
NORM	This mode is usually planned for mission segments in all types of terrain, low threat, and good weather.
LPI	Selected via the TFR page on the MFD or the run quiet switch and is usually used on longer/straight legs where minimum maneuvering is required and potential threats are present.
STBY	Stows the TFR antenna and should be used on the ground and airborne only when TF fly-up protection is not required/desired.
WX	The TFR processed data is reduced from 36,000 to 15,000 feet in front of the aircraft and the TFR look-up angle is reduced from 10 to 5 degrees. You may notice a degraded capability to detect man-made objects and low-reflective surfaces. Select the WX mode if clouds and/or actual precipitation are along the flight route. This does not guarantee a weather fly-up, but it improves the chances for smooth sailing.
ECCM	The TFR processed data is also reduced to 15,000 feet. This mode allows for operation in an ECM environment where numerous threats might be encountered. All other information is classified.
VLC	Enter VLC by selecting 100 feet SCP on the TFR page. Initial commands will be to 200 feet until the terrain data criteria is met for 100 feet SCP. If the terrain does not continue to meet system requirements for 100 feet, the SCP automatically bumps up to 200 feet and the aircraft climbs to 200 feet. A DMS forward anytime you are at 100 feet changes the SCP to 200 feet and climbs the aircraft. VLC is normally used in high threat and relatively flat terrain, where maneuvering is minimal.
UNCLASSIFIED	

8.13.3 Low-Level Operations. Executing the LANTIRN mission can be very hazardous if daytime habit patterns are carried over. Particular care must be given during the initial descent and high tasking periods of the mission.

8.13.3.1 Prior to TFR Letdown. Before initiating an AUTO TFR letdown, review all your planned data including TOT adjustments, terrain elevation, RAA, leg MSA, and minimum airspeed. Ensure all LANTIRN systems are on and functioning properly prior to beginning low-level operations (ALOW set 90 percent of SCP, CARA ON, TFR out of STBY). Take the time necessary to ensure the systems are operating properly and that you are prepared for the transition to low altitude. Rushing this transition may lead to task saturation that

may prove to be fatal. **Table 8.7**, RTFAM Check, may help remember major required tasks.

Table 8.7 RTFAM Check.

R—Radar altimeter—on
T—TFR—appropriate operating mode
F—FLIR—on HUD
A—AMS—auto engaged
M—Monitor
UNCLASSIFIED

8.13.3.2 TFR Letdown. The initial TFR letdown must be monitored to ensure proper system operation. Things to watch include dive angle does not exceed 12 degrees in an AUTO descent, the E2 scope has processed data displayed, the combined altitude radar altimeter (CARA) is decreasing properly, and that the aircraft initiates level off for the SCP selected. Initially set the stores control panel (SCP) to level off at 1,000 feet. After initial level off and verifying proper system operation, reset the SCP as required for the mission.

8.13.3.3 Tactical Navigation. Doing systematic checks at each steerpoint helps maintain SA. Setting the leg course in the course deviation indicator (CDI), setting the next heading with the Captain's bars, reviewing the update plan, checking gas, and clearing on the radar are some examples.

8.13.3.3.1 Given the limited FOV the FLIR gives you, it becomes even more imperative that the INS and system altitude be kept as tight as possible. Obviously, a HIGH/HIGH status is a wonderful thing and can greatly reduce your cockpit workload. Without GPS high accuracy valid slews are normally entered into the system to improve the KALMAN operation.

8.13.3.3.2 Due to changing conditions, you will probably also need to adjust FLIR Gain, brightness, and contrast along the route. The TDA may help anticipate areas where higher Gain may be required. The bottom line is to adjust the picture to make it work best for you. Auto Gain is always an option.

8.13.3.3.3 As you become more comfortable and proficient, you must guard against complacency when using the TFR LANTIRN system. Maintain the cross-check that you established in the day VFR low-altitude situation workload of cockpit data and rocks. When your GPS is not working and you must do manual fixes and ACALs, pacing and prioritization become critical. Knowing where, when, and how to do a fix is essential. Try to minimize time in the FIX modes and maximize A/A radar search time. For FCR modes, use the GM cursor for 6/12 slews and if the point can be brought near the HUD center, use the HUD diamond/OAP symbol for 3/9 slews. One technique for visual modes is to start a slight climb to aid in turnpoint identification and increase air-to-ground ranging (AGR) slant ranges for better accuracy. In any case, do not enter the FIX/ACAL update until you have checked your deltas and are satisfied with the correction.

8.13.3.4 Terrain Masking. Thorough route study prior to flight is imperative. Knowing where high/rough terrain is will allow you to follow the path of least resistance to optimize terrain masking. Use a combination of the FLIR and flight path marker (FPM) to help you terrain mask. In mountainous terrain, look long range in the FLIR for saddles in hills or the path of least resistance. Point the aircraft via the FPM, and use look-into-turn and snap-look to aid your decision.

8.13.3.5 Fly-Ups. Should a fly-up indication occur, roll to wings-level and allow the system to increase pitch until reaching a 20-degree climb. If the system resets before reaching 20 degrees, you may allow it to descend while verifying normal operation. At 20 degrees, depress and release the paddle switch. If this resets the system, verify normal operation and descend back to low altitude. If the paddle switch did not reset the system, hold the paddle switch and level above the MSA/RAA. If the malfunction can not be cleared, TFR operations can not be continued. Cease low-level operations and continue at the MSA. Once established at the MSA, determine whether to continue with the mission or RTB.

8.13.3.6 Low-Altitude Threat Reaction Considerations. At night, weapons explosions and secondaries from antiaircraft artillery (AAA) and surface-to-air missile (SAM) launches can be very disorienting. Having a solid cross-check and threat reaction game plan is essential. The aggressive maneuvers normally associated with threat reactions can be very disorienting at night. The maneuvers must be performed using aircraft references unless the horizon is clearly visible without reference to the FLIR. It may be more important to maintain orientation than to react to a threat that may not be targeting you. Since you cannot easily monitor other aircraft in the formation during a threat reaction, it is important that reacting pilots communicate information such as headings, altitudes, and type of reactions to other flight members when initiating a threat reaction. During all threat reactions, dispense chaff and/or flares as required and use electronic countermeasure (ECM) as required to degrade radar or missile capability.

8.13.3.7 Station Keeping Considerations. Station keeping consideration are identical to the medium-altitude considerations. There are several options for low-altitude threat reactions commencing below the MSA. The first option may be simply to select a lower SCP and check away from the threat. Use direct and indirect terrain masking to help deny acquisition. The second option is initially a climb to or above the MSA followed by maneuvering as required. This option can be used in cases where you have sufficient time after your initial threat indication to execute the climb and reaction prior to engagement. The final option is a 30- to 45-degrees bank oblique turn from below the MSA to an altitude at or above the MSA. If you pull more than approximately 2.5 G in a left turn or 1.7 G in a right turn you will exceed TF limits. Once reaching the MSA, over bank to approximately 90 to 120 degrees of bank and pull as required to the new heading. While in a low-altitude notch maneuver, a technique to dispense chaff with G on the aircraft is to momentarily pull up to 5 to 10 degrees nose-high with 3 to 4 G while simultaneously dispensing chaff. Release the stick immediately after dispensing chaff and the auto TFR will bring you back down with minimal exposure. This technique is sometimes referred to as a “porpoise.”

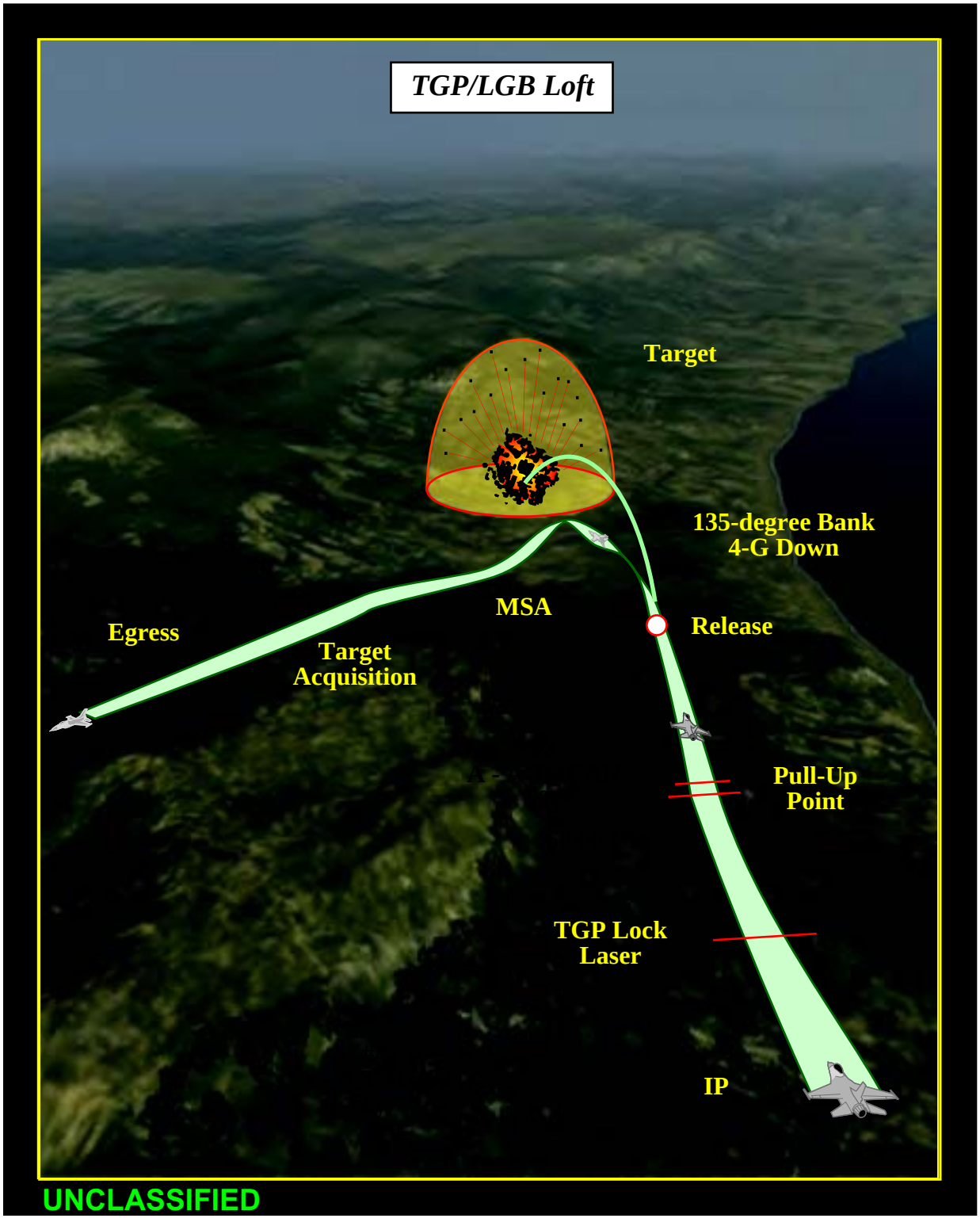
8.13.4 Low-Altitude LANTIRN Attack Options. The TGP provides an excellent capability for the delivery of both guided and unguided munitions. TGP passive and laser ranging com-

bined with an accurate navigational position and system altitude, provide a significant improvement in weapons delivery accuracy for unguided munitions.

8.13.4.1 System Updates. GM radar and visual slews can be used as a verification of GPS/DTS accuracy or as a backup for cases when GPS/DTS or coordinate accuracy are uncertain. Extensive knowledge of what you expect the target to look like and using all available sensors will help to defeat the enemy's camouflage, concealment, and deception techniques. If GPS/DTS is not available or GPS or DTS AUTO ACAL is not used, an ACAL should be accomplished in the target area. Ideally, a pre-IP should be used to update the system and provide attack axis alignment. If the TGP can be slewed to the IP, RP, or an OAP, your steering to the target will be updated. Laser ranging can be used to update height above target. You can also use the pop dot as a head-up reference for your pull-up or action point. Airspeed is a critical factor during climbing maneuvers. Ensure you accelerate as planned or you may not be able to execute the attack.

8.13.4.2 TGP/LGB Loft. The loft delivery with the TGP/LGB combination provides both target stand-off and precise guided weapons delivery. (See **Figure 8.21**, TGP/LGB Loft.) The LGB could be lofted upon mensurated coordinates with nothing but GPS/DTS to aim the system. Without GPS/DTS, a precise update on an accurate IP or VRP should be performed; and nothing more until after the LGB has been lofted. The problem is that at low-graze angles and long distances, there is little Delta T for the TGP to area track. Area tracking the DMPI prior to release will therefore result in a wandering TGP. Furthermore, the Area track crosshairs cannot be accurately placed over the DMPI from low-graze angles and long distances. Attempting to do so will impart an erroneous 2 to 3 mil error, which will become significant during the guidance segment of the loft. If a DMPI has enough vertical development and Delta T, then it can be point tracked during the IP-to-target run without any problems, until the loft pull-down when it will revert to Rates and impart an unwanted slew. Regardless of track mode, lasing the DMPI from low-graze angles and long distances will always impart an incorrect range to the system as it is too easy for the laser to miss the top of the DMPI by 1 mil and range-in several thousand meters long. The only acceptable answer is to point track the DMPI— without lasing it— and break lock prior to release.

Figure 8.21 TGP/LGB Loft.



8.13.4.2.1 TFR Attack Modes. There are several combinations of TFR modes that can be used to loft an LGB. The old method is to use MAN TFR for the run-in, pull-up, and recovery. This requires 100 percent of your attention be devoted to the FPM and MAN

TFR box. Another method is to remain in AUTO TFR throughout the loft maneuver. As long as you roll to beyond TFR global limits in less than 2 seconds, no fly-ups will result. This technique is good because you remain within AUTO TFR protection for a longer period of time. However, during the pull-up you will be fighting the AUTO TFR which is constantly attempting to pull you back down to the selected SCP. Furthermore, the AUTO TFR will descend you 12-degree nose-low during the LGB guidance segment, unless you manually hold the nose up. Another technique is to use ALTITUDE HOLD Blended mode for the LGB guidance segment of the loft. This is good in case of terrain or podium effect problems, but the aircraft vulnerable since it does not descend to low-altitude quickly. A final technique is to engage ATTITUDE HOLD Blended mode when inside the IP, level at the SCP. Remain in Blended throughout the loft maneuver; this will resemble AUTO TFR in the HUD and provide AUTO TFR protection. No back pressure will impede the pull up as you are not in AUTO TFR. No fly-ups will occur as long as you roll to beyond TFR global limits within 2 seconds. The LGB should be lofted at an angle between 30 to 35 degrees nose-high. Either the programmed loft angle and HUD climb cues can be referenced, or the constantly computed loft angle displayed next to the altitude scale in the HUD can be referenced.

8.13.4.2.2 After LGB release. After LGB release, always reference the target MSA prior to rolling to 135 degrees of bank and pulling down—not across the horizon—with 4 G to 5 degrees nose-low. Roll out wings-level at 5 degrees nose-low and keep your attention in the HUD until you see the ATTITUDE HOLD Blended TFR line below the FPM. A SWIM fly-up is not uncommon at this point if the RALT times in prior to the TFR. If this happens, paddle and release very quickly. To adjust the descent angle, simply place the FPM where you want it. Paddling to adjust the attitude-hold descent angle is not required. You will now have a 5-degree nose-low descent for LGB guidance—much improved LOS to the DMPI—without diverting any attention or effort to manually holding back stick pressure. Once the attitude hold blended TFR line is visible beneath the FPM, without any switch changes, devote your attention to the TGP display to acquire and track your DMPI. If you see masking indications, then simultaneously bank away from the target (5 degrees of bank or less) and depress the AMS to descend at 12-degree nose-low. Track the DMPI prior to laser start time. Minimize slews when the laser is firing and the LGB guiding. However, if the TGP wanders off the DMPI, put it back on. If still descending at 5 degrees, once the LGB detonates engage the AMS and have the AUTO TFR bring the aircraft down more quickly to the low-level structure. At this point there is sufficient attention and time available to devote to flying precise egress headings and regaining FLIR visual with your leader.

8.13.4.2.3 TGP Masking Considerations. Since the TGP is mounted on the right chin station, left turning egresses reduce the risk of a mask prior to weapon impact. Right turning egresses are possible; however, they are less tolerant of poorly executed escape maneuvers. If the situation permits, delay your descent to low-altitude until weapon impact to help maintain LOS to the target. Blended attitude or altitude hold may reduce task loading in this situation.

8.13.4.3 TGP/LGB Fly-Up Attack. If threats and the situation dictate, you can execute a fly-up attack to a level LGB delivery above weapon frag envelope. The fly-up allows a better view angle to the target and much easier target identification. Commence the fly-up at a range and angle that will allow enough time for TGP track and range update prior to release. Execute the egress the same as in a loft delivery. (See **Figure 8.22**, Targeting Pod/ Laser-Guided Bomb Fly-Up Attack.)

8.13.4.4 Unguided Weapons Attacks. The TGP/FLIR system allows for LDGP and CBU weapons attacks with accuracy approaching that of daytime operations. Attack selection varies based on expected target acquisition ranges, coordinate accuracy, and weapon impact requirements. Expected cloud bases and visibility also must be considered.

8.13.4.4.1 TGP/LDGP Loft or Fly-Up Attacks. If delivering unguided conventional weapons the TGP provides an excellent target identification and update capability. Loft execution through weapons release is identical to the LGB delivery. Since the weapons are unguided, there is no requirement to track and lase the target after release. Since a TGP lock is not required, you can also increase the G in your escape maneuver to 5 G. The important thing to stress here, however, is to not do any head down tasks prior to being in AUTO TF. If the target is visually acquired on a TGP assisted fly-up or direct attack and CCIP is selected, the TGP will break track and follow the pipper.

8.13.4.4.2 NVP Direct Attack. The direct pop provides an attack option for cases where stand-off deliveries are impossible or not desired (i.e., TGP failure, non-PGM, weather). (See **Figure 8.23**, Navigation Pod Direct Attack.) Select AG/CCRP and use the TGP/FCR/HUD FLIR to acquire the target. When conditions prevent target acquisition, rely on INS/GPS (break lock and cursor zero TGP/FCR) approximately 2 NM from action point and concentrate on the direct attack (HUD). Select MAN TF approximately 2 NM from your pull-up point. At the pull-up point, establish desired climb angle using the HUD FPM. There are two options for establishing the desired dive angle after reaching pull-down altitude. The first option is a 180-degree roll and pull. At planned pull-down altitude, roll the aircraft 180 degrees and pull straight down with 3 G. Do not attempt to correct steering inverted. At 5 degrees prior to the desired dive angle, reduce G and roll upright. Roll out in the same direction as the initial roll-in to minimize offset from the steering line. Adjust dive angle and the bomb fall line (BFL) as required. A SWIM fly-up may occur during this maneuver since the RALT may be slow to reacquire the ground prior to establishing TF limits. Another option is to perform a bunt at the pull-down altitude. For this attack you can remain in AUTO TF the entire time. At the push-down altitude the AUTO TFR will perform a perfect 0.2 G bunt if you just let go of the stick. Since the G during this maneuver is lower the pull-up point is farther from the target. Use caution when correcting for steering errors during the bunt. If you use negative G during the bunt, lift vector is out the bottom of the aircraft. To correct towards the vertical steering line, bank away from the line during the bunt. If this is too confusing, wait until after establishing aim-off distance (AOD) and make normal steering corrections. Abort the pass if parameters are not met. If you acquire the target, select CCIP for weapon release. Select CCIP at least 3 to 4 seconds prior to desired release to avoid having an unusable pipper as it does its initial AGR. Remember that AGR and FLIR boresight errors will affect bombing accuracy with

CCIP. If the target is not apparent in the HUD, deliver ordnance in CCRP (bomb the TD box).

Figure 8.22 Targeting Pod/Laser-Guided Bomb Fly-Up Attack.

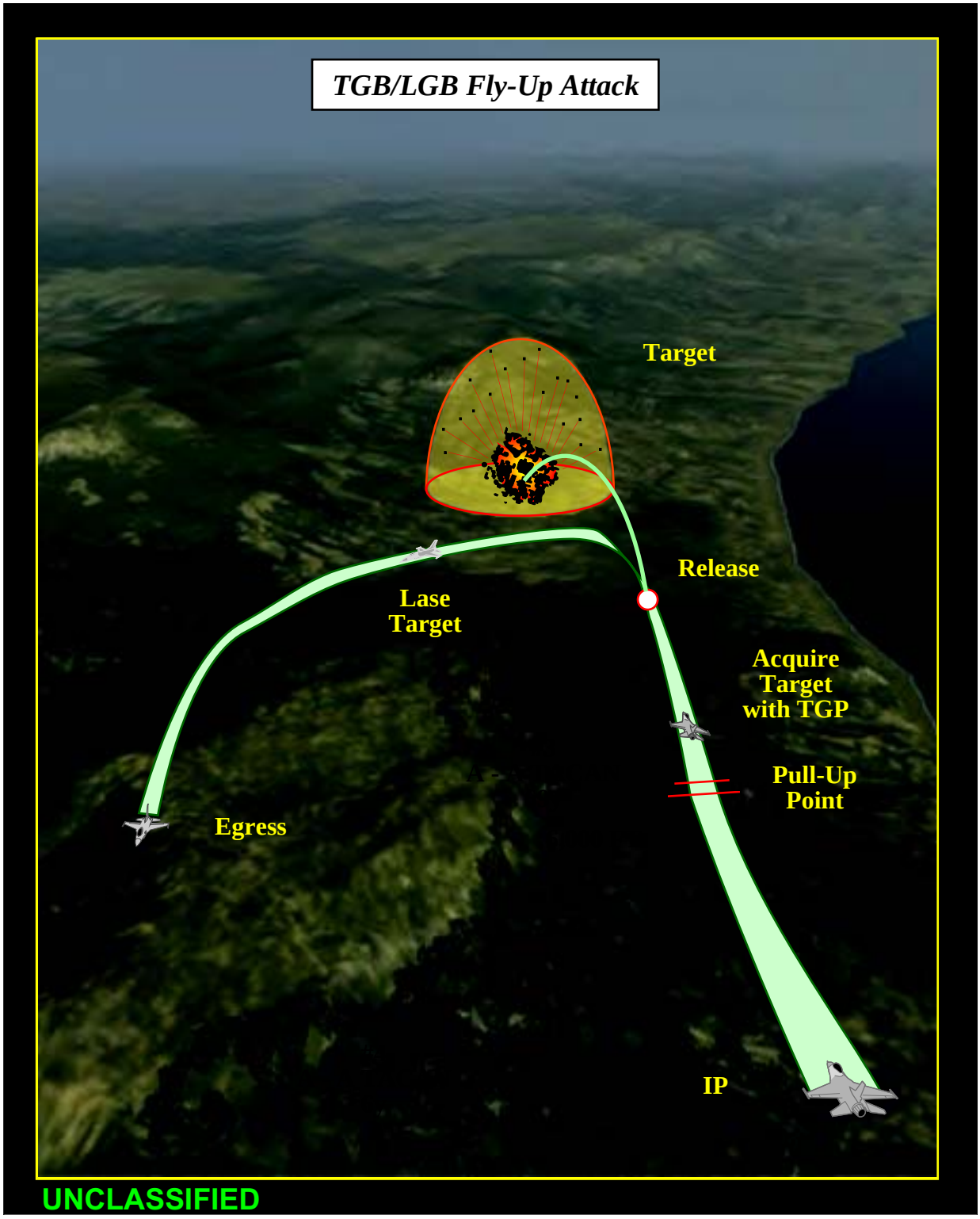
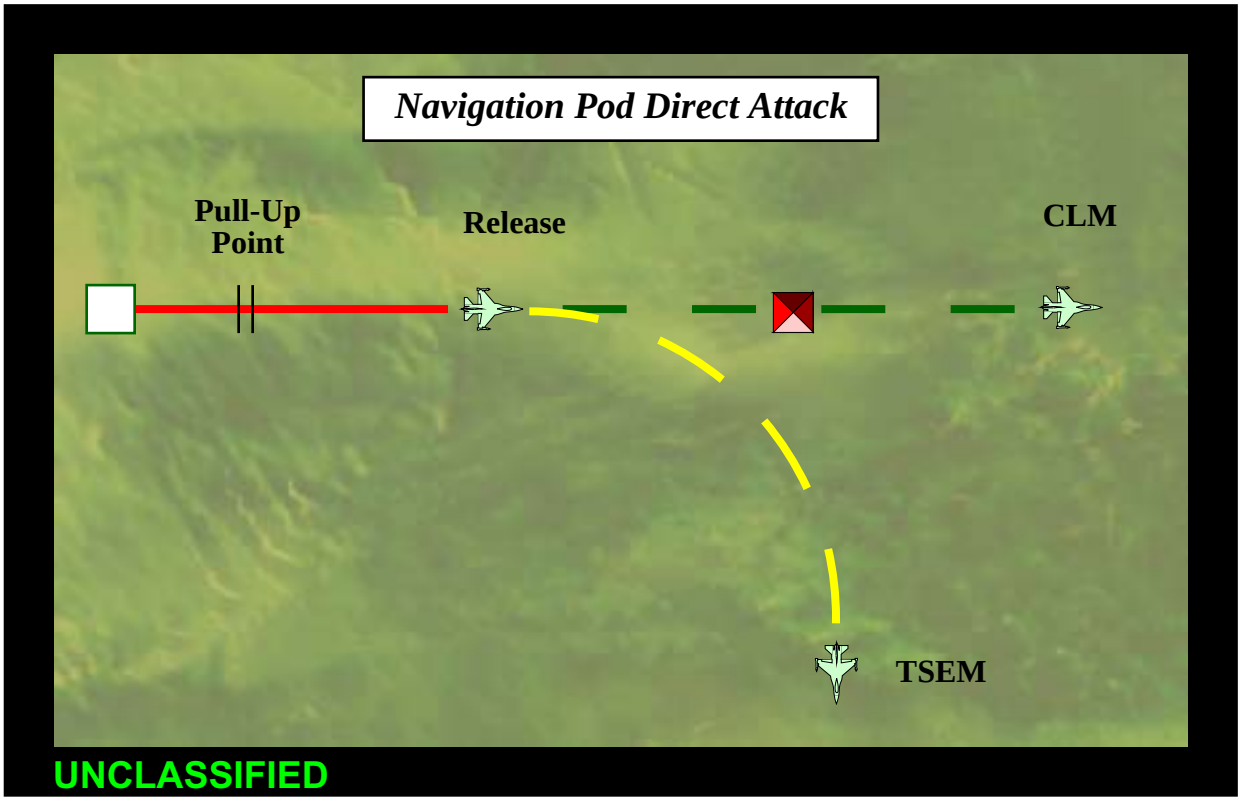


Figure 8.23 Navigation Pod Direct Attack.



8.13.4.4.3 Level Delivery. A level delivery provides a capability for high drag weapons employment when target acquisition may be limited, the pull-up point was missed or could not be identified, or with systems failures such as a HUD failure. Approaching the target, climb above computed MRA. Do this by either; remaining in AUTO and selecting a higher SCP, by pulling up and selecting blended TF, or by selecting MAN TF and climbing. Since MAN TF requires more concentration it is not recommended. If you can, acquire the target with the FCR or the TGP prior to release to use radar or laser ranging to update your weapons release solution. Without accurate HUD FLIR aiming, the best delivery option is a CCRP level. If you can only acquire the target in the HUD FLIR, use a CCIP delivery.

8.13.4.5 Low-Altitude Maverick Attacks. The TGP simplifies low-level MAVERICK employment and allows multiple shots per pass. Based on the forecast detection range, bump up for LOS to the target. Do this like the level delivery discussed in **paragraph 8.13.4.4.3**, Level Delivery. MAN TF may be selected just prior to launch. Use the FCR/TGP to identify your target. If using the TGP, simply Point track the target with the TGP to commence the missile hand-off. If the Maverick has not correlated, TMS right to reattempt hand-off. Use the WPN MFD page to verify correct Maverick hand-off. Cross-check range to the target prior to handing off a second missile. Once both Mavericks are locked, shoot each missile individually. Verify weapon track on the WPN page between shots. Since it is required that the pilot select the weapon as the SOI and adjust polarity prior to track without the TGP, it demands more time and may prevent a multiple launch opportunity. After

launch, based on range to the target, either execute an in TF limits turn or climb to or above MSA and execute a 4 to 5 G escape maneuver to the initial egress heading.

8.13.5 Escape Maneuvers. At night, treat the escape maneuver like an instrument maneuver. Concentrate on HUD and instrument references, especially bank and climb angle.

8.13.5.1 The preferred escape maneuver from a diving delivery is the turning maneuver level turn (TMLT). After releasing the weapons, execute a 5-G pull to the horizon to an altitude at or above the MSA, then execute a 5-G level to slightly climbing turn through a minimum of 60-degree heading change. If recovery altitude is below the MSA, then either adjust release altitude to recover at or above the MSA or execute a climbing safe escape maneuver (CSEM).

8.13.5.2 The CSEM is less desirable since you will complete the maneuver 30-degree nose-high, at a higher altitude with low airspeed. However, terrain or weapons release may force you into a situation where the CSEM is required.

8.13.5.3 Escape and egress maneuvers should be well understood, solidly briefed, and precisely flown IAW squadron standards. There should not be confusion over release altitudes, climb angles, power settings, level-off altitudes, and egress heading so that wingmen can successfully fly through lead's smoke trail and reestablish a FLIR visual without the help of lead's strobe light (as in a combat environment).

8.13.5.4 TFR Use/Safe Escape. You should plan to use AUTO TF as much as possible. Run-in altitudes at higher SCPs in AUTO may increase LOS range to the target and provide full TF protection while using head down displays. The final portion of most attacks or escape maneuvers require out of limit maneuvering (loft, direct pop, CSEM, and TMLT). If you roll to beyond TFR global limits in less than 2 seconds, these out of limits maneuvers can be performed in auto TFR without any fly-ups. This technique is safer, easier to perform, and more tactically sound. Recovery maneuvers should be planned as accurately as possible to increase SA about where and how the egress and descent back to low-altitude will occur.

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ATTACHMENT 1

OPERATIONAL BREVITY WORDS, DEFINITIONS, AND COMMUNICATION STANDARDS

A1.1 General. This attachment establishes commonality among units, and provides a baseline for the integrated employment of multiple MDSs in the area of joint brevity codes, communications standards, and definitions. Understanding the terms and standards allows minimized radio transmissions while executing tactics described in the AEM. This common understanding, however, is dependent on the following rules:

- These lists are not all inclusive.
- Use plain English when required.
- Words listed below should be used in lieu of words or phrases with similar definitions.
- When a flight lead makes directive calls, wingmen must respond with the directed action to the best of their ability.
- If the wingman uses a "directive" term/word, it is a request, and the flight/element lead reserves the right to approve or deny the wingman's requested action.
- Squadron unique standards will not contradict this attachment.
- Deviations from these standards will be briefed prior to mission execution.
- The communications examples in these standards may be truncated and/or combined to preserve brevity in communication intensive phases of the mission.

A1.2 Layout. This attachment contains four sections.

A1.2.1 Paragraph A1.3, Joint Operational Brevity Words. This section contains the approved most commonly used brevity words approved by ALSA for joint forces. **Table A1.1**, Key to Multi-Service Brevity Codes, contains a key to **paragraph A1.3**, Joint Operational Brevity Words.

A1.2.2 Paragraph A1.4, Categorized Brevity Lists. This listing categorizes words by mission types. These lists provide a quick reference for brevity standards required by aircrews upgrading into unfamiliar missions or integrating with other mission-assigned aircraft.

A1.2.3 Paragraph A1.5, Terms and Definitions. This section is a listing of common terms and their definitions.

A1.2.4 Paragraph A1.6, Communication Standards. This section establishes commonality between all joint and combined combat assets in the area of communication formats, control, identification, and integration.

Table A1.1 Key to Multi-Service Brevity Codes.

Code	Definition
*	Meaning may differ with other theater's brevity word.
***	USAF specific codeword.
[term]	An underlined term indicates a new brevity code, an additional meaning, or a deleted meaning to an existing term.
[A/A]	Brevity code meaning applies to air-to-air (A/A) operations.
[A/S]	Brevity code meaning applies to air-to-surface (A/S) operations.
[S/A]	Brevity code meaning applies to surface-to-air (S/A) operations.
[S/S]	Brevity code meaning applies to surface-to-surface (S/S) operations.
[EW]	Brevity code meaning applies to electronic warfare (EW) operations.
[AIR-MAR]	Brevity code meaning applies to maritime air (AIR-MAR) operations.
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A1.3 Joint Operational Brevity Words.

ABORT—Directive call to cease action, attack, event, or mission.

ACTION—Directive call to initiate a briefed attack sequence or plan.

(system) ACTIVE (location/direction)—[EW] Referenced emitter is radiating at the stated location or along the stated bearing.

ADD (system/category)—[EW] Directive call to add a specific system or electronic order of battle (EOB) category to search responsibilities.

ALARM—Directive or informative call indicating the termination of EMCON procedures. Opposite of **SNOOZE**.

ALLIGATOR—Link-11.

ALPHA CHECK—Request for confirmation of bearing and range from own ship to described point.

ANCHOR(ED) (w/location)—

(1) Informative call to indicate a turning engagement at the specified location.

(2) Directive call to orbit about a specific point.

(3) Refueling track flown by tanker.

ANGELS—Height of friendly aircraft in thousands of feet mean sea level (MSL).

ANYFACE—Friendly GCI/airborne early warning (AEW) command and control agency when

call sign is not known.

ARIZONA—No ARM ordnance remaining.

ARM— [A/A] CONTACT(S) resulting from target maneuvers exceeding GROUP criteria.

ARM/ARMED (SAFE/HOT)—Select armament (safe/hot) or armament is safe/hot.

AS FRAGGED—Unit or element will be performing exactly as stated by the air tasking order (ATO).

ATTACK(ING)—[A/S] Directive/(informative) call indicating aircraft are committed to air-to-surface delivery on a specific ground target. Direction/bearing from which the weapon will be coming may be given.

ATTACK COMPLETE—[A/S] Mandatory call from the attack aircraft to the Joint Terminal Attack Controller (J-TAC) during Type III control indicating completion of ordnance release. (See also CLEARED TO ENGAGE.)

AUTHENTICATE—To request or provide a response to a coded challenge.

AUTOCAT—Any communications relay using automatic retransmissions.

(weapon) AWAY—Release/launch of specified weapon. ***NOTE:*** Include launch location in bullseye format and weapons track direction for PIGS and LONG RIFLE.

AZIMUTH—

(1) [A/A] A picture label describing two GROUPs separated laterally. GROUP names will be referenced by cardinal directions (e.g., NORTH GROUP, SOUTH GROUP, or EAST GROUP, WEST GROUP) See **Figure A1.1**, Two Groups AZIMUTH.

(*2) [S/A] Direction to the threat.

BANDIT—An aircraft identified as an enemy IAW theater identification criteria. The term does not necessarily imply direction or authority to engage.

BANZAI—[A/A] Informative or directive call to execute launch-and-decide tactics.

BASE (+/-)—Reference number used to indicate such information as headings, altitudes, and fuels.

BAY—[N] [EW] Carry out deception plan indicated or IAW previous orders.

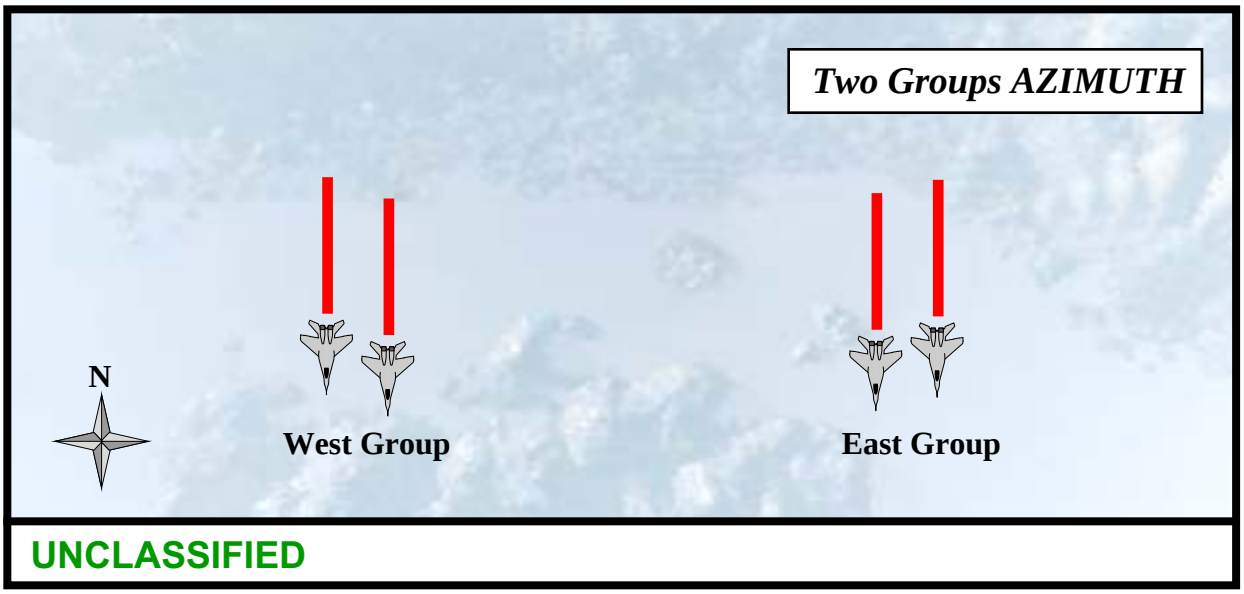
BEAD WINDOW—Last transmission potentially disclosed unauthorized information.

BEAM (w/cardinal direction)—[A/A] Target stabilized within 70 to 110 degrees of aspect; generally given in cardinal directions: east, west, north, and south.

BEANSTALK—[N] Data link users should check equipment for spurious tracks.

(system) BENT—System indicated is inoperative.

Figure A1.1 Two Groups AZIMUTH.



BINGO—Fuel State needed for recovery.

BIRD—Friendly surface-to-air missile (SAM).

BIRD(S) AFFIRM—[S/A] Call indicating friendly unit is able and prepared to engage a specific target with SAMs. Opposite of BIRD(S) NEGATE.

BIRD(S) AWAY (group name)—[S/A] Call indicating friendly SAM has been fired at designated target.

BIRD(S) NEGATE—Surface-to-air informative call indicating unit is unable to engage a specified target with SAMs. Opposite of BIRD(S) AFFIRM.

BITTERSWEET—Notification of possible blue-on-blue (fratricide) or blue-on-neutral situation relative to a designated track or friendly.

BLACK TIMBER—Joint Range Extension Application Protocol Alpha (JREAP A). Half-duplex token passing data link that primarily uses ____ kHz. Demand Assigned Multiple Access (DAMA) UHF satellite communications to send the common tactical picture (CTP)/common operational picture (COP) beyond LOS. USN employs a similar link called Satellite TADIL J (STJ).

BLIND—No visual contact with FRIENDLY aircraft/ground position; opposite of VISUAL**.**

BLOTTER—[N] [EW] ECM receiver.

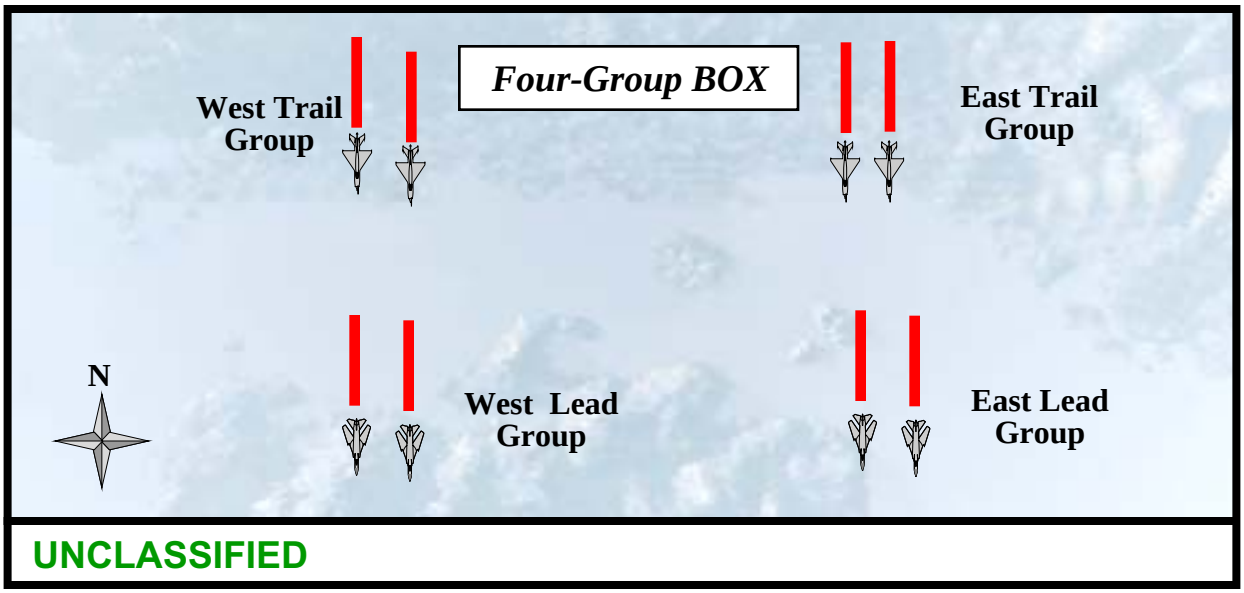
BLOW THROUGH—[A/A] Directive or informative call that indicates aircraft will continue straight ahead at the merge and not become ANCHORED with target/targets.

BOGEY—A radar or visual air CONTACT whose identity is unknown.

BOGEY DOPE—[A/A] Request for target information as requested or closest GROUP in **BRAA** with appropriate fill-ins.

BOX—[A/A] A picture label describing four distinct groups with two in front and two behind in a square or offset square orientation. (See **Figure A1.2**, Four-Group BOX.)

Figure A1.2 Four-Group BOX.



BRAA—Tactical control format providing target bearing, **r**ange, **a**ltitude, and **a**spect, relative to a friendly aircraft. Aspect is only required if other than HOT.

BRACKET (w/direction)—Directive call to maneuver to a position on opposing sides, either laterally or vertically from the targets.

BREAK (w/direction)—Directive call to perform an immediate maximum performance 180-degree turn (or as directed) in the indicated direction. Default is a 180-degree turn. Assumes a defensive situation requiring infrared missile defense (IRMD).

BREAK AWAY—Tanker or receiver call indicating immediate vertical and nose/tail separation between tanker and receiver is required.

BROKE LOCK— Advisory call regarding loss of radar/IR lock-on.

BRUISER—Friendly air launched anti-ship missile.

BUDDY (LASE/GUIDE)—[A/S] Request or informative communications to have guidance of a weapon from a source other than delivering aircraft.

BUDDY LOCK—[A/A] Locked to a known friendly aircraft. Normally a response to a SPIKE or BUDDY SPIKE call.

BUDDY SPIKE (position/altitude/heading)—Friendly aircraft air-to-air (A/A) radar track indication on radar warning receiver (RWR).

BUGOUT (w/direction)—Separation from that particular engagement/attack/operation; no intent to reengage/return.

BUGSY—***Non-friendly*** unit/entity conducting terrorist or asymmetric warfare activities.

BULLDOG—[S/S] Friendly surface/submarine launched antiship missile.

BULLRING—[AIR-MAR] Maritime aircraft patrol zone.

BULLSEYE—An established reference point from which the position of an object can be referenced by bearing (Magnetic) and range (NM) from this point.

BULLSEYE CHECK—Request for confirmation of ownship position relative to BULLSEYE.

BUMP/BUMP-UP—[A/S] A climb to acquire LOS to the target or laser designation.

BURN—[A/S] Informative call that EO/IR illuminator is being used to provide illumination. Typically employed by AC-130 to illuminate surface points of interest.

BUSTER—Directive call to fly at max continuous speed (Mil power).

BUTTON—Radio channel setting.

BUZZER—**Electronic communications jamming.

CANDYGRAM—[EW] Informative call to aircraft that electronic warfare (EW) targeting information is available on a pre-briefed secure net.

CANYON—[N][EW] Use electronic jamming on radar frequency indicated or IAW previous orders.

CAP (location)—Directive call to establish a combat air patrol at a specified point.

CAPPING (location)—Descriptive term for aircraft in a CAP.

(target/object) CAPTURED—[A/S] Aircrew has acquired and is able to track a specified air-to-ground (A/G) target with an on-board sensor.

CAV-OK—ICAO term meaning no significant clouds below 5,000 feet, visibility at least 6 NM, no precipitation or storms.

CEASE (activity)—Directive to discontinue stated activity (e.g., CEASE BUZZER and CEASE LASER).

CEASE ENGAGEMENT—

(1) [S/A] A fire control order used to direct air defense units to stop tactical action against a specified target. Guided missiles already in flight will continue to intercept.

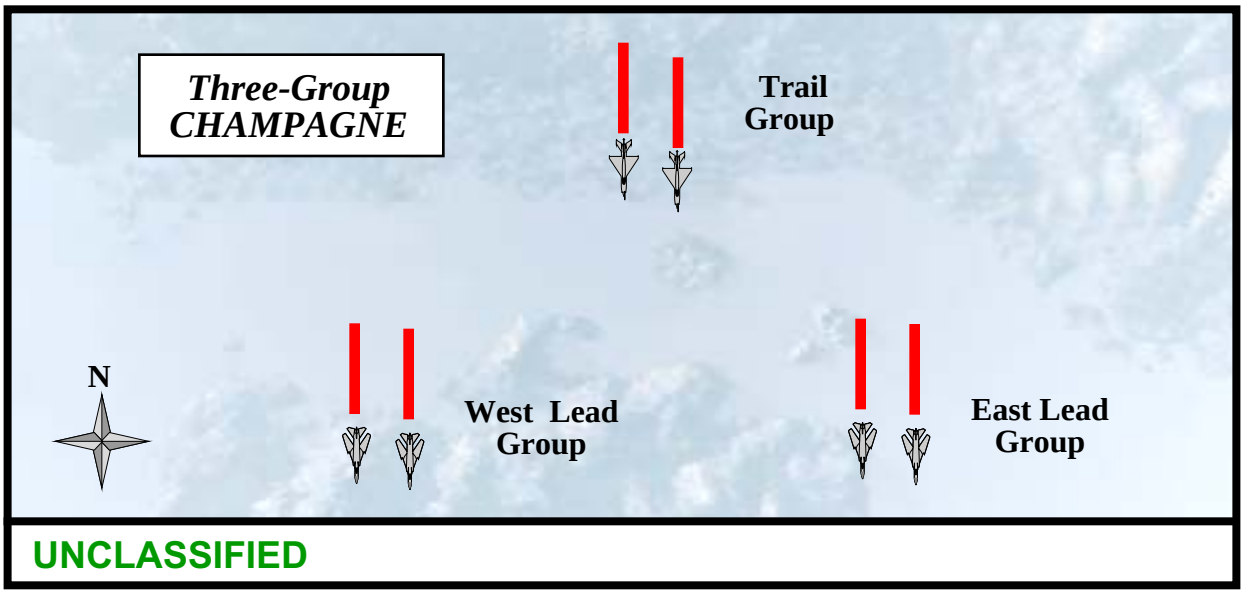
(2) ***In air-to-air, break the engagement on the target specified. Missiles in flight will continue to intercept.

CEASE FIRE—[S/A] Discontinue firing/do not open fire. Complete intercept if weapons are in flight. Continue to track.

CEASE LASER—***Directive to stop firing laser. Opposite of LASER ON.

CHAMPAGNE—[A/A] A picture label describing three distinct groups with two in front and one behind. (See **Figure A1.3**, Three-Group CHAMPAGNE.)

Figure A1.3 Three-Group CHAMPAGNE.



CHANNEL—Stacked net within a Link-16 Network.

CHATTERMARK—Begin using briefed radio procedures to counter communications jamming.

CHEAP SHOT—AIM-120 missile data link terminated between high pulse repetition frequency (HPRF) and medium pulse repetition frequency (MPRF).

CHECK (number, left/right)—Turn (number) degrees left or right and maintain new heading.

CHECK FIRE/FIRING—** [S/S] Immediate pause of planned for current indirect fires.

CHECK TIDS—* Directive/descriptive call to reference data link display; may be followed by amplifying information.

CHERUBS—Altitude of friendly aircraft in hundreds of feet above ground level (AGL).

CHICKS—FRIENDLY aircraft.

CLAM—[EW] Cease emissions on specified equipment.

CLEAN—

(1) No sensor information on non-friendly aircraft of interest.

(2) No visible battle damage.

(3) Aircraft not carrying external stores.

CLEARED—

(1) Requested action is authorized. ***NOTE:*** Engaged/support roles not established.

(2) *** Flight lead response. Requested action is authorized. Mutual support may be detached to fulfill briefed contracts (e.g., split criteria, shot doctrine). Wingmen will ensure deconfliction from flight lead.

CLEARED HOT—[A/S]

(1) Type I and Type II close air support terminal control clearance to release ordnance on this pass.

(2) Training range operations authorizes ordnance release.

(3) *** General term authorizing ordnance release.

CLEARED TO ENGAGE—

(1) [A/S] J-TAC Type III control clearance. Attack aircraft flight leaders may initiate attacks within the parameters imposed by the JTAC. Attack platform will provide ATTACK COMPLETE call to JTAC, indicating completion of ordnance release.

(2) [A/A] [N] Clearance to fire on designated group/target.

CLOAK—Directive/informative call to switch from normal/overt external lighting to covert night vision device (NVD) only compatible lighting.

CLOSING—Decreasing in separation.

COLD—

(1) A descriptive/directive call to initiate a turn in the CAP away from the anticipated threats.

(2) Groups heading away from friendly aircraft.

(3) Attack geometry will result in a pass or roll out behind the target.

(4) Defined area is not expected to receive fire (enemy or friendly).

COMEBACK (w/direction)—Directive call to reverse course.

COMEOFF (w/direction)—

(1) (A/A] Directive call to maneuver as indicated to either regain mutual support or to deconflict flight paths. Implies both **VISUAL** and **TALLY**.

(2) [A/S] Directive call to maneuver or execute a specific instruction (e.g., **COMEOFF DRY**).

COMMIT—[A/A] Directive call to intercept a group of interest.

CONFETTI—Chaff lane or corridor.

CONS/CONNING—Threat/bogey aircraft leaving contrails.

CONTACT—

(1) Sensor contact at the stated position.

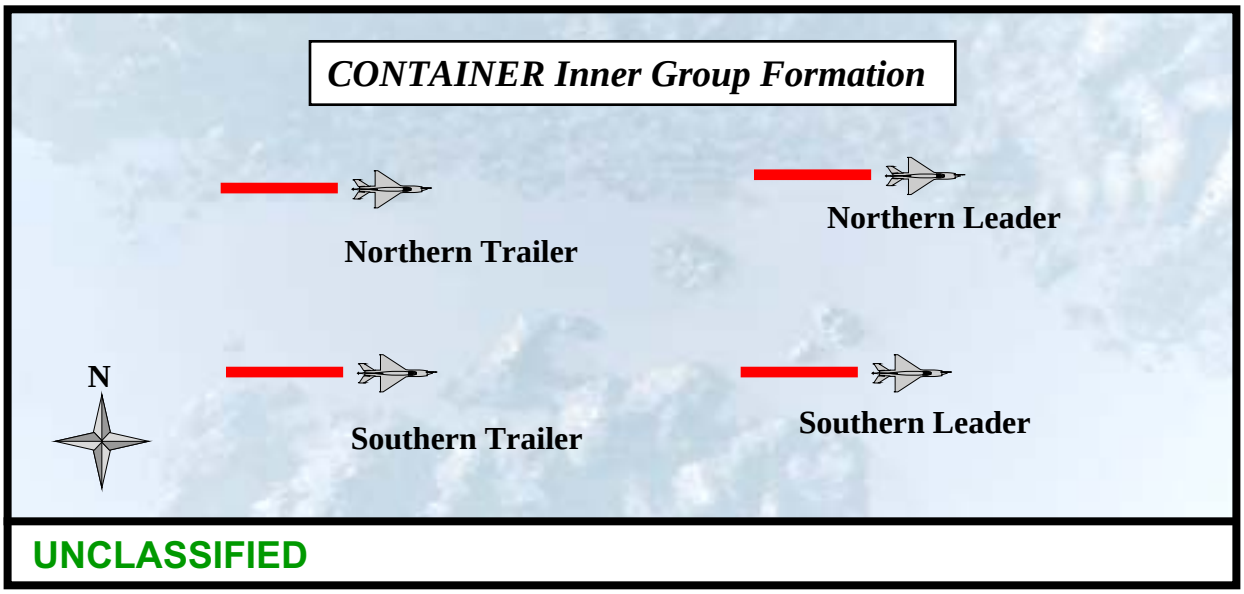
(2) Acknowledges sighting of a specified reference point.

(3) Individual radar return within a group or arm.

CONTACT POD—[A/S] Acknowledges sighting of a specified reference point with EO/IR sensor.

CONTAINER—Inner group formation with four contacts oriented in a square or offset square. (See **Figure A1.4**, CONTAINER Inner Group Formation.)

Figure A1.4 CONTAINER Inner Group Formation.



CONTINUE—Continue present maneuver; does not imply a change in clearance to engage or expend ordnance.

CONTINUE DRY—Continue present maneuver; ordnance release not authorized. ***NOTE:*** Simulated weapons deliveries may be performed.

COVER—Directive/informative call to assume a supporting position that will allow engagement of a specified track or threat to the flight if required.

CRANK (w/direction)—F-Pole maneuver; implies illuminating target at radar gimbal limits.

CRISS CROSS—[N] [EW] A position or track derived from the plotting of DF bearings.

CROSSING—[A/A] Two GROUPS initially separated in azimuth decreasing azimuth separation to pass each other.

CURVE—[N] [EW] Deception signal.

CUTOFF—Request for, or directive to, intercept using cutoff geometry.

CYCLOPS—Any unmanned aerial vehicle (UAV).

DANGER CLOSE—[A/S], [S/S] Informative call that FRIENDLY troops are within close proximity of the target (determined by the weapon/munition delivered/fired). (***NOTE:*** Specific DANGER CLOSE distances, assumptions, and procedures are contained in JFIRE guide.)

DASH (#)—Aircraft position within a flight. Use if specific call sign is unknown.

DATA (object, w/position)—Standby for data link message concerning object at stated location.

DEADEYE—Informative call by an airborne laser designator indicating the laser system is inoperative.

DECLARE—Inquiry as to the identification of specified tracks, targets, or correlated group. Core information must accompany declaration responses.

DEEP—[A/A] Descriptive term used to indicate separation between the nearest and farthest GROUPS in range in a relative formation; used to describe a LADDER, VIC, CHAMPAGNE, or BOX.

DEFENSIVE—Speaker is under attack, is maneuvering defensively, and is unable to ensure deconfliction or mutual support.

DEFENDING (w/direction)—Aircraft is in a defensive position and maneuvering with reference to a surface-to-air threat.

DELOUSE—Directive call to detect, identify, and engage (if required) unknown aircraft trailing friendly aircraft.

DEPLOY—Directive call for the flight to maneuver to briefed positioning.

DETAILS—Request for modified J-FIRE 9-Line Brief.

DIAMONDS (w/position)—A surface IR event location.

DIRT—** RWR indication of surface threat in search mode.

DIRTY—Link is not encrypted.

DIVERT—Proceed to alternate mission/base.

DOLLY—Link-4A.

(system) DOWN (location/direction—[EW] Referenced emitter has stopped radiating at the stated location or along the stated bearing. (***NOTE:*** DOWN does not mean destroyed.)

DRAG (w/cardinal direction)—[A/A] Target stabilized at 0- to 60-degree angle from tail or 120- to 180-degree angle from nose.

DROP—

(1) Directive/informative call to stop monitoring a specific emitter/target and resume search responsibility.

(2) Remove the emitter/target from the tactical picture/track stores.

(3) Directive call to remove a specific system or EOB category from search responsibilities.

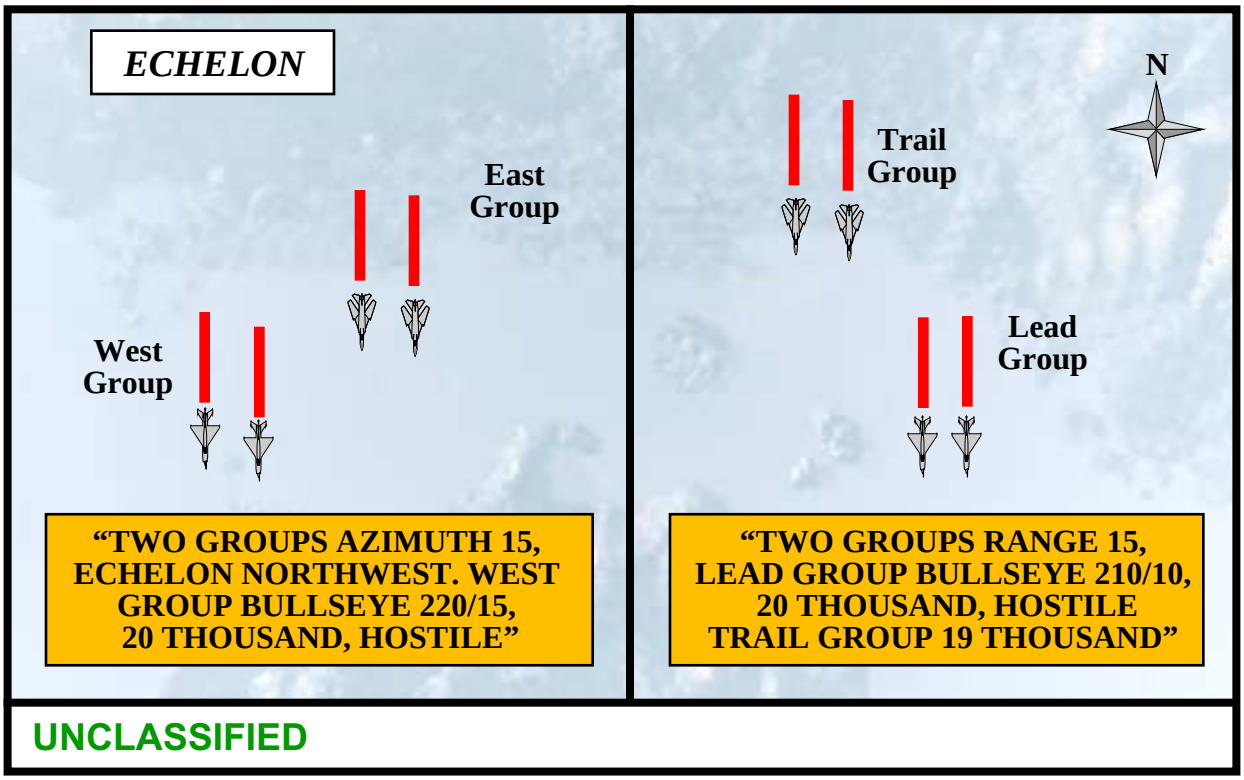
DROPPING—Informative call that a fighter has discontinued targeting responsibility.

DUCK—[N] Informative/directive call to descend and increase speed.

DUFFER—[EW] DF-equipped unit.

ECHELON (w/sub-cardinal direction)—[A/A] A fill-in to a picture label describing groups aligned behind and to the side of the closest group. (See **Figure A1.5**, ECHELON.)

Figure A1.5 ECHELON.



EMPTY—No emitters of interest detected.

ENGAGE—A fire control order used to direct or authorize units and/or weapons systems to fire on a designated target.

ENGAGED—Informative call used to establish engaged and support roles in the visual arena.

ESTIMATE—Provides estimate of the size, range, height, or other parameters of a specified contact; implies degradation.

EXTEND (w/direction)—[A/A] Short-term maneuver to gain energy, distance, or separation normally with the intent of reengaging.

EYEBALL—

(1) Electro-optical (EO)/IR/night vision device (NVD) acquisition of an aircraft normally followed by number of aircraft observed.

(2) Fighter with primary visual identification responsibility.

EYEBALL NARROW—**[A/A] EO/IR contacts are too close for resolution via radar.

FADED—Radar contact is lost on a non-friendly aircraft/surface contact and any positional information given is estimated.

FAST—***Target speed is 600 to 900 knots ground speed/Mach 1 to 1.5.

FATHER—Surface tactical air navigation (TACAN) station.

FEELER—[N] [EW] Shipborne fire control radar.

FEET WET/DRY—Flying over water/land.

FENCE (IN/OUT)—Set cockpit switches as appropriate prior to entering/exiting the combat area.

FERRET—[N] [EW] Airborne electronic reconnaissance activity or aircraft.

FILL-IN (group)—*** Request for all available fill-ins on a specific group/arm/contact.

FLANK (w/ direction)—Contact aspect stabilized at 120- to 150-degree angle from the tail or 30- to 60-degree angle from nose.

FLARE—Directive to deploy flares.

FLASH (system)—Temporarily activate specified system for identification purposes (e.g., IFF, afterburner, flare, or chaff).

FLASHLIGHT—Directive term for helicopter to turn on IR floodlight (pointed at ground to aid in visual acquisition by escort aircraft).

FLAVOR—Visually identified nationality of a contact.

FLOAT—Directive or informative call to expand the formation laterally within visual limits to maintain radar contact or prepare for a defensive response.

FLOW—Directive call to fly stated heading.

FOX—A/A weapons employment.

FOX 1—Simulated or actual launch of semiactive radar-guided missile.

FOX MIKE—VHF/FM radio.

FOX 2—Simulated or actual launch of IR-guided missile.

FOX 3/SECOND FOX 3—Simulated or actual launch of active radar-guided missiles on the same target.

FOX 3 CLOSE/MEDIUM/LONG—Shot/kill communications brevity.

FOX 3 (X) SHIP (formation description)—Valid missile shot against (x) separate targets (assumes 1 missile per target).

FREEZE BURN—Directive call to AC-130 to freeze the gated laser illumination (GLINT) position in the present location.

FRIENDLY—A positively identified friendly aircraft or ground position.

FURBALL—Response to a DECLARE request indicating known bandits and friendlies in close proximity. Provide amplifying information if available (i.e. call sign of engaged friendlies).

GADGET—Radar or emitter equipment.

GATE—Directive/informative call to fly as quickly as possible, using afterburner/max power.

GENIE—[EW] Emitter is employing electronic protection measures.

GIMBAL (w/BRAA)— Radar target is approaching azimuth or elevation limits.

GINGERBREAD—Voice imitative deception is suspected on this net.

GO ACTIVE—Go to briefed HAVE QUICK net.

GO BROADCAST—Request or directive call to switch to broadcast control.

GO CLEAR—Use unencrypted voice communications.

GO SECURE—Use encrypted voice communications.

GO TACTICAL—[A/A] Request or directive call to switch to tactical control.

GOGGLE/DEGOGGLE—***Directive call to put on/take off NVDs.

GOGGLES ON/GOGGLES OFF—***Informative call that NVDs are on/off.

GOODWILL—Informative call indicating the boundary of an active friendly MEZ.

GOPHER—A **CONTACT** that has not conformed to safe passage routing, airspeed, or altitude procedures. Will only be used when safe passage or minimum risk routing procedures are part of an ID matrix.

GORILLA—[A/A] Large force of indeterminable numbers and formation.

GRAND SLAM—All HOSTILE aircraft of a designated track (or against which a mission was tasked) are shot down.

GREEN (w/ direction)—Direction determined to be clearest of enemy A/A activity.

GREYHOUND—Friendly ground attack cruise missile.

GROUP—[A/A] Aircraft within 3 NM in azimuth or range.

GUNS—***An air-to-air or air-to-surface gunshot.

HANDSHAKE—

(1) Link-16 air control net participant group (NPG) initiation between air control unit and controlled aircraft.

(2) ** Full motion video signal and data operative to ROVER.

HARD (w/direction)—High-G, energy sustaining 180-degree turn (or as directed) in the indicated direction.

*****HEADBUTT**—Directive term to fighters/interceptors to immediately divert a track of interest clear of a restricted or prohibited area. Also referred to as INTERVENE.

HEADS UP—Alert of an activity of interest.

HEAVY—A group known to contain three or more entities.

HIGH—CONTACT is greater than 40,000 feet MSL.

HITS—

(1) [A/A] Momentary radar returns in search.

(2) [A/A] Indicates approximate target altitude (e.g., “GROUP BULLSEYE 360/10, HITS 15 THOUSAND”).

(3) [A/G] Weapons impact within lethal distance.

HOLD DOWN—Directive call to key transmitter for direction finder (DF) steer.

HOLD FIRE—[S/A] An emergency fire control order to stop firing on a designated target to include destruction of any missiles in flight.

HOLDING HANDS—Aircraft in visual formation.

HOLLOW—

(1) Any data link message not received.

(2) ** Lost full motion video signal and/or data to ROVER.

HOMEPLATE—Home airfield or carrier.

HOOK (_)—

(1) (W/direction)—Directive call to perform an in-place 180-degree turn.

(2) (W/directive/descriptor) Link 16 directive call to cue sensors to A/G point (point of interest, SAM, markpoint, track number (TN), etc.)

HOOTER—FRIENDLY jammer.

HOSTILE—A contact identified as enemy upon which clearance to fire is authorized in accordance with theater rules of engagement. (***NOTE:*** Theater commander should specify in ATO SPINS the exact definition of HOSTILE brevity term for combined operations.)

HOT—

(1) A descriptive/directive call to initiate a turn in the CAP toward the anticipated threats.

(2) ***Groups heading towards friendly aircraft. Opposite of COLD.

(3) Ordnance employment intended or completed.

(4) Defined area is expected to receive fire (enemy or friendly).

(5) Contact aspect stabilized at 160- to 180-degree angle from tail or 0- to 20-degree angle from nose.

(6) Intercept geometry will result in passing in front of the target.

HOTDOG—Informative/directive call that an aircraft is approaching or at a specified standoff distance from the sovereign airspace of a nation (as defined by national boundaries or territorial sea and airspace). (Color may indicate additional standoff distance.) Follow briefed procedures.

HOUNDOG—[N] [A/A] Call made by a free fighter indicating the free fighter is in a position to employ weapons.

HOTEL FOX—HF radio.

HUSKY—[A/A] Informative call that the AIM-120 is at HPRF active range.

ID—

(1) Directive call to identify the target

(2) Aircrew identification accomplished, followed by type aircraft or "FRIENDLY/HOSTILE."

ID (tail/type/nationality)—[AD] Directive call to identify the target/TOI. Also, aircrew identification is accomplished following amplifying information.

IDLE— call indicating surface vehicles are stationary.

IN—

(1)[A/A] Informative call indicating a turn toward a known threat.

(2)[A/S] Entering terminal phase of an air-to-ground attack. Opposite of OFF.

IN PLACE (w/direction)—Perform indicated maneuver simultaneously.

INDIA—Mode 4.

INSPECT—***[AD] Establish visual contact with cockpit of TOI (implies closure inside 500 feet). Attempt communications and report all observations of activity.

INTERROGATE—Interrogate the designated contact of the identification, friend or foe (IFF)/selective identification feature (SIF) mode indicated.

INTERVENE—[A/A] Immediately divert a track of interest clear of a restricted or prohibited area.

IN THE DARK—Contact is in a known radar blind zone.

INTRUDER—An individual, unit, or weapon system in or near an operational or exercise area, which represents the threat of intelligence gathering or disruptive activity.

INVESTIGATE—Verify specified elements of ROE, PID, CDE, and/or coordination of forces on the referenced target/track.

JACKAL—Surveillance network participating group (NPG) of Link-16/TADIL-J.

JAMMER—Non-friendly jammer.

JELLO—Inverse synthetic aperture radar (SAR).

JINK—Directive call to perform an unpredictable maneuver to negate a gun tracking solution.

JOKER—Fuel state above BINGO at which separation/bugout/event termination should begin.

JUDY—Aircrew has radar or visual contact on the correct target, has taken control of the intercept, and requires only situation awareness (SA) information; weapon director (WD) will minimize radio transmissions.

KICK (appropriate frequency)—Change radio or data link to a specified net or frequency.

KELLOGG—***JREAP B. Full-duplex synchronous or asynchronous point-to-point data link that can use any point-to-point media.

KILL—

(1) ***Directive call to fire on designated target.

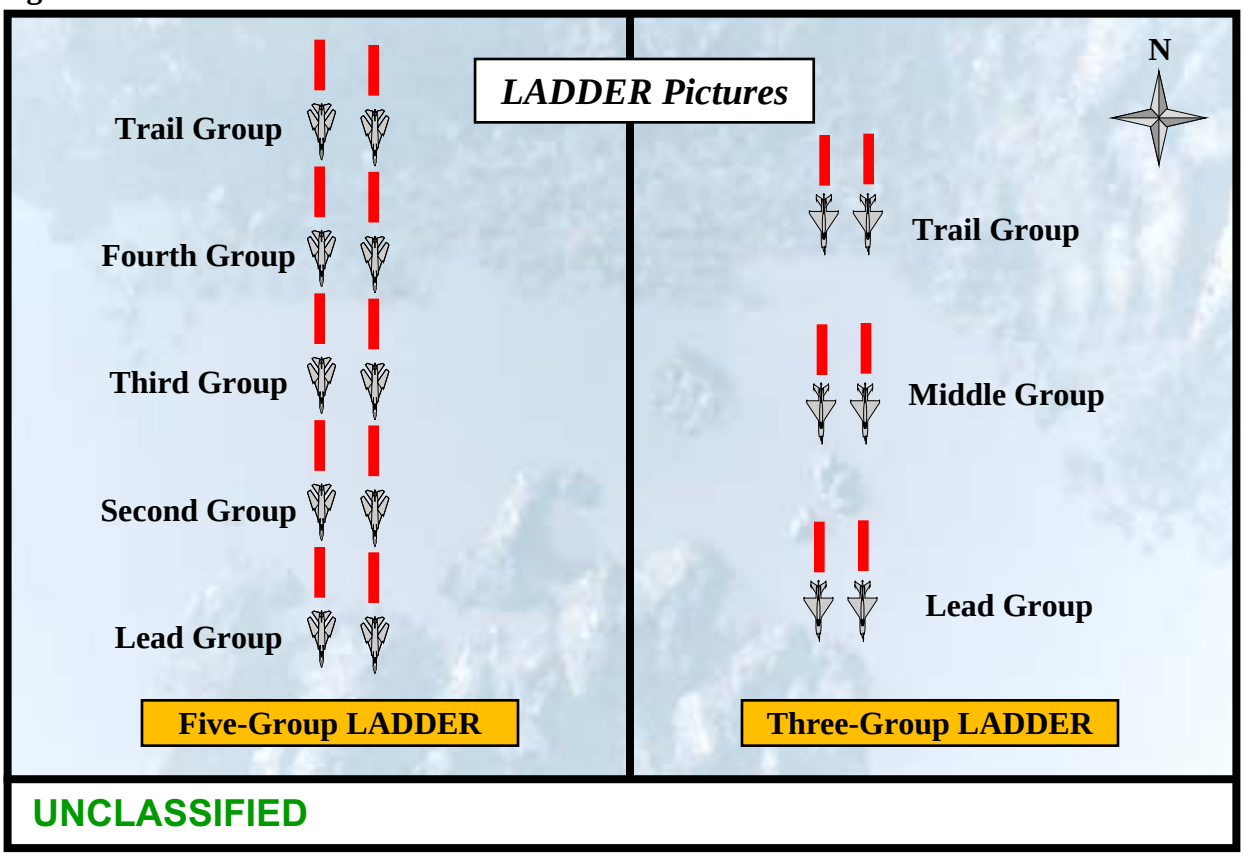
(2) ***In training, a fighter call to indicate kill criteria have been fulfilled.

KNOCK-IT-OFF—Directive call to cease air combat maneuvers/attacks/activities.

LADDER—A picture label describing three or more groups separated in range. (See **Figure**

A1.6, LADDER Pictures.)

Figure A1.6 LADDER Pictures.



LAME DUCK—An aircraft in a minor state of emergency.

LASER—Platform is able to laser target designate.

LASER ON—Directive call to start laser designation.

LASING—Informative call indicating that the speaker is firing the laser.

LAST—Command and control (C^2) term that provides the last contact altitude from a high fidelity source (fighter radar).

LEAD-TRAIL—Inner-group formation of two or more contacts separated in range. (See **Figure A1.7**, LEAD-TRAIL Inner Group Formation.)

LEAKERS—Airborne threat has passed through a defensive layer. Call should include amplifying information.

LEAN (direction)—Directive/informative call to maneuver in a direction ***to avoid the threat***.

LEVEL—[A/A] Inter-flight informative call that contact is coaltitude.

LIGHTBULB—Directive call for flight to turn all position lights to bright.

LIGHTS ON/OFF—Directive to turn on/off exterior lights.

LINE ABREAST—Inner group formation of two or more contacts separated in azimuth. (See **Figure A1.8**, LINE ABREAST Inner Group Formation.)

Figure A1.7 LEAD-TRAIL Inner Group Formation.

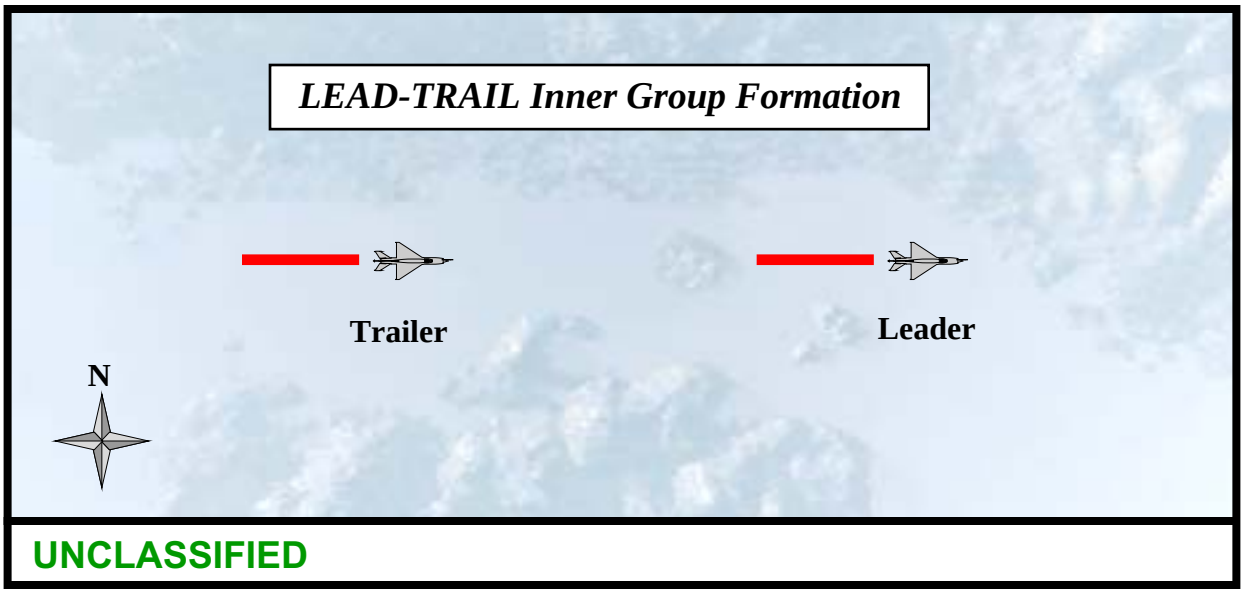
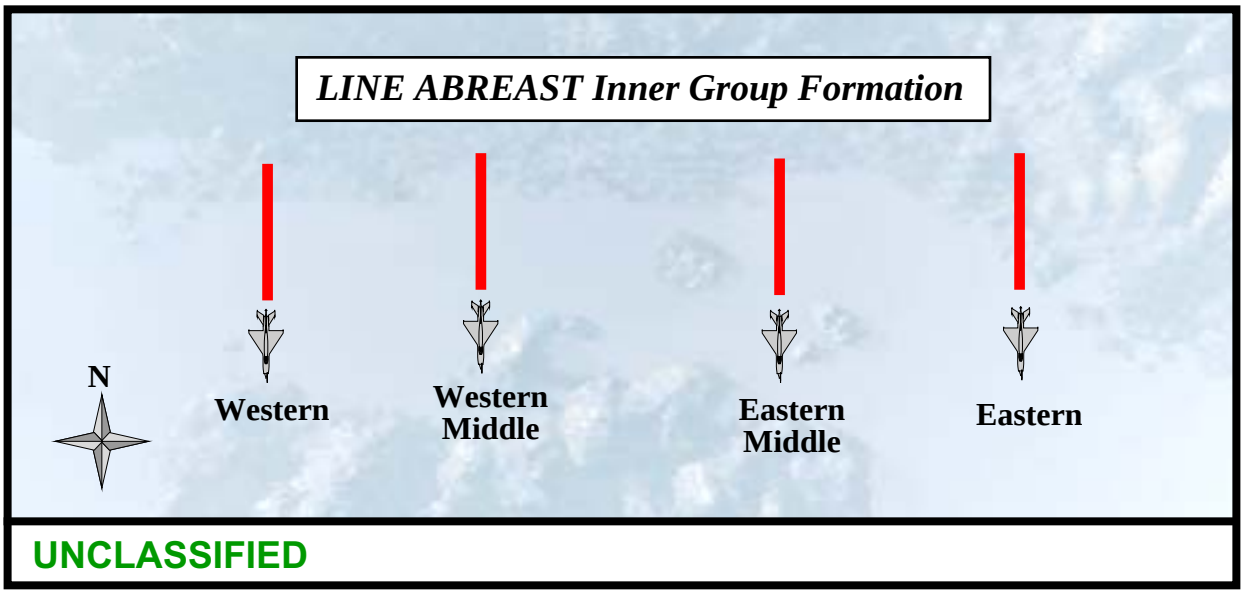


Figure A1.8 LINE ABREAST Inner Group Formation.



LINER—[N] Fly at speed giving maximum cruising range.

LOCKED—

(1) (w/position)—Radar lock-on; correct targeting is not assumed.

(2) (w/group name)—Radar lock-on; sort is not assumed.

LONG RIFLE (launch location in bullseye format and weapons track direction)—[A/S] Friendly, long-range air-to-surface missile launch.

LOOKING—.Aircrew does not have the ground object, reference point, target in sight (opposite of **CONTACT**).

LOST CONTACT—

(1) Previous contact lost; provide target information.

(2) Sensor information on friendly contact is lost.

LOW—***Target altitude is below 10,000 feet MSL.

LOWDOWN—**A request to provide tactical ground information pertinent to the mission in a digital bullseye format.

MADDOG—[A/A] Visual AIM-120 launch.

MAGNUM (system/location)—[A/S] Launch of friendly antiradiation missile (ARM).

MANEUVER (AZIMUTH/RANGE/ALTITUDE)—[A/A] Informative call that said group is maneuvering in azimuth, range, and/or altitude.

MANFRED—[EW] I am unable to operate (radar or emitter indicated) for reasons of national security

MAPPING—[A/S] Multi-function radar in an A/G mode.

MARK—

(1) Record the location of a point/object of interest

(2) [A/S], [S/S] Spotting round, normally white phosphorous (WP) or illumination on the deck to indicate targets to aircraft, ground troops, or fire support.

MARKING—Friendly aircraft leaving contrails.

MARKPOINT—Data link non-designated geographic point of interest.

MARSHAL(ING)—Establish(ed) at a specific point.

MATCH SPARKLE—Overlay IR point.

MEDIUM—***Target altitude between 10,000 and 40,000 feet MSL.

MELD—**[A/A] Bias radar coverage IAW briefed parameters.

MERGE(D)—(1) Informative call that friendlies and targets have arrived in the same visual arena and (2) call indicating radar returns have come together.

MICKEY—HAVE QUICK time-of-day (TOD) signal.

MIDNIGHT—Informative call advising that C^2 radar functions are unavailable due to degradation. Advisory information is still available. Opposite of SUNRISE.

MINIMIZE—The radio frequency is becoming saturated, degraded, or jammed and briefer transmissions must follow.

MILLER TIME—Informative call indicating completion of air-to-ground ordnance delivery. Generally used by the last aircraft in conjunction with a pre-coordinated egress plan.

MONITOR(ING)—

(1) Maintain(ing) sensor awareness on specified GROUP.

(2) [AIR-MAR] Directive call to an aircraft to maintain contact/targeting information on a maritime surface.

MOTHER—[AIR-MAR] Parent ship.

MOVE BURN (bearing)—Move EO/IR illumination in specified direction. ***NOTE:*** Do not use LEFT/RIGHT for moving a BURN.

MOVER(S)—Unidentified surface vehicles in motion.

MUD (type w/direction)—

(1) Indicates radar warning receiver (RWR) ground threat displayed with no launch identification.

(2) RWR indication of surface threat in track mode. See DIRT and SINGER.

MULTIPLE—[N] [EW] There are number of stations on the same frequency.

MUSIC—Radar electronic deceptive jamming.

NAILS (direction)—

(1) RWR indication of AI radar search.

(2) *(A/S) 2.75-inch flechette rockets.

NAKED—No RWR indications.

NEAR-FAR—[A/A] Fighter term depicting a radar-apparent description of two or more contacts within a group separated in range.

NEGATIVE CONTACT—Sensor information on a friendly aircraft is lost. ***Termination of CONTACT, track plotting is not warranted.***

NEGATIVE LASER—[A/S] Aircraft has not acquired laser energy.

NEW PICTURE—[A/A] Used by controller or aircrew when tactical picture has changed. Supersedes all previous calls and re-establishes picture for all players.

NEUTRAL—**A positively identified aircraft, ship, or ground position whose characteristics, behavior, origin or nationality indicate that is neither supporting nor opposing FRIENDLY forces.

NIMBUS—***JREAP C. Transmission control protocol (TCP) or user datagram protocol (UDP)/Internet protocols (IP) data link that transmits on local area networks (LAN) or wide area networks (WAN).

NO FACTOR—Not a threat.

NO JOY—Aircrew does not have visual contact with the target/BANDIT/BOGEY/landmark; opposite of TALLY.

NOTCH(ING) (w/direction)—Directive (informative) for an all-aspect missile defensive maneuver to place threat radar/missile near the beam.

NOTCH RANGE (NR)—***The range at which a spiked fighter will notch in order to be established prior to threat F-Pole with a pre-determined buffer. The buffer allows for two things: (1) the spiked fighter will be established in the notch with range to survive; and (2) the flight lead has time (during the fighter's maneuver to the notch) to make a merge decision and still call the flight "OUT" and trap the threat outside of a stern WEZ on both element members.

OCCUPIED—Ground equipment present at tasked target location. Opposite of VACANT.

OFF (w/direction)—Informative call indicating attack is terminated and maneuvering to the indicated direction.

OFFSET (w/direction)—Informative call indicating maneuver in a specified direction with reference to the target.

(system) OKAY—***System indicated is fully operative (cancels BENT).

ORBIT(ING)—Directive/descriptive call to hold on current or indicated position.

ON STATION—Informative call that unit/aircraft has reached assigned station.

OPENING—Increasing in separation.

OUT (w/direction)—Informative call indicating a turn to a cold aspect relative to the known threat.

OUTLAW—Informative call that a CONTACT has met point of origin criteria.

PACKAGE—Geographically isolated collection of GROUPS.

PACMAN—[N] Fighters have found the end of the threat formation and are converting; given in range and bearing from BULLSEYE (e.g., "FRENCHY 1 is PACMAN 290/5").

PADLOCKED—Informative call indicating aircrew cannot take eyes off an aircraft or ground target without risk of losing tally/visual.

PAINT(S)—An interrogated group/radar contact that is responding with <u>any</u> of the specified IFF/SIF modes and correct codes established for the identification criteria.

PAN (left/right/up/down)—Move the sensor in the indicated direction relative to the current image.

PARROT—IFF/SIF transponder.

PASSING—Descriptive term for when two GROUPS initially separated in range decrease range and pass each other.

PEDRO—[N] Rescue helicopter.

PEEPSHOW—** Perform non-traditional ISR on the referenced track/target.

PICTURE—* [A/A] A request to provide air information pertinent to the mission in a digital bullseye format unless briefed otherwise.

PIGEONS—Magnetic bearing and range to HOMEPLATE.

PIGS AWAY (launch location in bullseye format and weapons track direction)—Friendly glide weapon (i.e., SLAM-ER).

PILLOW—[EW] Pulse repetition interval.

PINCE—Threat maneuvering for a bracket attack.

PINNACLE—[N] [EW] An emission believed to originate from a platform assumed to be FRIENDLY.

PITBULL—[A/A] Informative call that the AIM-120 is at MPRF active range.

PITCH/PITCHBACK (LEFT/RIGHT)—Directive call for fighter/helo or flight to execute a nose-high heading reversal.

PLAYMATE—Cooperating aircraft.

PLAYTIME—Amount of time aircraft can remain on station, given in hours plus minutes (e.g., ONE PLUS THIRTY equals 1 hour and 30 minutes).

(freq) POGO (freq)—Switch to communication channel number preceding POGO. If unable to establish communications, switch to channel number following POGO. If no channel number follows POGO, return to this channel.

POINT—Link point/track of interest; can be associated with directive call.

**** DROP POINT—**Data link target sorting message is no longer needed/desired

**** HOLD POINT**—Maintain PDT on the current track to maintain the data link target sorting message.

****TARGET POINT**—Target the referenced data link target sorting message.

POND—[N] [EW] Carry out jamming plan indicated or IAW previous orders.

POLAR BEAR—[N] FRIENDLY aircraft has VISUAL/CONTACT on FRIENDLY package and is joining.

POP—

(1) Starting climb for A/S attack.

(2) Max performance climb out of low-altitude structure.

POPCORN—Helicopter departing the landing zone (LZ). Usually followed by number of recovered personnel (e.g., “STING 1, POPCORN, PLUS 2”).

POPEYE—Flying in clouds or area of reduced visibility.

POP-UP—

(1) [A/A] Informative call of a GROUP that has suddenly appeared inside of briefed range.

(2) [S/A] Criteria used as a self defense method, within the ROE, to protect friendly air defense elements from HOSTILE aircraft.

POSTHOLE—Rapid descending spiral.

POSIT—Request for friendly position; response in terms of a geographic landmark or off a common reference point.

PRESS—Directive call to continue the attack; mutual support will be maintained. Supportive role

will be assumed by the speaker.

PULSE—Informative/directive call used to illuminate an enemy position with flashing IR energy.

PUMP—[A/A] A briefed maneuver to low aspect to stop closure on the threat or geographical boundary with the intent to reengage.

PURE—[A/A] Informative call indicating pure pursuit is being used or directive to go pure pursuit.

PUSH (channel/frequency)—Go to designated frequency; no acknowledgment required.

PUSHING—

(1) Departing designated point.

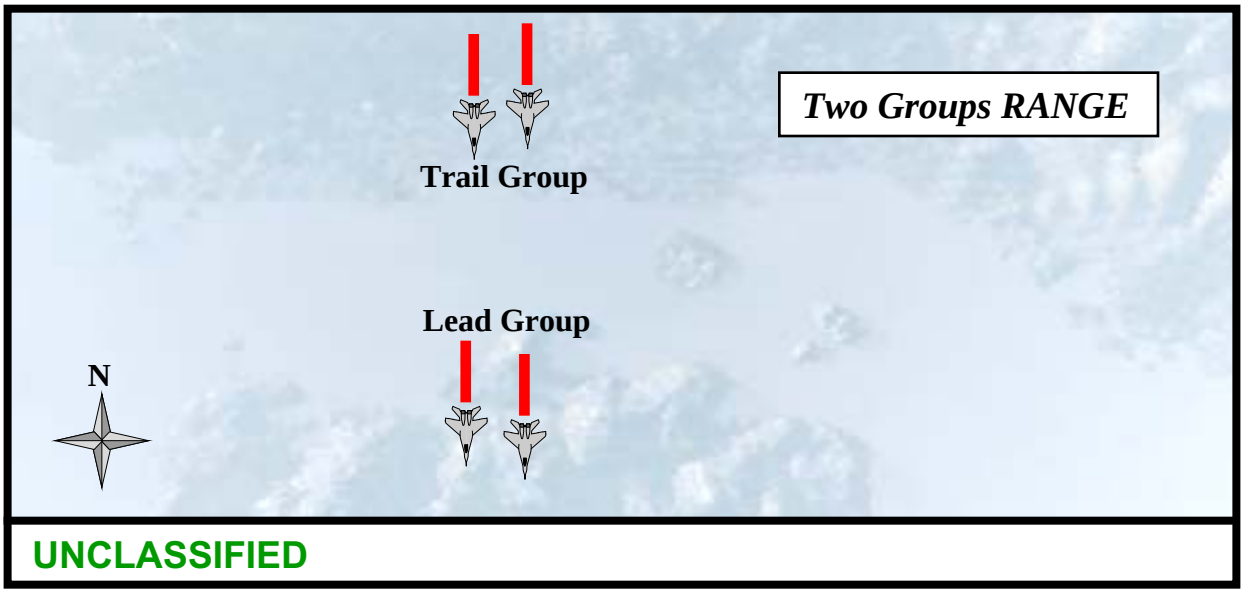
(2) GROUP(S) have turned cold and will continue to be monitored.

QUAIL—Enemy air/surface launched cruise missile.

RACKET—[EW] Intercepted electronic emission that has been assigned to a number of the track block.

RANGE—[A/A] A picture label describing two GROUPs separated in distance along the same line of bearing. Group names will be LEAD GROUP/TRAIL GROUP. (See **Figure A1.9**, Two Groups RANGE.)

Figure A1.9 Two Groups RANGE.



RAYGUN (position/heading/altitude)—[A/A] indicating a radar lock on to unknown aircraft. A request for a BUDDY SPIKE reply from friendly aircraft meeting these parameters.

RED LIGHT—Time when search and rescue (SAR) aircraft is no longer SAR capable.

REFERENCE (direction)—Directive to assume stated heading.

RENEGADE—A civil platform that is assessed as operating in such a manner as to raise suspicion that it might be used as a weapon to perpetrate a terrorist attack.

RENT—[EW] Report of characteristics of an intercepted signal.

REPEAT—

(1) **[S/S] (during adjustment) Fire again using the same fire method.

(2) **[S/S] (during fire for effect) Fire the same number of rounds using the same method of fire.

REPORTED (information)—Information provided is derived from an off-board source.

RESET—Proceed to a pre-briefed position or area of operation (AO).

RESTAKE—Request for Joint STARS to drive a new STAKE at the target centroid reported with direction of travel and elevation. Initiated by aircrew.

RESUME—Resume last formation/route/mission ordered.

RETROGRADE(ING)—Withdraw/withdrawing, while executing defensive procedures in response to a threat.

RIDER—A **BOGEY** that is conforming to safe passage routing, airspeed, or altitude procedures.

RIFLE—[A/S] Friendly air-to-surface missile launch.

RIPPLE—[A/S] Two of more munitions released or fired in close succession.

ROBBER—* A surface vessel that is identified as an enemy IAW theater ID criteria. The term does not necessarily imply clearance to engage.

ROGER—Indicates aircrew understands the radio transmission; does not indicate compliance or reaction.

ROLEX (+/-time)—Time line adjustment in minutes always referenced from original preplanned mission execution time. Plus means later; minus means earlier.

ROPE—Circling an IR pointer around an aircraft to help the aircraft identify the friendly ground position.

ROTATOR—Joint STARS moving target indicator (MTI) return that signifies a high probability of a rotating antenna.

ROVER—Platform is video downlink capable.

RUMBA—

(1) * Radar has detected jamming/mutual interference but has not resolved the type.

(2) [N] Ownship maneuvering for ranging.

SADDLED—Informative call from wingman or element indicating the return to briefed formation position.

SAM (w/direction)—Visual acquisition of a SAM in flight or a SAM launch, should include position and type if known.

SAME—Informative reply indicating that the aircrew has the identical information as was just stated.

SANDWICHED—A situation where an aircraft or element finds themselves between opposing aircraft or elements.

SAUNTER—Fly at best endurance.

SCAN—[N] Search sector indicated and report any contacts.

SCHLEM—***Simulated high off boresight IR missile launch. Not assessable for simulated kill/kill removal.

SCRAM (direction)—

(1) Friendly asset is in immediate danger. Withdraw in the direction indicated for survival. No further HVAA mission support is expected.

(2) Cease the intercept and take immediate evasive action. Implies that the target aircraft is being engaged by SAMs or other air defense fighters.

SCRAMBLE—Takeoff as quickly as possible.

SCRUB— (MTI) return that signifies a low, slow airborne target.

SCUD—Any threat theater ballistic missile (TBM).

SEARCH—[AD] Perform radar search of indicated position.

SEPARATE—[A/A] Leaving a specific engagement; may or may not reenter.

SEPARATION—Request for separation between two GROUPs. Response will include the follow-on GROUP's separation, altitude, and fill-ins.

SET—

(1) A directive to set (or have set) a particular speed. May be in knots/indicated or in Mach.

(2) * No longer slewing sensor and awaiting further updates.

SHACKLE—One weave, a single crossing of flight paths; maneuver to adjust or regain formation parameters.

SHADOW—Follow indicated target.

SHEPARD (contact/group)—*** [A/A] Informative call that described entity has a valid, reduced P_k (e.g., nominal or EA) AIM-120 inbound and shooter cannot employ a second shot.

SHIFT (direction)—[A/S] Directive call to shift/laser/IR/radar/device energy.

SHOOTER—Aircraft designated to employ ordnance.

SHOPPING—An aircraft request to FAC/JTAC/C^2 for a target.

SHORT SKATE—*** Directive to execute launch and leave mechanics no later than minimum abort range or notch range.

SHOT—** [S/S] Rounds have been fired.

SHOTGUN—Pre-briefed weapons state

(system) SICK—** System indicated is degraded/partially operative. Cancelled by SWEET.

SIDE-SIDE—Fighter term depicting a radar-apparent description of two or more contacts within a group separated in azimuth.

(system) SILENT—

(1) (time)—System will be unavailable for time indicated.

(2) Directive/informative call to indicate data link is, or should be placed, in receive only.

(3) [N] [EW] Broadcast station is not transmitting. May also be used as an order and must be followed by a frequency or station designator. If possible, it should be followed by an estimated time of return to the air.

SINGER (type w/direction)—Informative call of RWR indication of surface-to-air missile launch.

SINGLE—Descriptive call indicating one GROUP, CONTACT, etc.

SKATE—[A/A] ******* Informative or directive call to execute launch-and-leave tactics and be out no later than desired out range (DOR)/minimum out range (MOR).

SKINNY—Current survivor coordinates or info followed by date/time stamp. Also request for databurst of survivor data.

SKIP IT—Veto of fighter commit call, usually followed with further directions.

SKOSH—[A/A] Aircraft is out of or unable to employ active radar missiles.

SKUNK—A radar or visual maritime surface contact whose identity is unknown.

SLAPSHOT (type, bearing)—Directive call for an aircraft to immediately employ a best-available HARM against a specified threat at the specified bearing.

SLICE/SLICEBACK (LEFT/RIGHT)—Directive call to perform a high-G descending turn in the stated direction, usually 180-degree turn.

SLIDE—Directive/informative call to/from high value airborne asset (HVAA) to continue present mission while flowing from station in response to perceived threat; implies intent to RESET.

SLIP(PING)—Time delay to individual flight/element event. ***Slip time will always be referenced from original execution time*.**

SLOPE—[EW] Pulse repetition frequency.

SLOW—Target with ground speed of 150 to 400 knots.

SMACK—[A/S], [S/S] Clearance to employ ordnance/fires on surface target coordinates. ROE, PID, CDE, coordination of forces, and commander's guidance requirements on the referenced target/track have been satisfied and coordinate accuracy is sufficient for coordinate seeking weapon employment.

SMASH (ON/OFF)—Directive call to turn on/off anti-collision lights.

SMOKE—[A/S] Smoke marker used to mark a position.

SNAKE—[A/S] Directive call to oscillate an IR pointer about a target.

SNAP —

(1) [A/A] Fighter request for immediate BRAA call (with appropriate fill-ins) to the group described. Indicates fighter intent to intercept/join.

(2) (heading) Urgent directive call to turn to a heading.

SNAPLOCK —I[A/A] indicates fighter has obtained a radar contact inside pre-briefed range or with a pre-briefed radar mode.

SNEAKER—[EW] An intelligence gathering vessel.

SNIPER (type, location [range, bearing])—Directive call for an aircraft to employ a range-known HARM against a specified threat at the specified location.

SNOOZE—Directive or informative call indicating initiation of emission control (EMCON) procedures.

SORT (_)**—**Directive call to assign responsibility within a GROUP; criteria can be met visually, electronically (radar), or both.

SORTED—SORT responsibility within a group has been met.

SOUR (mode/type)—Opposite of SWEET.

(1) Invalid/no response to an administrative IFF/SIF check.

(2) (Timber) Indicates there are potential problems with net entry and initiates pre-mission link troubleshooting.

SPADES—An interrogated bogey group/radar contact which lacks all of the ATO (or equivalent) IFF/SIF modes and codes required for the identification criteria.

SPARKLE—[A/S] Target marking by IR pointer or by gunship/forward air control-airborne (FAC[A]) using incendiary rounds.

SPIKE (w/direction)—RWR indication of an AI threat in track or launch.

SPIN—Directive or informative call to execute a timing/spacing maneuver.

SPITTER (w/direction)—An aircraft that has departed from the engagement or is departing the engaged fighter's targeting responsibility.

SPLASH—

(1) (Air-to-Air) Target destroyed.

(2) (Air-to-Surface) Weapons impact.

SPLIT—*An informative/directive call* that a flight member is leaving formation to pursue a separate attack; visual may not be maintained.

SPOOFER—[EW] An entity employing electronic or tactical deception measures.

SPOOFING—Informative call that voice deception is being employed.

SPOT—Acquisition of laser designation.

SQUAWK (mode/code)—Operate IFF/SIF as indicated or IFF/SIF is operating as indicated.

SQUAWKING (mode number)—An informative call denoting a bogey is responding with an

SIF mode or code other than prescribed by the ATO/identification criteria.

STACK—Two or more CONTACTs within GROUP criteria with an altitude separation in relation to each other.

STAKE—

(1) Reference point for air-to-ground targeting operations.

(2) A full motion video system mark has been set and is used as a frame of reference.

STANDBY—

(1) More information is coming

(2) [A/A] Eyeball fighter is preparing to call VID of target aircraft. No radio transmissions should be made until either ID is made or the eyeball fighter calls "UNABLE VID."

STARE (w/ laser code and reference point)—Directive call to cue the targeting pod and enable the laser spot search (LSS) function on the specified laser code in relation to the specified reference point. Reference point may include the following: INS steerpoint, GEOREF, bearing and range, data link point, or laser mark.

STATUS—

(1) Request for an individual's tactical situation.

(2) (Group name) Request for a full positional update in on the specified group; bullseye is the default format.

STEADY—[A/S] Directive call to stop oscillation of IR pointer.

STERN—[A/A] Request for or directive to intercept using stern geometry.

STINGER—

(1) [A/A] Three-ship inner GROUP formation with two lead CONTACTs line abreast and the Single in trail. (See **Figure A1.10**, STINGER Inner Group Formation.)

(2) * [S/A] An IR man-portable air defense system (MANPADS).

STOP—Stop IR illumination of a target.

STOP BURN—[A/S] Directive call to stop IR/EO illumination of a target.

STRANGER—Unidentified traffic that is not a participant with the action in progress.

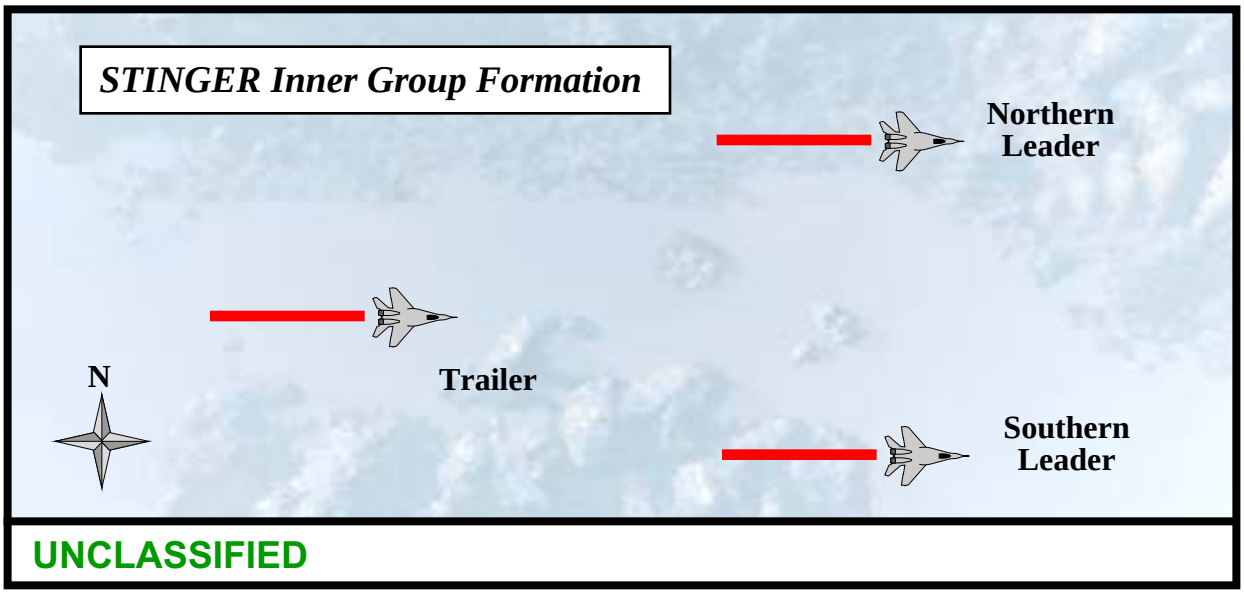
STRANGLE (system)—Turn off equipment indicated.

STRENGTH—[A/A] Numerical strength of a TRACK/GROUP.

STRIPPED—Informative call that aircraft is out of briefed formation.

STROBE (w/bearing)—Radar indications of noise jamming.

Figure A1.10 STINGER Inner Group Formation.



SUNRISE—Informative call that C^2 radar functions are available. Opposite of **MIDNIGHT**.

SUNSHINE—Directive or informative call indicating illumination of target is being conducted with artificial illumination.

SUPER—Speed 600 knots ground speed or Mach 1.0 or greater.

SUPPORTING—Speaking unit or element is assuming a supporting role, is in a position to influence the outcome, and assumes deconfliction responsibility.

SWEET—(Opposite of SOUR)

(1) (mode/type)* Valid response to an administrative IFF/SIF check request.

(2) (link name)* (e.g., TIMBER SWEET) Confirms receipt of data link information.

(3) Equipment indicated is operating efficiently.

SWEPT (w/sub-cardinal direction)—[A/A] Inner GROUP formation with the trailer displaced approximately 45 degrees behind the leader. (See **Figure A1.11**, Swept Inner Group Formation)

SWITCH (item)—

(1) ** Switch the setting on the referenced item.

(2) ** (Camera)—Switch full motion video to EO or IR.

(3) ** (Polarity)—Switch IR polarity to black hot or white hot.

SWITCHED—Indicates an attacker is changing from one aircraft to another.

TALLY—Sighting of a target, bandit, bogey, or enemy position. Opposite of NO JOY.

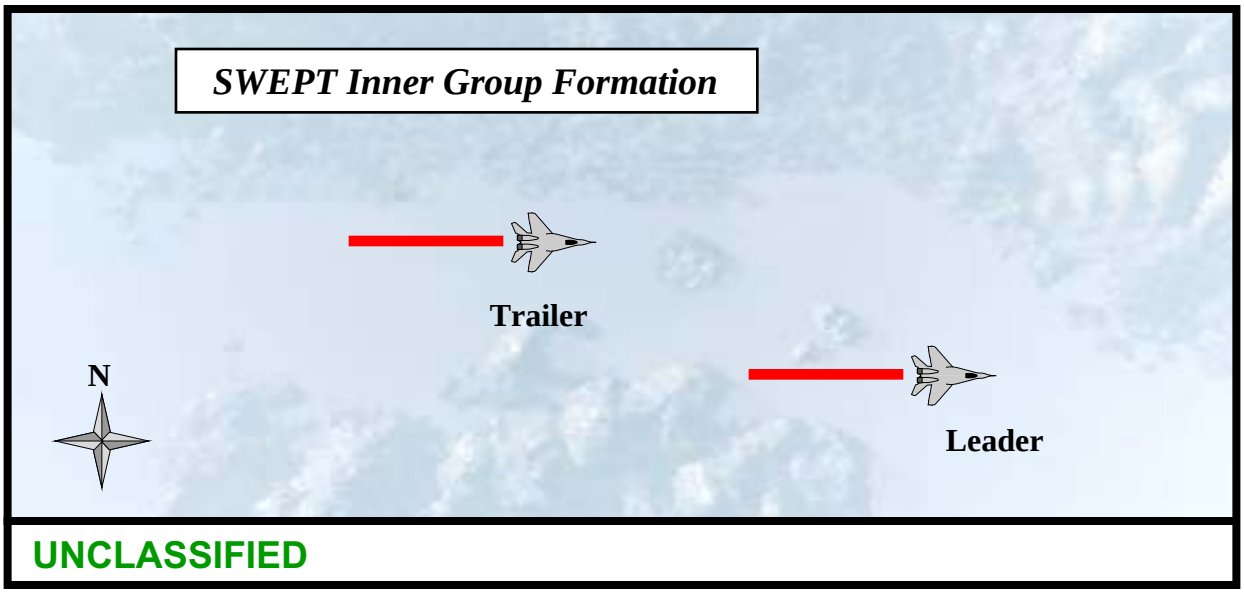
TARGET (_)—

(1) **** Assignment of targeting responsibilities.

(2) [A/S], [S/S] ROE, PID coordination of forces, and commander's guidance requirements

on the referenced track/target have been satisfied. Target/track correlation and CDE must be accomplished prior to employing ordnance/fires.

Figure A1.11 Swept Inner Group Formation.



TARGETED (_)—Group responsibility has been met.

TEN SECONDS—Directive to terminal controller to standby for LASER ON call in approximately 10 seconds.

TERMINATE—

(1) Stop laser illumination of a target.

(2) In training, cease local engagement without affecting the overall exercise.

THREAT (w/direction)—Untargeted HOSTILE/BANDIT/BOGEY is within pre-briefed range and/or aspect to a friendly.

THROTTLE(S)—Reminder to set throttles appropriately considering the IR threat and desired energy state.

THUNDER—Informative call 1 minute prior to air-to-surface weapons impact.

TIED—Positive radar contact with element or aircraft.

TIGER—Enough fuel and ordnance to accept a commit.

TIMBER—The Link-16 network.

TIMBER CHANNEL—Stacked net within a Link-16 network.

TIMECHECK—Informative call to check/change IFF code.

TOGGLE—Execute a pre-briefed change of an avionics setting.

TRACK (w/direction)—Group/contact flight direction in eight cardinal directions.

(system) TRACKING—***Enemy air defense system is maintaining situational awareness on

FRIENDLY.

TRACK NUMBER (number)—Data link information file.

TRASHED—Informative call missile has been defeated.

TRAVEL—[N] [EW] Change radar frequency.

TRESPASS (system, w/position)—The addressed flight is entering the surface-to-air threat ring of a specific (system) at the stated location.

TUMBLEWEED—Indicates limited SA, NO JOY, and BLIND. A request for information.

UNABLE—Cannot comply as requested or directed.

UNIFORM—UHF/AM radio.

VACANT—Ground equipment not present at tasked target location. Opposite of OCCUPIED.

VAMPIRE—Hostile antiship missile launch.

VERY FAST—Target speed greater than 900 knots ground speed/Mach 1.5.

VERY LOW—Target altitude less than 1,000 feet above surface.

VERY SLOW—Target speed less than 150 knots ground speed.

VIC—Picture label with three groups with the single closest in range and two groups, azimuth split, in trail. Group names should be LEAD GROUP and NORTH TRAIL GROUP and SOUTH TRAIL GROUP or EAST TRAIL GROUP and WEST TRAIL GROUP. (See **Figure A1.12**, Three-Group VIC.)

VICTOR—VHF/AM radio.

VISUAL—Sighting of a friendly aircraft or ground position. Opposite of BLIND.

WALL—A picture label describing three or more groups separated primarily in azimuth. (See **Figure A1.13**, Four-Group WALL.)

WARNING (w/color)—Hostile attack is:

(1) RED—Imminent or in progress.

(2) YELLOW—Probable.

(3) WHITE—Improbable (all clear).

WEAPONS (_)—Fire only:

(1) FREE**—**At targets not identified as friendly IAW current ROE.

(2) TIGHT—At targets positively identified as hostile IAW current ROE.

(3) HOLD (USAF, USMC, USA)/*SAFE (USN)*—In self-defense or in response to a formal order.

WEDGE—Three-ship inner-group formation with a single contact closest in range and two trail contacts line abreast. (See **Figure A1.14**, WEDGE Inner Group Formation.)

Figure A1.12 Three-Group VIC.

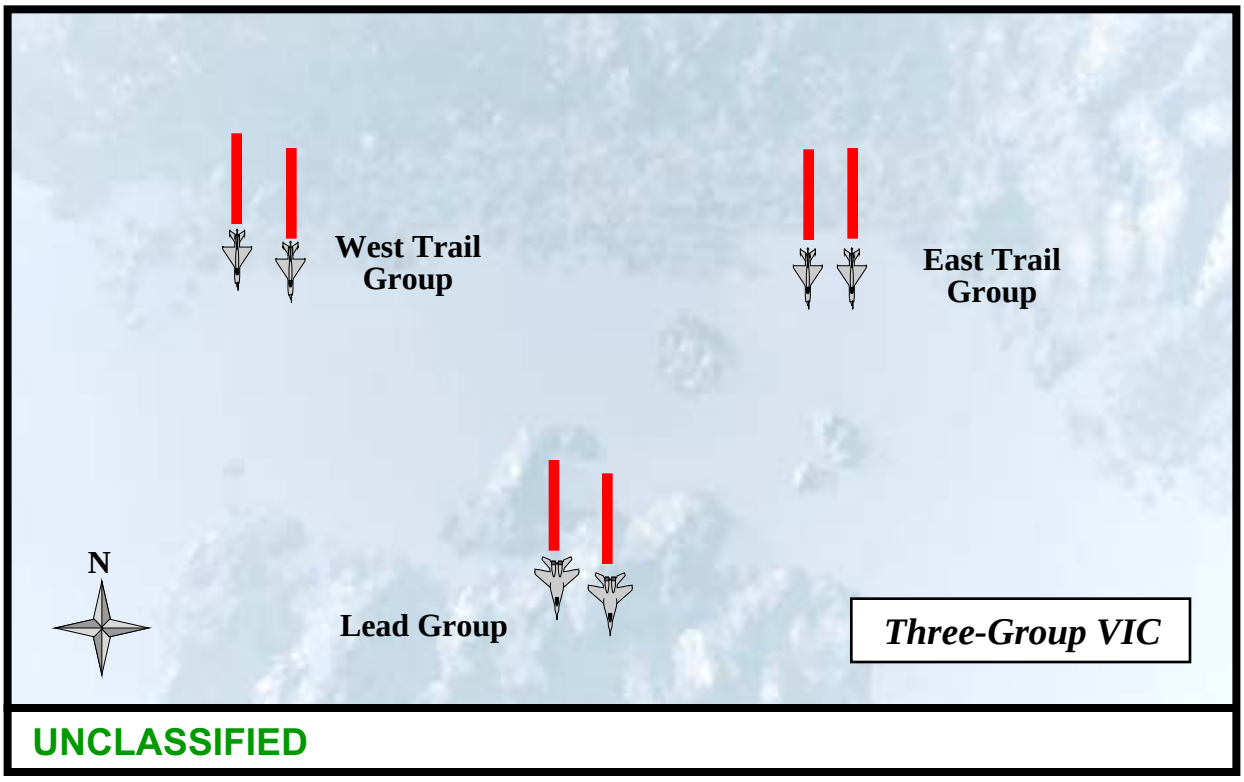


Figure A1.13 Four-Group WALL.

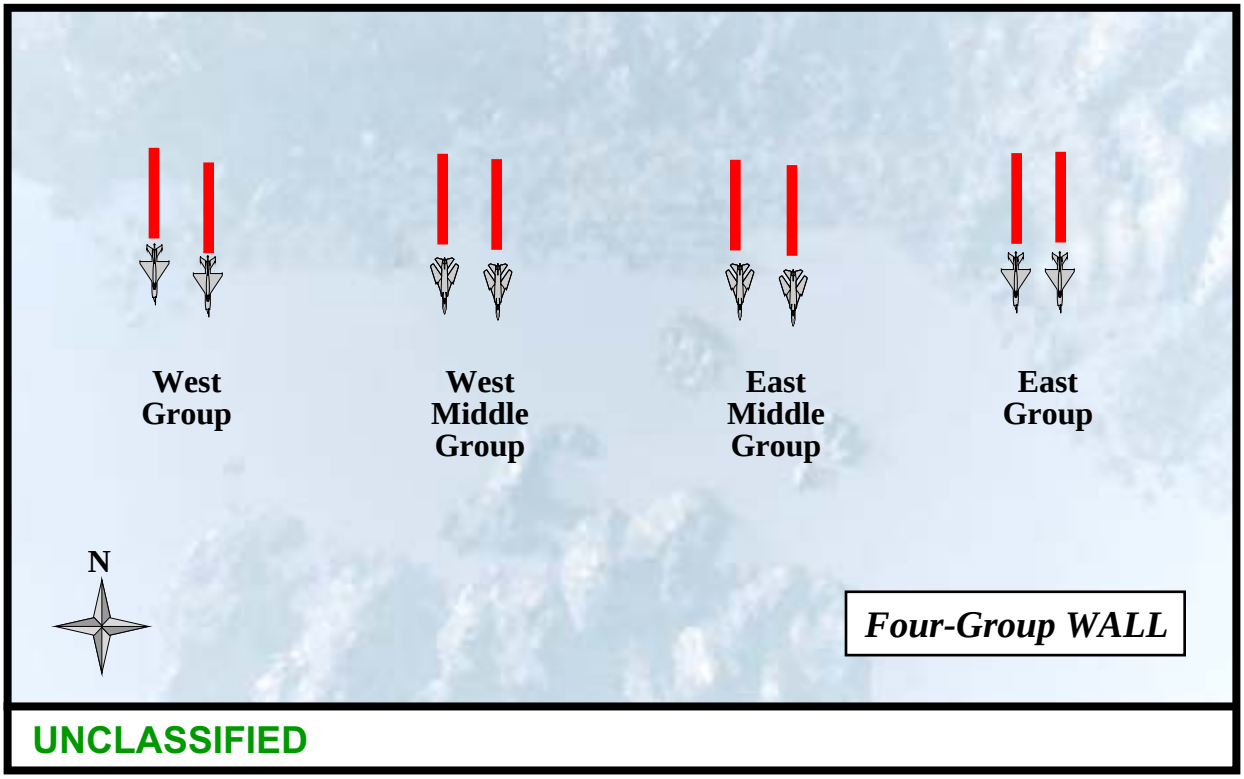
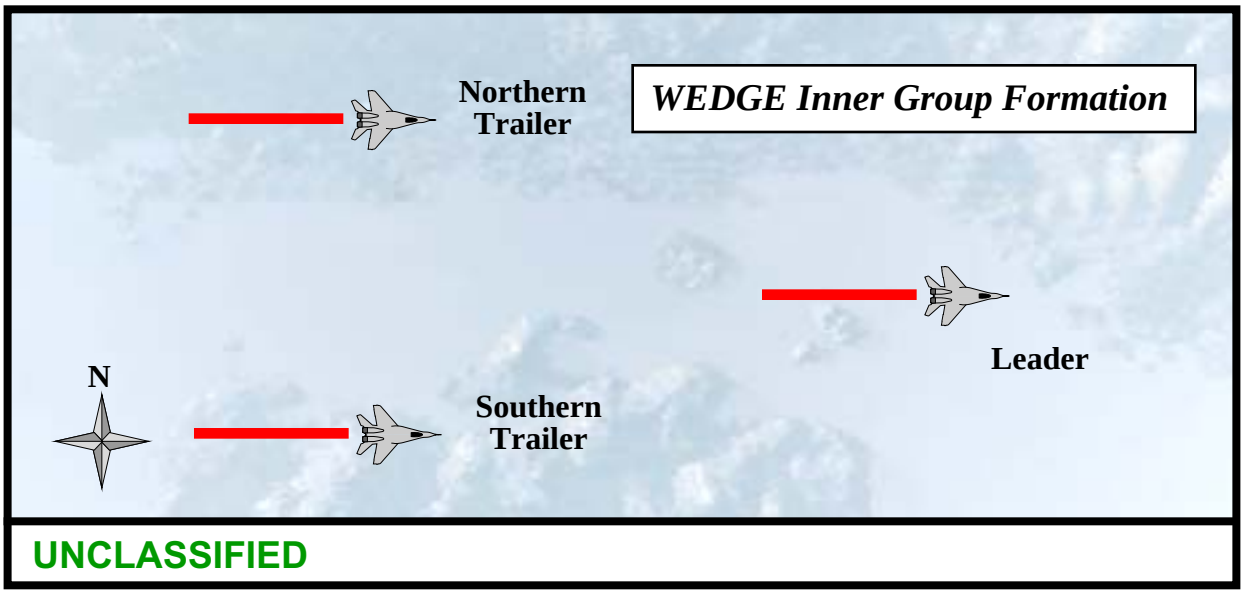


Figure A1.14 WEDGE Inner Group Formation.



WEIGHTED (cardinal direction)—Descriptive term used for a multiple GROUP formation (WALL, LADDER, VIC, CHAMPAGNE) that is offset in one direction.

(system) WELL—***System indicated is fully operative.

WHAT LUCK—Request for results of mission or tasks.

WHAT STATE (_)—Request for amount of missiles and fuel remaining. Response to "WHAT STATE" is:

(1) (1st number) Number of active radar missiles remaining.

(2) (2nd number) Number of semiactive radar missiles remaining.

(3) (3rd number) Number of IR missiles remaining.

(4) (Minus) No gun/not sufficient ammunition for gun attack by (4th number) thousands of pounds of fuel (given to one decimal point) or time remaining.

WIDE—Descriptive term used to indicate the separation between the GROUPS in azimuth in a WALL, VIC, CHAMPAGNE, or BOX.

WILCO—Will comply with received instructions.

WINCHESTER—No ordnance remaining.

WINGS LEVEL—***Informative call from aircraft to FAC reporting rolled-out on final attack heading.

WOOFER—[N], [EW] Off-board active radar decoy.

WORDS—Directive or interrogative call regarding further information or directive pertinent to the mission.

WORKING—

(1) (system w/location) Platform gathering EOB on a designated emitter.

(2) Platform executing electronic identification (EID) on a specific aircraft/group to obtain identification necessary for beyond visual range (BVR) employment.

YARDSTICK—Directive to use A/A TACAN for ranging.

ZAP—Request for data link information.

ZIPLIP—Limit transmissions to critical information only. (See MINIMIZE.)

ZOOM—Increase/decrease the sensor's focal strength. ***NOTE:*** ZOOM IN/OUT is normally followed by "ONE, TWO, THREE, or FOUR" to indicate the number of FOVs to change.

A1.4 Categorized Brevity Lists. This listing categorizes words by mission types. Aircrews assigned to specific missions can review the list for words they can expect to use or to hear. Tables are as follows.

- **Table A1.2**, Basic Air-to-Air Employment.
- **Table A1.3**, Basic Air-to-Surface Employment.
- **Table A1.4**, Close Air Support.
- **Table A1.5**, Combat Search and Rescue.
- **Table A1.6**, Command/Control.
- **Table A1.7**, EW Integration.
- **Table A1.8**, Laser.
- **Table A1.9**, Night Vision Device/IR Illuminator.
- **Table A1.10**, Data Link.
- **Table A1.11**, MTI.
- **Table A1.12**, Joint Maritime Operations.

Table A1.2 Basic Air-to-Air Employment.

ARM	CUTOFF	INTERVENE	RESAN	SNAPLOCK
AZIMUTH	DECLARE	KNOCK-IT-OFF	RESET	SPITTER
BANZAI	DEEP	LAME DUCK	RIDER	STATUS
BEAM	DELOUSE	LEAD-TRAIL	SCHLEM	STINGER
BEARING	DEFENSIVE	LINE ABREAST	SCRUB	SUPER
BOGEY DOPE	DOG	LOST CONTACT	SEPARATE	SWEPT
BRAA	DRAG	LOW	SHADOW	TARGET
BRACKET	ECHELON	MELD	SHEPARD	TARGETED
BUGOUT	ENGAGED	MEDIUM	SHOTGUN	TERMINATE
BUSTER	EXTEND	MONITOR(ing)	SIDE-SIDE	THREAT
CHAMPAGNE	FADED	NEAR-FAR	SKATE	TRASHED
CHEAPSHOT	FAST	PICTURE	SKIP IT	VERY FAST
CHICKS	FILL-IN	PITBULL	SKOSH	VERY LOW
CLEAN	FURBALL	POP-UP	SLIDE	VERY SLOW
CLEARED	GOPHER	POSIT	SLOW	VIC
CONTACT	GORILLA	POSTHOLE	SNAP	WALL
CONTAINER	HIGH	PRESS	SORT	WIDE
CONTINUE	HUSKY	PUMP	SORTED	WINCHESTER
CRANK	ID	PUSHING	SOUR	
CROSSING	INSPECT	RANGE	SPADES	

UNCLASSIFIED

Table A1.3 Basic Air-to-Surface Employment.

ATTACKING	CONTINUE DRY	OCCUPIED	SPLASH
BRACKET	IN	OFF	TARGET
BUMP/BUMP UP	INVESTIGATE	POP	THUNDER
CLEARED HOT	MAPPING	SMACK	VACANT
COMEOFF	MILLER TIME	SMOKE	WINGS LEVEL

UNCLASSIFIED

Table A1.4 Close Air Support.

CAPTURE	COME OFF	FREEZE BURN	IN	RIFLE
CLEARED HOT	CONTACT	FRIENDLY	MOVE BURN	THUNDER
COLD	CONTINUE DRY	HITS	OFF	WINGS LEVEL
UNCLASSIFIED				

Table A1.5 Combat Search and Rescue.

FLASHLIGHT	MARK	POPCORN	
HOLD DOWN	PEDRO	RED LIGHT	SKINNY
UNCLASSIFIED			

Table A1.6 Command/Control.

ARM	ESTIMATE	LINE-ABREAST	RANGE	TARGET
AUTHENTICATE	FLANK	LOW	RENEGADE	TERMINATE
AZIMUTH	FRIENDLY	MANEUVER MANFRED	REPORTED RETROGRADE	TRACK
BANDIT	FURBALL	MARSHALING	RIDER	TRESPASS
BEAD WINDOW	GADGET	MEDIUM	ROLEX	THREAT TIMBER
BEAM	GO ACTIVE GO BROADCAST GO CLEAR	MERGE(D)	SAUNTER	UNABLE
BEARING	GO SECURE GO TACTICAL	MICKEY	SCRAM	UNIFORM
BENT	GOPHER	MIDNIGHT	SKINNY	VIC
BITTERSWEET	GORILLA	MILLER TIME	SKIP IT	WALL
BOGEY	GREEN	MINIMIZE NEGATIVE CONTACT	SLIDE	WARNING (color)
BOX	GROUP	NEW PICTURE	SLOW	WEAPONS FREE
BRAA	HEAVY	NO FACTOR	SOUR	WEAPONS TIGHT
BUGSY BULLSEYE	HIGH	ON STATION	SPADES	WEAPONS HOLD
CAP CAV-OK	HOSTILE	OPENING	SPITTER	WEAPONS SAFE
CEASE	HOT	OUTLAW	SPOOFING	WEDGE
CHAMPAGNE	HOTDOG	PACKAGE	SQUAWK	WEEDS
COLD	HOTEL FOX	PAINTS	SQUAWKING	WHAT LUCK
COMMIT	INDIA	PARROT	STACK	WHAT STATE
CONTACT	KICK	PICTURE	STATUS	WIDE
CONTAINER	KNOCK-IT-OFF	PIGEONS	STINGER	WORDS
DOLLY	LADDER	POGO	STRANGER	TIMBER
DRAG	LAST	POP-UP	STRANGLE	
ENGAGEMENT	LEADER(S)	POSIT	SUNRISE	
	LEAD-TRAIL	PUSH (channel)	SWEET	

Table A1.7 EW Integration.

ACTIVE	DATA	JAMMER	SAM	THUNDER
ADD	DIRT	MAGNUM	SLAPSHOT	TRESPASS
ARIZONA	DROP	LOWDOWN	SINGER	ZAP
ATTACKING	DUFFER	MUD	SLOPE	WEAPONS( )
CANDYGRAM	EMPTY	PILLOW	SNEAKER	WORKING
CANYON	GINGERBREAD	RENT	SNIPER	
CAPTURED	HOLLOW	RETROGRADE	SPLASH	
CLAM	HOOTER	ROTATOR	SPOOFER	
UNCLASSIFIED				

Table A1.8 Laser.

CAPTURED	DEADEYE	SHIFT	STARE
CEASE LASER	LASER ON	SPLASH	TEN SECONDS
CONTACT	LASING	SPOT	
UNCLASSIFIED			

Table A1.9 Night Vision Device/IR Illuminator.

BURN	FLASH (system)	LIGHTS ON/OFF	SNAKE	SUNSHINE
CLOAK	FLASHLIGHT	PAN	SPARKLE	TALLY
DEGOGGLE	GOGGLE	ROPE SHIFT	STEADY	UNPLUG
EYEBALL (NARROW)	LIGHTBULB	SMASH	STOP	
UNCLASSIFIED				

Table A1.10 Data Link.

CHECK TIDS POINT	HANDSHAKE HOLLOW	MARKPOINT	TAG DATA	TRACK
CAPTURED DATA	HOOK	SILENT SWEET/SOUR	TIMBER (CHANNEL)	ZAP
UNCLASSIFIED				

Table A1.11 MTI.

DETAILS	LOWDOWN	ROTATOR	SILENT
IDLE	MOVERS	SCRUB	
UNCLASSIFIED			

Table A1.12 Joint Maritime Operations.

AUTOCAT	BULLDOG	GREYHOUND	POGO	THROTTLES
BEAD WINDOW	BULLRING	HOMEPLATE	ROBBER	TIGER
BIRD	CEASE	HOT DOG	SCRAM	VAMPIRE
BIRD AFFIRM	DASH (#)	LIGHTS ON/OFF	SINGER	
BIRD AWAY	DUCK	MOTHER	SKUNK	
BIRD NEGATE	ENGAGEMENT	ON STATION	SMASH	
BRUISER	FATHER	PIGEONS	STRIP	
UNCLASSIFIED				

A1.5 Terms and Definitions.

A-Pole—The distance from the launching aircraft to the target when a missile begins active guidance.

ACA (airspace coordination area)—A 3-dimensional box in the sky defined by grid and/or land references and an altitude block (AGL). The intent of an ACA is to allow simultaneous attack of targets near each other by multiple fire support means, one of which is air.

ACBT (air combat training)—A general term which includes dissimilar basic fighter maneuvers ([D]BFM), dissimilar air combat maneuvers ([D]ACM), and dissimilar air combat training ([D]ACT).

ACC (air component commander)—The commander of a Joint Task Force's (JTF) air components; the air operational commander.

acceleration maneuver—An offensive or defensive maneuver, flown in the vertical plane, if possible, designed to increase or reduce distance from an object.

ACM (air combat maneuvering)—Training designed to achieve proficiency in element formation maneuvering and the coordinated application of BFM to achieve a simulated kill or effectively defend against one or more aircraft from a planned starting position.

ACO (airspace control order)—Document that details all approved airspace requests. The ACO will complement the ATO cycle and serve as the single planning document for airspace considerations.

ACT (air combat tactics)—Training in the application of BFM, ACM, and intercept skills to achieve a tactical A/A objective.

advisory control—A mode of control in which the controlling agency has communications but no radar capability.

AHC (advanced or aircraft handling characteristics)—Training designed to gain proficiency in and to exploit the flight envelope of the aircraft, consistent with operational and safety constraints.

airborne order—A command authorization for tactical flight (departure time will be specified).

air refueling time—Planned lapsed time from air refueling contact time (ARCT) to drop off.

AOR (area of responsibility)—Airspace radar search responsibility of an individual fighter.

arcing—Flying a circular flight path which allows another aircraft the use of cutoff to gain closure.

ARCP (air refueling control point)—The planned geographic point over which the receivers arrive in the observation or precontact position with respect to the assigned tanker.

ARCT (air refueling control time)—The planned time that the receiver and tanker will arrive over the ARCP.

ARIP (air refueling initial point)—The planned point to enter the refueling track.

armament safety check—Action taken by an aircrew to review armament selection switches to preclude the inadvertent launch or release of armament (switches safe).

aspect angle— The angle measured from the tail of a target to the position of an attacker. Attacker heading is irrelevant.

ATO (air tasking order [frag])—Assigns A/A and A/S targets, time on target (TOT), and mission support information.

attack axis—This is an imaginary line which extends from the bandits through the leading element and back to the trailing element.

attack restriction—Ingress, ordnance delivery, or egress restrictions, depending on situation (i.e., threats, weather, terrain, and ROE).

autonomous—Aircrew is operating without command and control.

BFM (basic fighter maneuvers)—Training designed to apply aircraft handling skills to gain proficiency in recognizing and solving range, closure, aspect, angle off, and turning room problems in relation to another aircraft to either attain a position from which weapons may be employed, deny the adversary a position from which weapons may be launched, or defeat weapons employed by an adversary.

BHM (basic helicopter maneuvers)—Training designed to apply helicopter handling skills to gain proficiency in recognizing and solving range, closure, aspect, angle off, and turning room problems in relation to another aircraft to either attain a position from which weapons may be employed, deny the adversary a position from which weapons may be employed, or defeat weapons employed by an adversary.

broadcast control—A mode of control that passes target information by referencing a designated location or series of locations.

BZ (buffer zone)—Airspace of defined dimension and adjacent to or near borders which may have special restrictions.

CAP (combat air patrol)—Refers to either a specific phase of an A/A mission or the geographic location of the fighter's surveillance orbit during an A/A mission prior to committing against a threat.

CCR (cursor coordination range)—A pre-briefed or standard range where acquisition symbols are initially placed to establish fighter radar altitude coverage.

cell—Two or more tankers flying in formation.

chaff—A passive form of electronic countermeasure used to deceive airborne- or ground-based radar.

clock position—Description of position using the aircraft as a reference: the nose is 12 o'clock and the tail is 6 o'clock.

close control—A mode of control varying from providing vectors to providing complete assistance including altitude, speed, and heading.

closure—Relative velocity of one aircraft in relation to another.

collision course—A flight path which directs an aircraft towards a point where it will collide with another aircraft.

combat identification (CID)—The process of identifying a contact as friendly, bandit, or neutral. A contact that remains unidentified is a bogey (unknown).

combat identification system (CIDS)—Identification systems that exploit physical or electronic characteristics of a contact using cooperative and non-cooperative methods such as signals intelligence (SIGINT) and electronic warfare support (ES).

combined—Multinational; between two or more forces or agencies of two or more allies.

comm jamming—Attempt to interrupt communications.

composite force—Formations of dissimilar aircraft working in concert to accomplish the same mission.

composite force training—Scenarios employing multiple flights of aircraft, each under the direction of its own flight leader. Requires a minimum of three different types of aircraft in three different mission roles.

corner velocity—The minimum airspeed at which the maximum allowable aircraft G can be generated.

defensive maneuvering—Maneuvers designed to negate the attack or ordnance of a threat.

defensive spiral—A descending, accelerating dive using high G and continuous roll to negate an attack and gain lateral separation.

DMC (digital maneuvering cue)—Used to assess kinematic capability of a missile against a maneuvering target.

DOR (desired out range)—Range from the closest group where a fighter's "out" maneuver will defeat any weapons in the air or still on the jet and preserve enough distance to recommit with sufficient time to re-engage the same group with launch-and-decide tactics.

DR (decision range)—The minimum range at which a fighter can execute the briefed notch maneuver, remain there for a pre-briefed period of time in an attempt to defeat spikes, and then execute an abort maneuver. This maneuver will kinematically defeat any missiles shot at the fighter and momentarily keep the fighter outside the threat's maximum stern weapons employment zone (WEZ) once the abort maneuver is completed. This definition does not address an adversary's capability to eventually enter a stern WEZ by continuing to run down the fighter.

DR (dead reckoning)—Navigation technique estimating position based on last known position, heading, speed, and time.

EA (electronic attack)—Actions taken to prevent or reduce the effective use of the electromagnetic spectrum, primarily through jamming and deception.

EID—Electronic identification.

element—A flight of two aircraft.

EM (energy maneuverability) diagram—A chart depicting an aircraft's turn rate, radius, and excess power for a specific set of conditions.

engagement—Maneuvers by opposing aircraft attempting to achieve/prevent weapons firing positions.

EON—AIM-120 engagement order number.

EP (electronic protection)—Actions taken to protect personnel, facility, and equipment from any effects of friendly or enemy employment of electronic warfare that degrades, neutralizes, or destroys friendly combat capability.

E-Pole—The range from a threat aircraft that an abort maneuver must be accomplished to kinematically defeat any missile the bandit could have launched or is launching.

ES (electronic warfare support)—Actions tasked by or under direct control of an operational commander (OPCON) to search for, intercept, identify, and locate sources of intentional and unintentional radiated electromagnetic energy for the purpose of immediate threat recognition.

F-Pole—F-Pole is the separation between the launch aircraft and the target at missile endgame/impact.

FR (factor range)—During merge tactics, the minimum acceptable distance between the group being merged with and the next nearest group. Groups outside of this range are unlikely to affect the merge with the targeted group. FR should allow engaging and killing the targeted group, egressing tail aspect to the second group, and remaining outside that group's maximum stern WEZ. FR is driven by threat weapons capability, fighter weapons capability, closure, and proficiency.

FSCL (fire support coordination line)—FSCLs facilitate the expeditious attack of surface targets of opportunity beyond the coordinating measure. Short of an FSCL, the appropriate land or amphibious force commander controls all air-to-ground and surface-to-surface attack operations.

FEBA (forward edge of the battle area)—The foremost limits of an area where ground combat units are deployed. Designated to coordinate fire support, position forces, or maneuver of units.

FLOT (forward line of own troops)—A line indicating the most forward position of friendly

forces.

frag—

(1) Fragmentary order (ATO).

(2) Fragmentation pattern of a weapon.

fratricide—Destruction of friendly forces when destruction of enemy forces is intended.

HAVE QUICK—A UHF jam-resistant radio.

HCA (heading crossing angle)—The angular difference between the longitudinal axes of two aircraft.

high angle (snap) shot—A gunshot made with a high track-crossing angle, normally attempted because a tracking shot was not possible or desired.

hostile—Operational command ROE definition of an enemy aircraft or action.

HOTAS—Hands on throttle and stick.

intercept—A phase of an A/A mission between the commit and engagement.

ITW (imminent threat warning)—SA/warning of enemy activity from a C^2ISR to friendly assets. This does not imply commit or engage authority or the ability to direct assets.

JAAT (Joint Air Attack Team)—Coordinated employment of attack helicopters and fighters employed against enemy ground vehicles and personnel.

jink—Aircraft maneuvers designed to change the flight path of the aircraft in all planes at random intervals (usually to negate a gun attack).

joint—Activities, operations, or organizations in which elements of more than one service of the same nation participate.

(lag pursuit—An attack geometry where the attacker's nose points behind the target.

lead pursuit—An attack geometry where the attacker's nose points ahead of the target.

lethal envelope—The envelope within which the parameters can be met for successful employment of munitions by a particular weapons system.

line of sight—A line from a sensor to an object (usually target) being viewed.

line-of-sight rate—The rate of change in an object's line of sight, usually expressed in degrees per second.

lock range (LR)—The radar LR gives the fighter enough time to lock, identify, make an engagement decision, and still maintain FLO.

lufberry—A circular, stagnated fight with no participant having an advantage.

maximum performance—The best possible performance without exceeding aircraft limitations.

meld—The pre-briefed range where radars come out of their primary search responsibilities to find the primary target/sort responsibility, the next highest threat, and the whole picture if able.

military crest—A position along a ridge or hill two-thirds the distance from the base to the

summit.

MAR (minimum abort range)—The range at which an aircraft can execute an MDS-specific standard abort maneuver, kinematically defeat any missiles and momentarily remain outside an adversary's WEZ.

mixed force—Multiple type aircraft operating in the same formation under the direction of the same flight lead.

MOR (minimum out range)—Range from the closest group to a fighter when an "out" maneuver will defeat any adversary weapons (prelaunch or postlaunch) and preserve enough distance for the fighter to make a follow-on recommit with sufficient time to re-engage the same group with launch-and-notch tactics. For further information, see the AEM.

MTR (minimum targeting range)—The range that the element lead needs to target or share a group to ensure group elimination or support planned intercept flow in cases where the wingman has targeted first. MTR is also where flight members may auto target any unassigned group in their AOR coverage in accordance with the targeting plan. For further information, see the AEM.

mutual support—The coordinated efforts of two or more aircraft to provide combined firepower and survivability.

offensive maneuvering—Maneuvers against an opponent to achieve weapons parameters.

off-station—Not in position.

ops check—Periodic check of aircraft systems performed by the aircrew (including fuel) for safety of flight.

peeking—Used to describe moving a radar coverage out of the briefed AOR to see targets in other flight members' AOR.

positive identification (PID)—The unambiguous label (friendly, bandit, or neutral) given to contacts identified from a combat ID system (CIDS) and/or visual sources.

primary force—The flights that are being protected or escorted.

primary locker—The fighter responsible for multitargeting a group.

procedural identification—Identification determined solely be track behavior. Examples of this are point of origin, BVR kill zones, boxes or lanes, guilt by association, friendly routes, and lack of IFF/SIF.

pure pursuit—An attack geometry where the attacker's nose points directly at the target.

quick flow refueling—Receiver next in line will fly formation off the current receiver to expedite the flow of receivers across the boom.

RESAN (re-sanitize)—A range (prior to MELD) at which fighters who have been peeking, reset the radar coverage to search the extremes of their altitude AOR.

rules of engagement (ROE)—ROE contain the criteria and guidelines for weapons employment against an enemy. ROE provide direction to the shooter governing what level of identification confidence is required to shoot. ROE also include, but are not limited to, definitions of weapons control states (hold, tight, and free) and self-defense criteria.

sanitize—Using sensors to search an area for threats.

SARDOT—Search and rescue reference point used only to reference survivor.

SARNEG—Search and rescue numerical encryption grid.

scramble order—Command authorization for tactical flight establishing an immediate departure time.

secondary locker—Fighters responsible for assisting the primary locker. The secondary locker will shoot into a group when directed or other briefed criteria are met (e.g., SPITTER, primary locker's shot trashed, primary locker calls CLEAN, secondary locker sees untargeted group).

semiactive—A system wherein the receiver uses radiation or reflections from the target that has been illuminated by an outside source.

separation—Distance between an attacker and defender; can be lateral, longitudinal, or vertical.

shot depth—The range behind the closest bandit group within which trailing groups will be shot.

situational awareness (SA)—The level the warfighter is able to recognize, process, and react to both external and internal factors in a dynamic environment to increase lethality, survivability, and mission effectiveness.

sort—Briefed responsibility within a group—either visual, radar, or electronic. Used in determining ordnance expenditure assignments in A/A engagements or A/G deliveries.

sorting—Using any available information (e.g., radar presentation, C^2 information) to determine which bandit to attack.

specific excess power (P_S)—A measure of an aircraft's ability to gain or lose energy in terms of altitude, airspeed, or a combination thereof. Also called energy rate and expressed in feet per second or knots per second.

split-plane maneuvering—Aircraft or elements maneuvering in relation to one another but in different planes and/or altitudes.

TAC-A (tactical air coordinator-airborne)—An airborne agency located far enough away from threats and jamming to provide a communications relay between fighters, FACs, and ground agencies; typically aboard a FAC aircraft.

tactical control—A mode of control providing information in BRAA, bullseye, or geographic reference.

targeting depth (TD)—the maximum distance from the leading edge of a targeted group that a flight member must target. Beyond this range, C^2 owns targeting responsibility.

TOF (time of flight)—The time from weapon release to weapon impact.

TCT (time critical targeting)—Pertains to TST targeting processes, team specifics, and systems processes

TST (time sensitive target)—Those targets which require immediate response because they pose (or will soon pose) danger to friendly forces or are highly lucrative, fleeting targets of opportunity.

V_C—Closure between fighter and target expressed in knots.

Willy Pete—A white phosphorus smoke, rocket, grenade, or artillery round used to provide a ground reference; can be employed as a bomb to provide a smokescreen.

zap zone—Indicates an area of maximum exposure to enemy fire.

A1.6 Air-to-Air Communication Standards. This section establishes air-to-air comm standards between fighters and command and control. This section governs areas of communication formats, control, identification, and integration.

A1.6.1 Communications Plan. The mission commander will brief the overall communications plan, to include CHATTERMARK procedures, who holds CHATTERMARK authority, and which frequencies will be used.

A1.6.2 Communications Fundamentals.

A1.6.2.1 **Bullseye Check.** Aircraft's range and bearing from bullseye. Normally passed after check-in for force accountability. Bullseye check is correlated if within 3 NM.

A1.6.2.2 **Group Criteria.** Group criteria will be IAW **paragraph A1.3**, USAF and Joint Operational Brevity Words; aircraft within 3 NM in azimuth and range.

A1.6.2.3 **BRAA or Bullseye.** BRAA, BULLSEYE, or assigned ACO code name for BULLSEYE will accompany all calls to reduce or eliminate ambiguity. BULLSEYE will not be truncated to "bull" to avoid it being interpreted as BRAA in heavy comm situations.

A1.6.2.4 **Command and Control (C^2) Altitude Capability.** Early warning and surveillance radar systems can be off by as much as 10,000 feet or more. ABM/WDs will round off to the nearest thousand feet indicated on their system. ABM/WDs will not use LOW, MEDIUM, or HIGH except when it is "reported" from an off-board source. If exact altitude is unknown, ABM/WDs will transmit "altitude unknown".ABM/WDs will use the term "last" to indicate a fighter-provided altitude (e.g., "DARKSTAR, TRAIL GROUP OVER BULLSEYE, 27 THOUSAND LAST").

A1.6.2.5 **Call Sign Usage.** A call sign will be associated with every radio transmission. Normally, use your own call sign if being informative or descriptive. If being directive, use the call sign of the aircraft being directed. Finally, if "relaying" a call, preface with "relay," include the call sign of the person making the call, and do not include your call sign.

- (Directive): "VIPER 1, TARGET GROUP BULLSEYE 360/10, 25 THOUSAND, HOSTILE."
- (From Snake 11 relayed by Hog 1): "RELAY, SNAKE 11 IS IP INBOUND."

A1.6.2.6 **General Guidance on Aircrew Requests for Adversary Information.** The primary terms used by aircrews to request adversary information from the ABM/WD are as follows:

- PICTURE.
- STATUS.
- BOGEY DOPE.

- SNAP.
- CUTOFF.

A1.6.2.6.1 If the aircrew requests PICTURE, with no other modifying remarks, the ABM/WD will respond with the full tactical picture, using digital bullseye format, labeled if possible, and all appropriate fill-ins.

- "DARKSTAR, RAMBO 1, PICTURE."
- "DARKSTAR, 2 GROUPS, GROUP B/E 250/15, 25 THOUSAND, BOGEY. GROUP B/E 290/25, 15 THOUSAND, SPADES, HEAVY, TRACK NORTH."

A1.6.2.6.2 If the aircrew requests STATUS (group name), the ABM/WD will respond with the bullseye, altitude, and appropriate fill-ins (including ID) of the referenced group, unless otherwise briefed.

- "BANDSAW, SNAKE 1, STATUS NORTH GROUP."
- "BANDSAW, NORTH GROUP, B/E 212/21, 26 THOUSAND, HOSTILE."

A1.6.2.6.3 If the aircrew requests BOGEY DOPE, the ABM/WD will respond with BRAA (with fill-ins, ID) to the nearest group. Aircrew can request BRAA to any other group by calling BOGEY DOPE (group label).

- "COWBOY, CONAN 1, BOGEY DOPE SOUTH GROUP."
- "CONAN 1, SOUTH GROUP BRAA, 190/22, 17 THOUSAND, HOSTILE, 2 CONTACTS SWEPT NORTHEAST 2 MILES."

A1.6.2.6.4 If the aircrew requests a SNAP (group name/aircraft call sign), the ABM/WD response will be identical to BOGEY DOPE replies. SNAP may be used to request BRAA to enemy or friendly forces. The only other difference between SNAP and BOGEY DOPE is that BOGEY DOPE is simply a request for information and SNAP conveys aircrew intent to attack/join the referenced group/aircraft.

A1.6.2.6.5 If the aircrew requires a vector to collision course intercept geometry on a specific group, the aircrew will request CUTOFF (group name). In this case, the ABM/WD will respond with the cutoff vector first, followed by BRAA (with fill-ins, ID) to the specified group. Since the requirement for cutoff geometry naturally implies flank/beam aspect, ABM/WDs should ensure the group's track direction is included in the BRAA fill-ins.

A1.6.3 Identification Criteria and Rules of Engagement.

A1.6.3.1 **ID Criteria.** ID criteria will be theater dependent; however, ID terminology will apply to all theaters of operation. Normally ID criteria will include some combination of lack of friendly (LOF) (e.g., flight plan, IFF/SIF, or safe passage) and positive enemy indication (PEI) (e.g., EID or VID). When providing ID, the highest levels of the ID matrix accomplished shall be given. Application of ID brevity terms follows.

A1.6.3.1.1 **BOGEY.** A radar or visual air contact whose identity is unknown. The use of the term BOGEY on the radio implies none of the ID criteria have been met. BOGEY will be assumed if no ID is given. If the ID process is partially completed, use

the appropriate terms (SPADES, RIDER, SQUAWKING, GOPHER,) in place of the word BOGEY.

A1.6.3.1.2 **BANDIT.** A BANDIT is an aircraft identified as an enemy IAW theater ID criteria. The term does not necessarily imply direction or authority to engage. The identification matrix required to identify a group as "BANDIT" may include PEI, LOF, or, more normally, both. In addition, a visual identification (VID) may fulfill BANDIT ID criteria as specified in theater ID criteria. The ability to meet "BANDIT" criteria can come from on-board systems, off-board systems, or a combination of both.

A1.6.3.1.3 **Positive Enemy Indication (PEI).** There are multiple sensors/sources that may satisfy PEI. All systems capable of satisfying PEI should be defined in theater-specific identification criteria.

A1.6.3.1.4 **Lack of Friendly (LOF) Indication.** In order to satisfy lack of friendly requirements, completed checks of identification, friend or foe (IFF)/selective identification feature (SIF) codes and/or minimum risk route (MRR) adherence must be accomplished. Specific IFF/SIF mode and code requirements will be theater dependent.

A1.6.3.1.4.1 **PAINTS.** An interrogated group/radar contact that is responding with any of the specified IFF/SIF modes and correct codes established for the ID criteria. PAINTS will be used to describe a group that does not meet lack of friendly criteria (that is, the group is squawking one or more of the required modes and codes as specified in the ATO/ACO).

- "FOCUS, GROUP BULLSEYE 250/15, 27 THOUSAND, PAINTS, TRACK WEST"

A1.6.3.1.4.2 **SPADES.** An interrogated group/radar contact which lacks all of the ATO (or equivalent) IFF/SIF modes and codes required for the ID criteria. SPADES will be used to describe a bogey group that does meet the IFF/SIF portion of the lack of friendly criteria (i.e., the group in question is not squawking required Modes 1, 2, 3, 3C, or 4, as specified in the ATO/ACO SPINS-defined requirements).

A1.6.3.1.4.3 **SQUAWKING (Mode #).** An informative call denoting a bogey is responding with an IFF/SIF mode or code other than prescribed by the ATO/ID criteria. SQUAWKING will be used to describe the SIF status of a group that does not meet SPADES or PAINTS criteria but is responding with a Mark X/XII-type SIF reply. For example, ID criteria may specify correct code Mode 1 of 42. A BOGEY squawking an incorrect Mode 1 may be reported as

- "FOCUS, GROUP BULLSEYE 240/35, 25 THOUSAND, SQUAWKING MODE 1 41."

A1.6.3.1.4.4 **Minimum Risk Route (MRR)**. An MRR is usually defined in a theater ACO to aid in the safe return of a friendly aircraft that is unable to communicate and/or cannot verify the working status of its IFF/SIF transponder. If an unidentified aircraft is on a published MRR, it will be called a RIDER.

A1.6.3.1.4.4.1 **MRR Parameters.** These may include any or all of the following:

- Transit level (TL)—altitude bands.
- Transit corridor (TC)—specified routes of flight.
- Airspeed.

A1.6.3.1.4.4.2 The term GOPHER may be used to designate targets which are not currently complying with MRR or who previously passed through an MRR zone without complying with MRR requirements.

A1.6.3.1.4.4.3 A positive enemy indication may override an MRR, but it cannot override a PAINTS call if an ambiguity exists.

A1.6.3.1.5 **Guilt by Association.** If a single group, previously declared BANDIT (or HOSTILE), maneuvers to subsequently become two or more groups, all of the subsequent groups will be BANDIT (or HOSTILE). If a single group, previously declared BOGEY, maneuvers to become two or more groups/arms, and one of those groups is subsequently declared BANDIT (or HOSTILE), that declaration applies only to that one group/arm/contact. When groups converge, the resulting group ID will resolve to the most restrictive ID (i.e., BOGEY or SPADES) unless continuous tracking is maintained as the groups separate after the convergence. If continuous tracking cannot be accomplished and the ID resolves to a partial ID, then the ID matrix must be re-accomplished. This guilt by association method requires that the groups/arms/contacts have been "continuously tracked" by one or more radars (i.e., fighter and/or GCI/AWACS).

A1.6.3.1.5.1 "Continuously tracked" for GCI/AWACS means the group can be faded for no more than 20 seconds.

A1.6.3.2 **Rules of Engagement (ROE).** Meeting identification criteria does not imply clearance to engage. The theater ROE will determine when an aircraft identified as a BANDIT may be engaged. This could come as the result of committing a hostile act as defined by theater commanders (e.g., crossing a political boundary). HOSTILE describes a contact identified as an enemy upon whom clearance to fire is authorized IAW the theater ROE. HOSTILE will be used to describe a BANDIT group that has completed a hostile act or shown hostile intent and may be engaged.

A1.6.3.3 **Clear Avenue of Fire (CAF).** Once a BANDIT/HOSTILE declaration has been achieved, the fighter must ensure a clear avenue of fire. MDS ROTs will address the specifics. ABM/WDs will transmit FURBALL when FRIENDLIES are within 5 NM of, and closing with, BOGEY, BANDIT, or HOSTILE groups. If FRIENDLIES are within 5 NM and separating from BOGEY, BANDIT, or HOSTILE groups, the ABM/WD will ensure there is a positive distinction between the FRIENDLY and other groups before responding with anything except FURBALL. FURBALL is a response to a DECLARE request indicating known BANDITS and FRIENDLIES are in close proximity.

A1.6.3.4 **Requests for ID.** DECLARE requests for ID of groups will follow one of the following formats.

A1.6.3.4.1 **Bullseye Format.** Call sign of control agency, the requesting fighter's call sign, "DECLARE GROUP BULLSEYE," position of the group in digital bullseye format, and altitude.

- "DARKSTAR, VIPER 1, DECLARE BULLSEYE 230/12, 12 THOUSAND."

A1.6.3.4.2 **Group Label Format.** A group declaration request can be made after the presentation has been labeled. The format will be call sign of control agency, requesting fighter's call sign, "DECLARE (group name)," and altitude.

- "DARKSTAR, VIPER 2, DECLARE EAST GROUP, 22 THOUSAND."
- "DARKSTAR, EAST GROUP B/E 230/12, 20 THOUSAND, HOSTILE."

A1.6.3.4.3 **Heading as a Discriminator.** The use of track directions/aspect will be by exception and as a discriminator for ambiguous situations. For headings, information will be passed in primarily track direction (e.g. "TRACK NORTH"), and secondarily in exact direction (e.g., "HEADING 360").

- "CHALICE, WOLF 1, DECLARE GROUP BULLSEYE 083/27, 17 THOUSAND, TRACK NORTH."

A1.6.3.4.4 **Declare Response.** Regardless of which DECLARE request format is used, the ABM/WD will respond to the DECLARE inquiry by anchoring the identified group using digital bullseye and altitude with the group label (if applicable), a heading discriminator (if applicable), and any additional fill-ins. The digital bullseye response of the ABM/WD might not be exactly the same as the position reported by the fighter due to the group's ground track/maneuvers while the identification process is completed. Criteria or ROTs to correlate group location should be decided in mission planning or outlined in theater SPINS and briefed accordingly. If an altitude of a "declared" group is thought to be below the radar coverage:

- "CHALICE, EAGLE 1, DECLARE GROUP BULLSEYE 125/27, 2 THOUSAND."
- "CHALICE, CLEAN BULLSEYE 125/27, 2 THOUSAND. CHALICE GROUP BULLSEYE 125/29, 15 THOUSAND, TRACK SOUTH (as a discriminator), HOSTILE."

NOTE: DECLARE responses might include FRIENDLY, BOGEY, BANDIT, HOSTILE, FURBALL, NON-PLAYER, STRANGER, SPADES, PAINTS, SQUAWKING, OUTLAW, RIDER, GOPHER, or CLEAN.

A1.6.3.4.5 **Hostile ID Through Shot Comm.** If a fighter determines a previously unidentified group is hostile IAW the ROE and fires weapons at this group, bullseye position, altitude, and "HOSTILE" will be included in the shot transmission to enable other fighters and the ABM/WDs to correlate and maintain the hostile declaration on this group.

- "RAMBO 1, FOX 3 LEAD GROUP, BULLSEYE 125/27, 19 THOUSAND, HOSTILE."

NOTE: If ABM/WD can correlate the shot and maintain continuous tracking on the group without hearing "HOSTILE," they may maintain the hostile declaration on the group to assist in follow-on declare requests.

A1.6.4 Tactical Admin Fundamentals.

A1.6.4.1 **Words.** Words will be established when information is available that will have an effect on or change the planned mission. Words will be generated by tactical C^2 agencies (e.g., CRC, AWACS, JSTARS, or E-2). If there are multiple C^2 agencies and theater SPINS do not dictate a priority, the CRC will serve as the RADC and, therefore, have final say on words generation. The WOC does not have the authority to establish words that affect the strike package. If there is a significant event, the wing operations center (WOC) will contact the combined air operations center (CAOC) or tactical C^2 to inform them of the event. If tactical C^2 determines words need to be created, the WOC will relay those to all players when they check in prior to taxi or take off. When tactical C^2 agencies create words, they will inform the CAOC and the WOC.

A1.6.4.2 **Roll Call.** After words, package status, and lowdown are passed, a roll call will be initiated. The roll call order should be briefed during mission planning.

- "ALL PLAYERS, COWBOY, STANDBY LOWDOWN: SA-6 ACTIVE, BULLSEYE 250/25, NORTH SA-3 OCCUPIED. WORDS CHARLIE CURRENT, PKG AS FRAGGED MINUS RAMBO 1. ROLL CALL."

A1.6.4.3 **Rolex.** Time line adjustment in minutes always referenced from the original preplanned mission execution timeline. Rolex will be used to adjust the package timing as a whole. If a TOT window extension is required to adhere to the rolex, C^2 agencies will request that approval and pass it to the affected flights. Rolexes should be made in 5-minute increments.

- "BARNYARD, ROLEX 10 MINUTES."

A1.6.4.4 **Slip.** Time delay to individual flight/element event.

- "DARKSTAR, HOSS 1, SLIP 3 MINUTES."

NOTE: For changes to training vul times, pass them to adversaries in plain language

- "MIGG 1, NEW VUL TIME 0910 TO 0940."

A1.6.4.5 BRAA or bullseye will accompany all appropriate calls to eliminate ambiguity. "BULLSEYE" will not be truncated to "bull" to avoid it being interpreted as "BRAA" over degraded radios.

A1.6.4.6 **Call Sign Use.** A call sign will be included with every radio transmission. Normally, use a call sign if being informative or descriptive. If being directive, use the call sign of the aircraft/agency you are directing. Finally, if relaying a call, use the call sign of the aircraft/agency making the call that you are relaying and not your call sign.

- "RELAY, SNAKE 21 IP INBOUND."

A1.6.5 Calling the Picture and Labels.

A1.6.5.1 **Core Information.** Core information will include the number of groups, location, altitude, ID, and track direction (hot is assumed). Bullseye will be the primary means to provide location. The reference point is the center of the leading edge of the group. FRIENDLY/NEUTRAL groups will not be included in total number of groups. If FRIENDLY/NEUTRAL groups are a factor, they will be addressed in a separate transmission using the same core information format.

A1.6.5.2 **Digital Bullseye and BRAA.** Digital bullseye is the only format that will be used for bullseye-referenced calls Fighters and ABM/WDs will use exact bearing and range off bullseye. For BRAA, ABM/WDs will round off the bearing to the nearest 5 degrees.

A1.6.5.2.1 **Core Information Format.** When using core information to anchor the location of groups, the format should be GROUP—no number—and anchor the location with altitude. For example, ". . . GROUP BULLSEYE 360/5 12 THOUSAND, GROUP BULLSEYE 040/15 . . ."

A1.6.5.2.2 **Anchoring Three or Less Group Locations.** Groups will be anchored off of bullseye in the following priority: (1) closest to the fighter, (2) heaviest, (3) Highest, 4) closest to the bullseye. If a group is within 3 NM of bullseye, it will be anchored as "group over bullseye."

- "CHALICE, GROUP OVER BULLSEYE, 15 THOUSAND, BOGEY, TRACK NORTH."

A1.6.5.2.3 **More than Three Groups.**

A1.6.5.2.3.1 If an ABM/WD/fighter detects more than three groups, the call will include the total number of groups but will only anchor the three groups closest to the fighters.

- "DARKSTAR, FOUR GROUPS, GROUP BULLSEYE 270/25, 15 THOUSAND, BOGEY, TRACK WEST, GROUP BULLSEYE 290/35 10 THOUSAND, HOSTILE, GROUP BULLSEYE 020/25, 27 THOUSAND, HOSTILE, TRACK EAST."

A1.6.5.2.3.2 In order to preserve valuable comm time, the technique of calling three groups in one transmission will only be done prior to the start of an intercept (e.g., pre-push or marshaling). In this case, the ABM/WD must use a slower cadence to ensure the fighters are able to comprehend all of the information.

A1.6.5.2.4 **Fill-In Information.** Fill-ins are amplifying information that may be added to called groups to increase SA. They may include, but are not limited to, numbers of contacts within a group, the inner-group formation, observed EA, maneuvers, or FADED. When available, fill-in information will follow the group name, or the group bullseye position, altitude and ID in the following order: (1) number of contacts/Inner group formation, (2) group maneuvers, and (3) other applicable plain language information.

- "BANDSAW, LEAD GROUP BULLSEYE 180/10, 20 THOUSAND, HOSTILE, TWO CONTACTS, LINE ABREAST TWO, FLANK SOUTH WEST, TARGETED BY RAMBO."
- "DARKSTAR NORTH GROUP, HOSTILE, 2 CONTACTS SWEPT NORTH WEST, 2."

A1.6.5.2.5 **Inner Group Formation.** When describing an inner group formation or "arm," ABM/WDs will use the term, "single contact," or the terms described later in this chapter in **Figure A1.33**, Inner Group Formations. Fighters can use "SIDE/SIDE" and "LINE/ABREAST" or "NEAR/FAR" and "LEAD/TRAIL" to describe inner group formation as displayed on the VSD/MFD.

A1.6.5.2.6 **ID Information.** ABM/WDs will provide IDs on the following calls:

- Core information calls.
- Strobe/music/spike responses.
- Threat calls.
- Requests for ID/declaration.

A1.6.6 Comm for Groups CAPping (Pre-Commit Pictures). The adversary CAP location will be anchored from bullseye to the point closest to the friendly fighters. (See **Figure A1.15**, CAP Comm.) CAP fill-ins include the CAP leg length, the types of CAPs (indicative of bandit S/A, technology, and capabilities), and HEAVY. For building the accurate CAP picture, use the following listed types of CAPs as a basis for speeding the information flow.

- Counteropposing CAPs (**Figure A1.16**, Counteropposing CAPs). "BARNYARD, 2 CAPs, NORTH SOUTH 10, NORTH CAP B/E 270/20, 25 THOUSAND, BOGEY, SOUTH CAP 27 THOUSAND, SPADES, 10 MILE LEGS."
- Beam CAP (**Figure A1.18**, Beam CAP). "DRAGNET, BEAM CAP, BULLSEYE 270/13, 20 THOUSAND, HOSTILE."
- Counterrotating CAP (**Figure A1.19**, Counterrotating CAPs). "CHALICE, TWO COUNTER-ROTATING CAPs, NORTH SOUTH, 10, NORTH CAP BULLSEYE 300/9, 25 THOUSAND, HOSTILE, SOUTH CAP 21 THOUSAND, SPADES."

A1.6.6.1 **Transitioning from Group CAPping Comm.** As a ROT, CAPs will have demonstrated intent to leave their CAP when two or more consecutive radar returns have passed their previous turn points. If a fighter or ABM/WD recognizes when they leave their CAP, call them as "COMMITTED." For example, "FOCUS, BOTH CAPS COMMITTED." Once the adversaries have committed from their CAP, ABM/WDs and fighters will use core information until a picture can be labeled.

A1.6.6.2 **Marshaling.** If one or more groups appear to be maneuvering within a limited area with no specific intent, they will be called MARSHALING. Anchor the closest of the marshaling groups to the fighters off bullseye. (See **Figure A1.17**, Marshaling Group.)

Figure A1.15 CAP Comm.

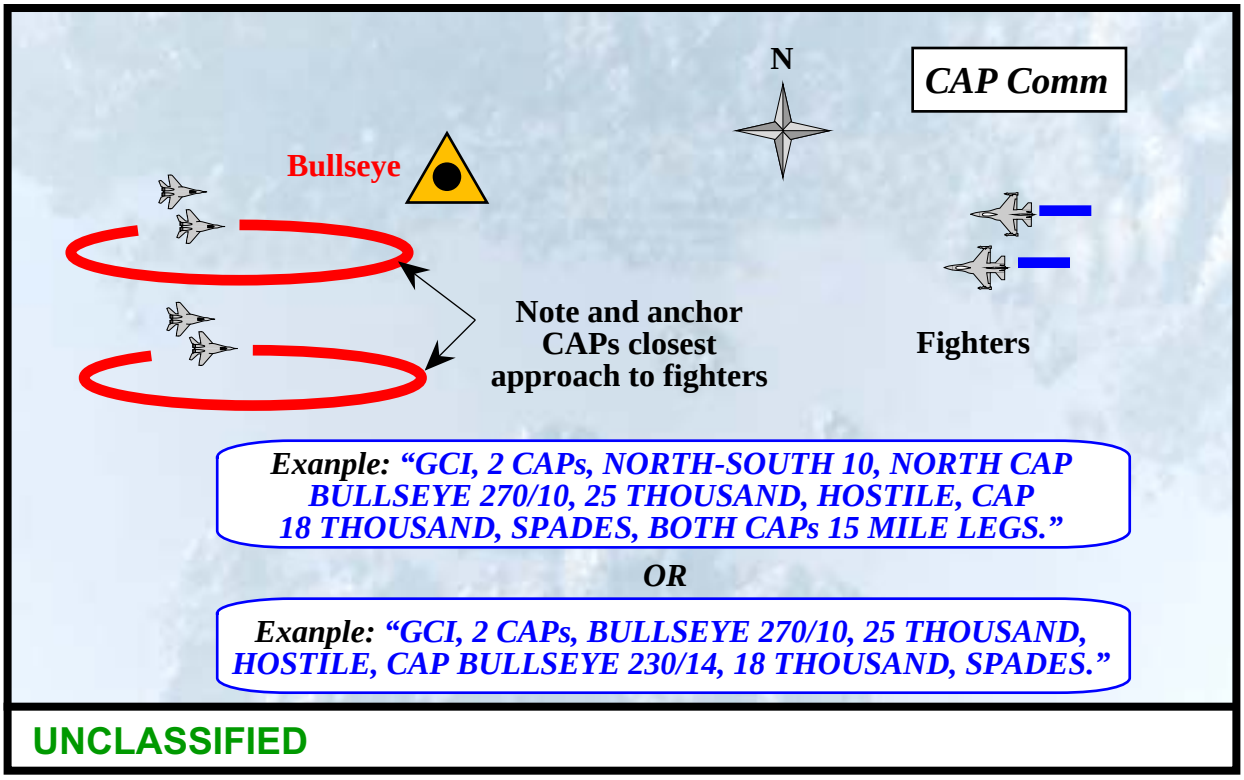


Figure A1.16 Counteropposing CAPs.

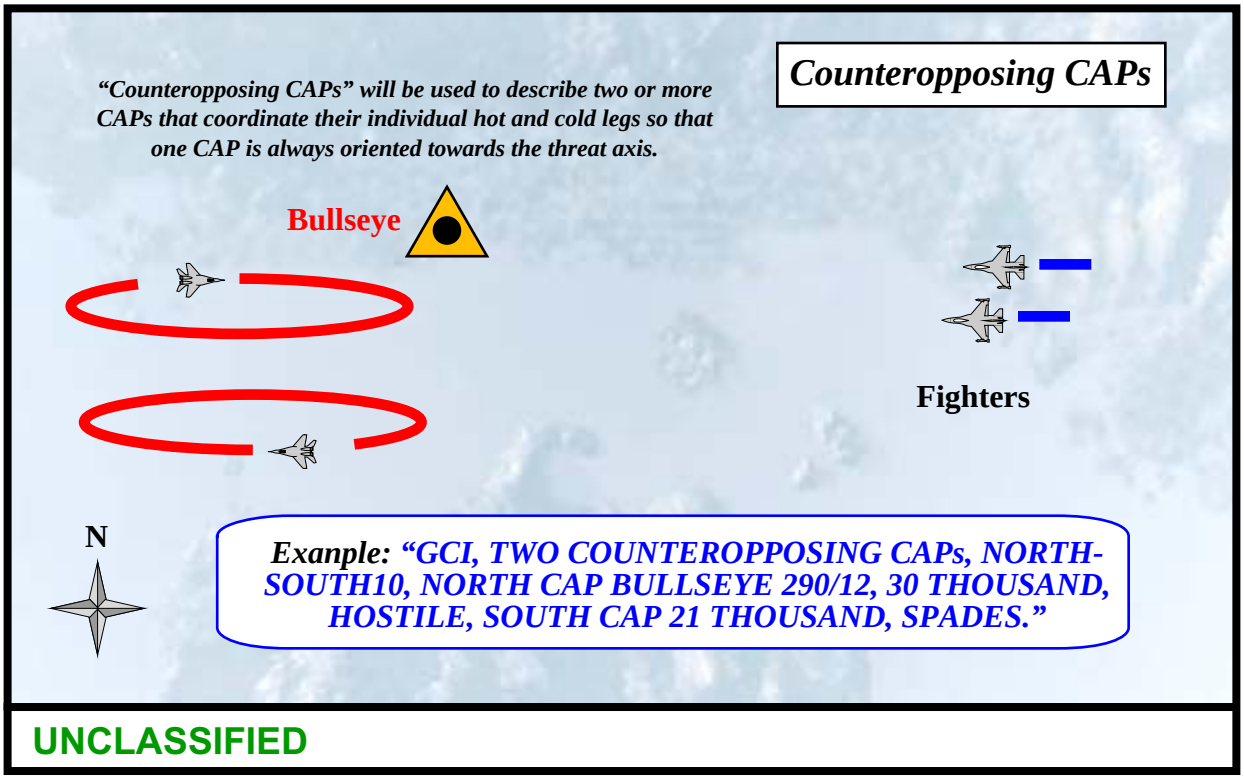


Figure A1.17 Marshaling Group.

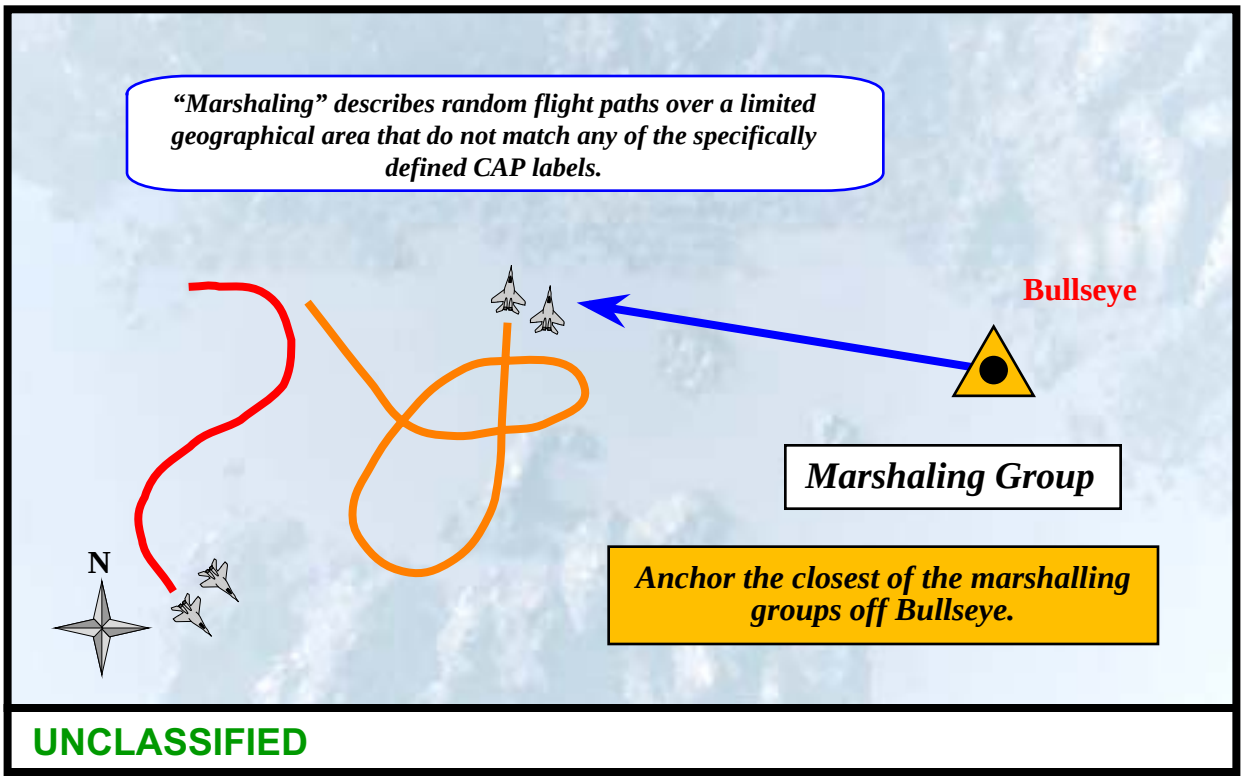


Figure A1.18 Beam CAP.

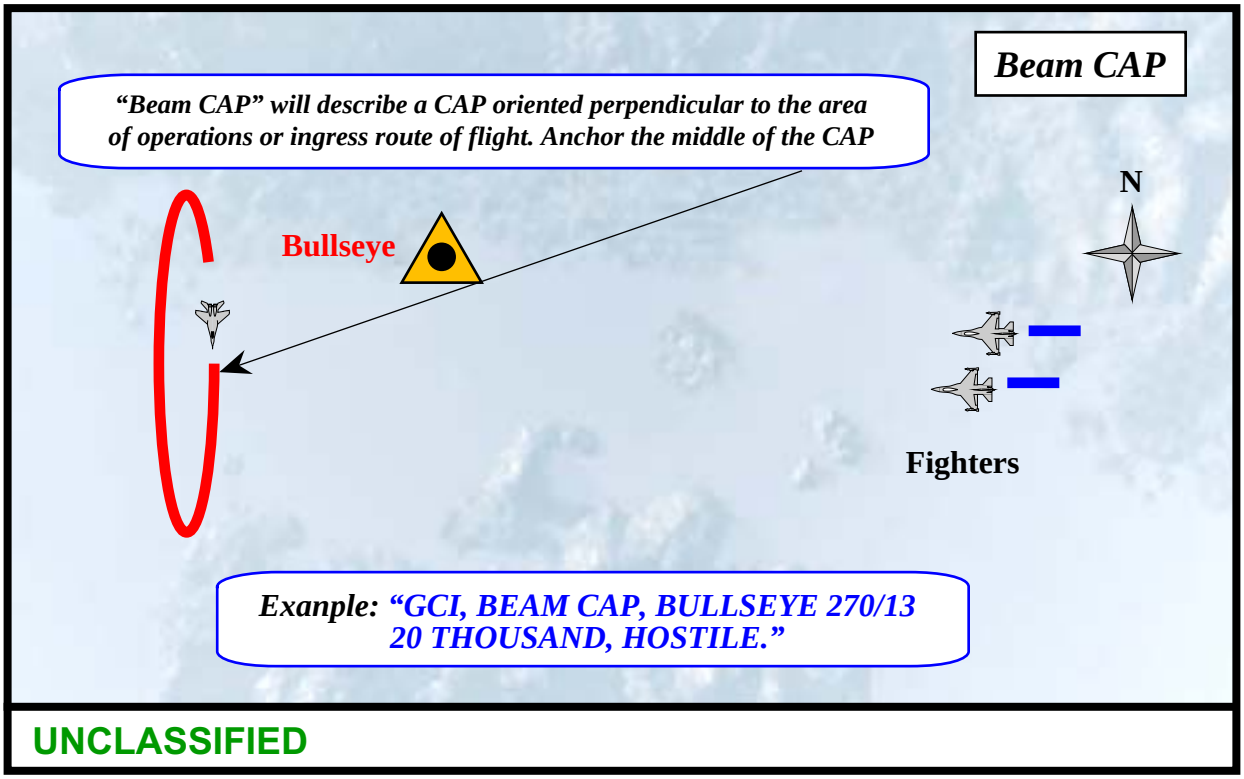
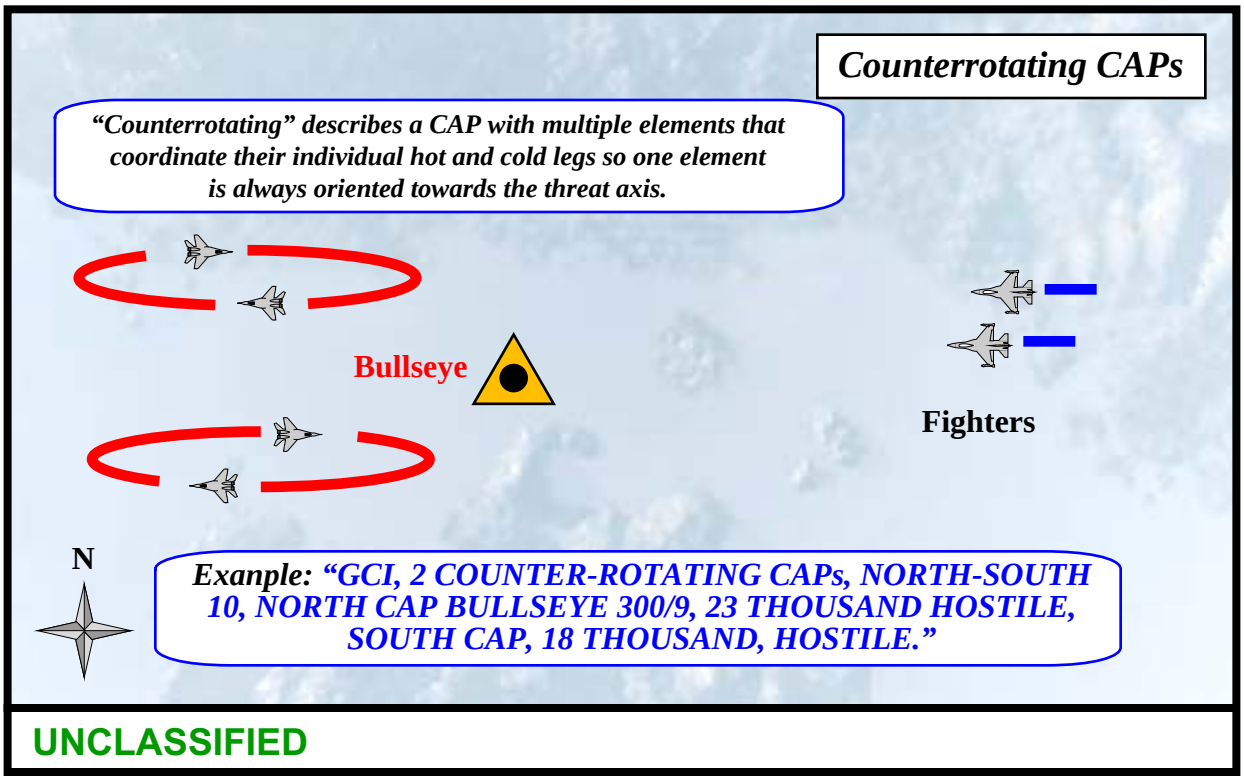


Figure A1.19 Counterrotating CAPs.



A1.6.6.3 **Picture Labeling.** If picture labeling criteria are not met, then the fighters and ABM/WDs should continue to use core information. A picture should never be forced as the entire engagement can be fought using only core information and appropriate fill-ins. Using common sense, label the picture from a god's eye view in conjunction with the following four criteria:

- Fighters committing/pushing.
- Bogies/bandits/hostiles are on a steady heading (greater than 12AA), and (i.e. they are "committed").
- Formation is determinable and labeling a picture will help build S/A.
- Groups are within bounding range. Use 30 NM unless briefed otherwise.

NOTE: F-16C/D pilots should brief a "re-dec" range, based on the expected contact range, during the mission briefing; if not, ABM/WDs will use 40 NM as the default range. At the briefed re-dec range the ABM/WD will voice the range, repeat the picture, and anchor each group (w/location, ID, and appropriate label) within 10 NM, or targeting depth if known, of the leading edge. All other groups will be included in the picture, but not anchored.

- "COWBOY, 40 MILES, 3 GROUP CHAMPAGNE, 10 WIDE, 13 DEEP, NORTH LEAD GROUP BULLSEYE 250/15, 25 THOUSAND, HOSTILE, SOUTH LEAD GROUP, B/E 230/18, 20 THOUSAND, HOSTILE, TRAIL GROUP 20 THOUSAND HOSTILE."

A1.6.6.4 In addition to the criteria above, if a picture cannot be labeled prior to MTR/meld range/NNP, labels should not be used. Continue to use only core information.

A1.6.6.5 If groups do not meet labeling criteria, but plain language group relationship exists and can be passed quickly and clearly, ABM/WDs and fighters should attempt to do so. Initially call the groups in core and then follow with a more plain language call.

- "BANDSAW, TWO GROUPS, EAST-WEST 19, CLOSING."

NOTE: This call, though not IAW the ROTs listed earlier, may help drive an intercept tactic better than the core information alone.

A1.6.6.6 **Standard Picture Labels.** The standard labels used by aircrews and ABM/WDs are SINGLE GROUP, RANGE, AZIMUTH, VIC, CHAMPAGNE, WALL, LADDER, and BOX. The term ECHELON is used as a fill-in on pictures having both RANGE and AZIMUTH components. These labels are depicted in **paragraph A1.6.6.8**, Naming the Groups. Figures are as follows.

- **Figure A1.20**, AZIMUTH.
- **Figure A1.21**, RANGE.
- **Figure A1.22**, ECHELON Fill-In.
- **Figure A1.23**, CHAMPAGNE.
- **Figure A1.24**, VIC.
- **Figure A1.25**, WALL and LADDER Presentations.
- **Figure A1.26**, Five-Group LADDER.

Figure A1.20 AZIMUTH.

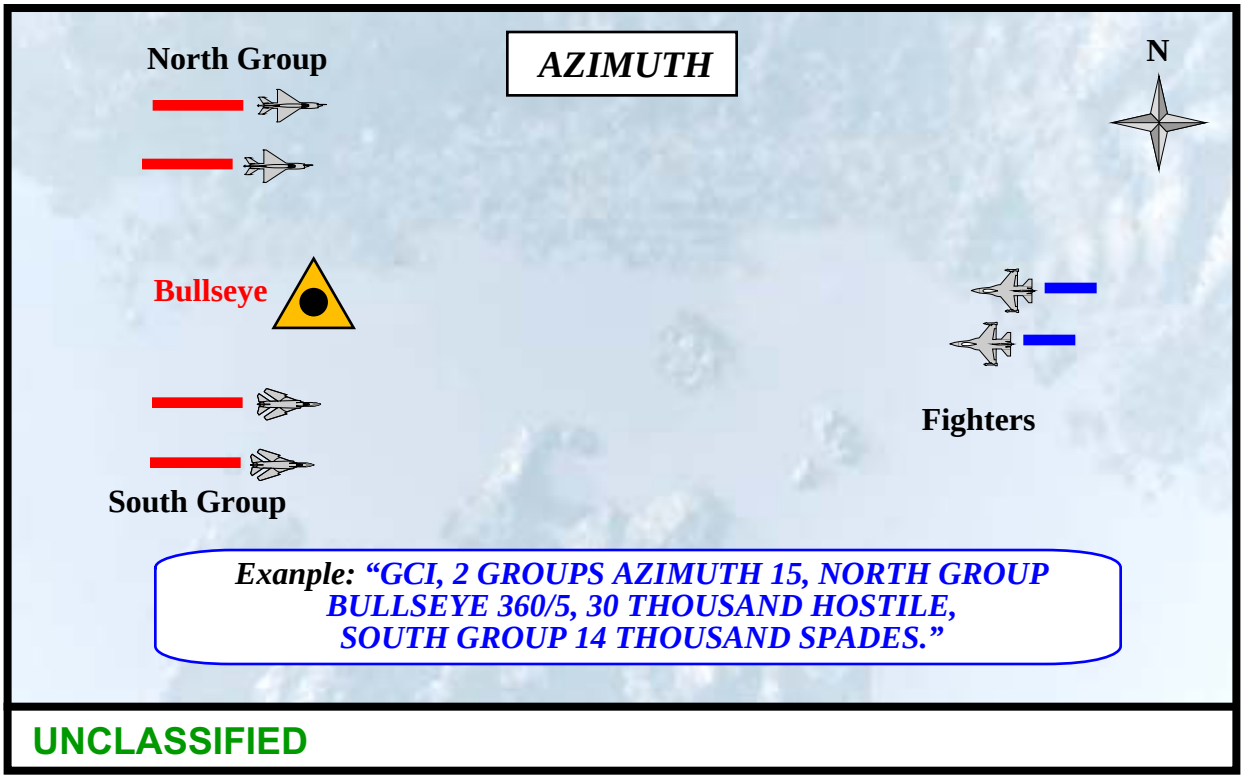


Figure A1.21 RANGE.

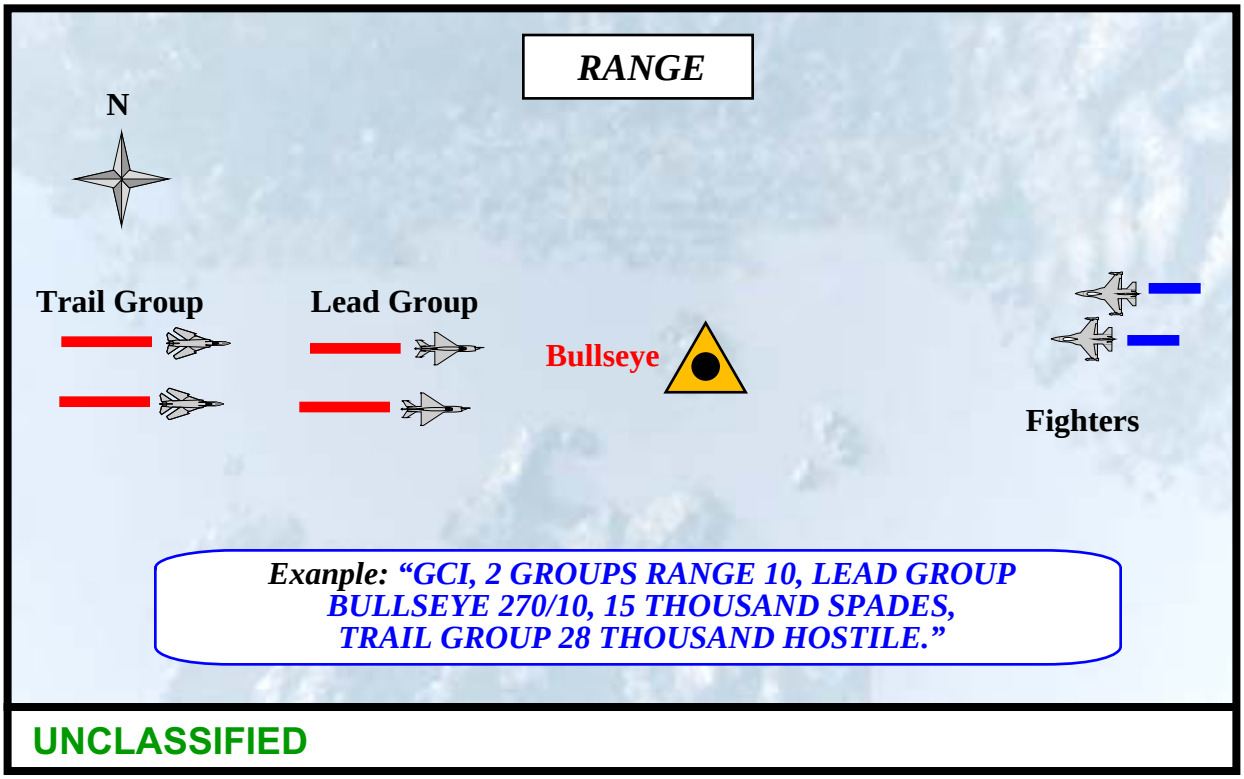


Figure A1.22 ECHELON Fill-in.

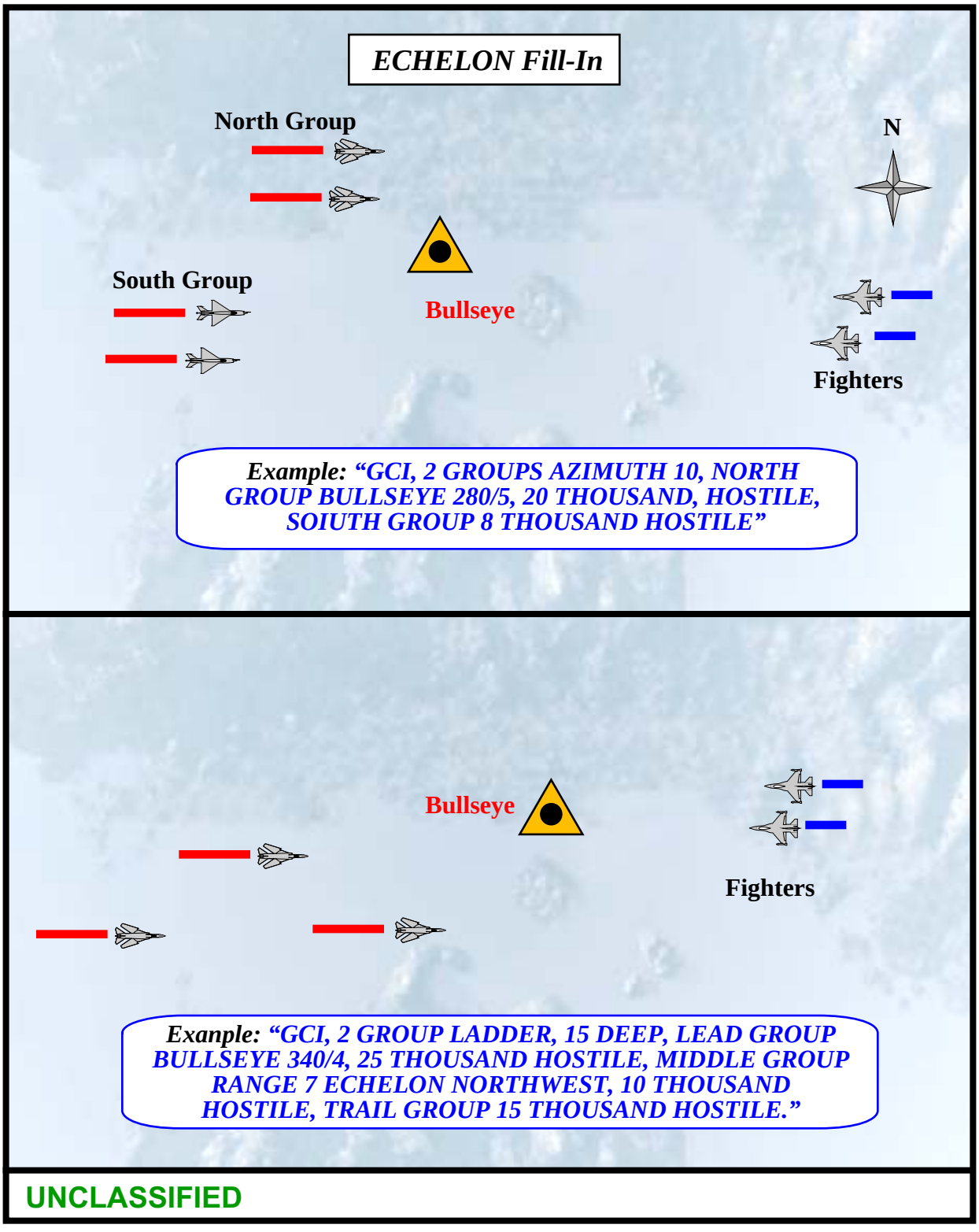


Figure A1.23 CHAMPAGNE.

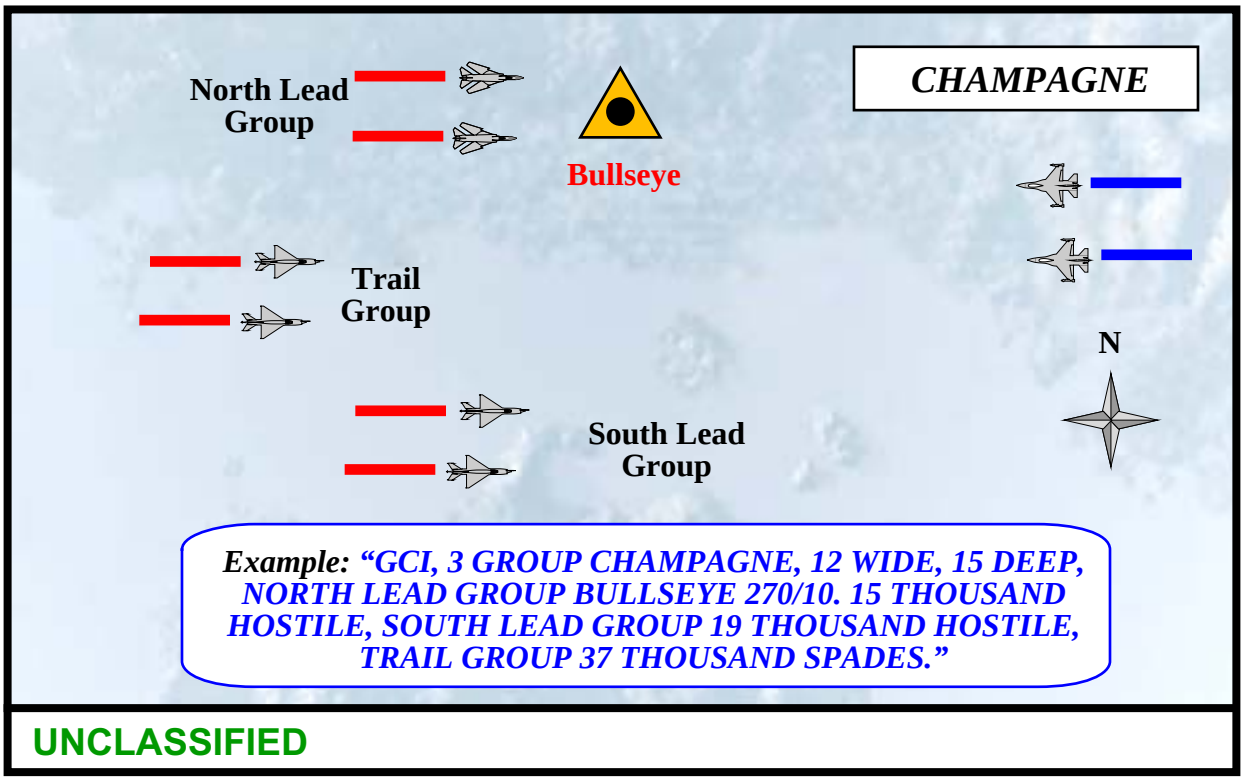


Figure A1.24 VIC.

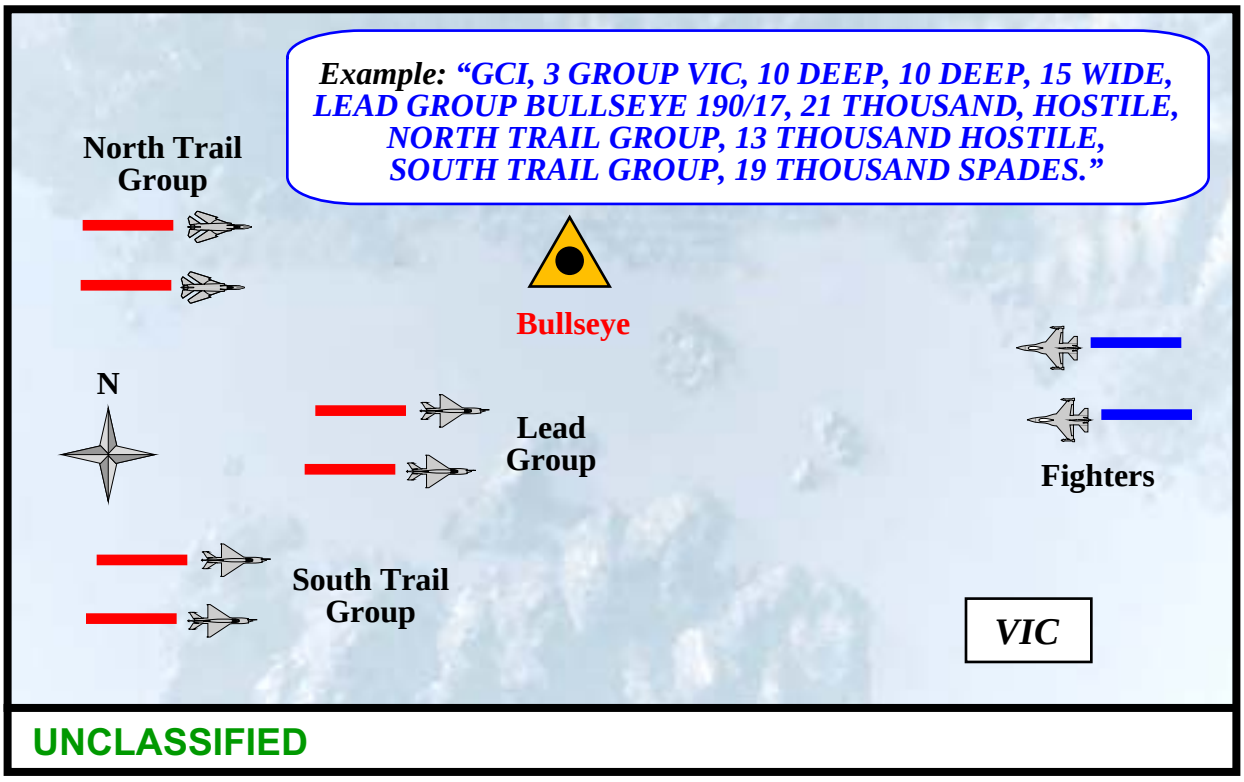


Figure A1.25 WALL and LADDER Presentations.

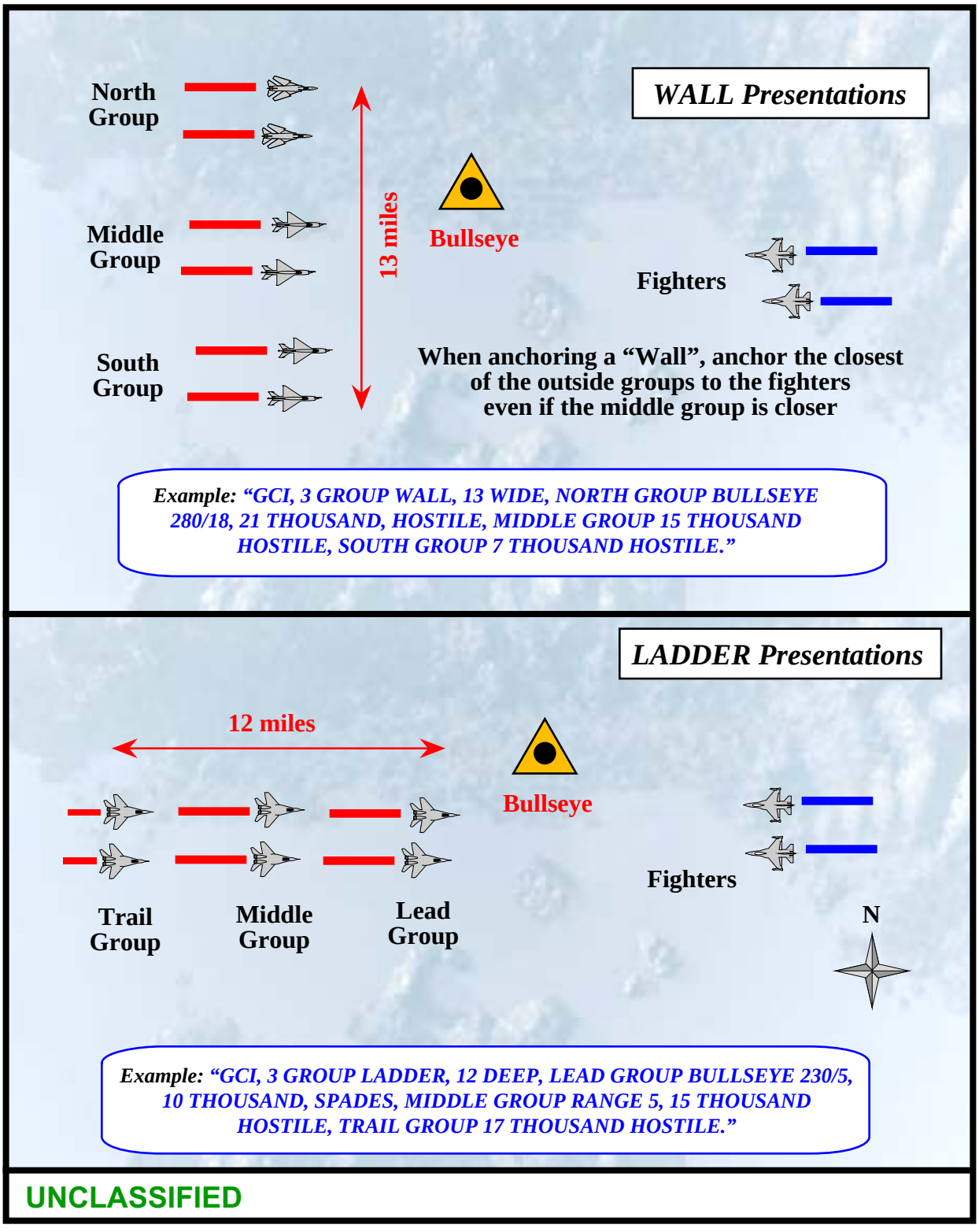
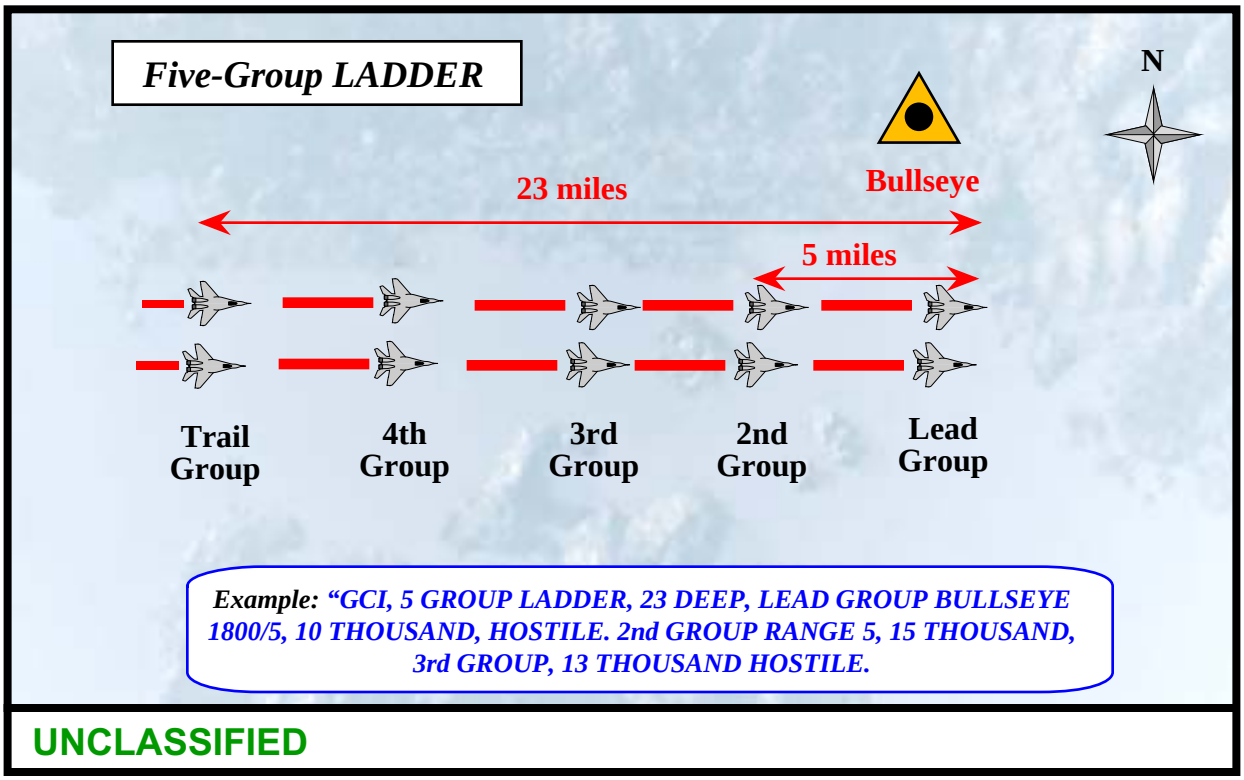


Figure A1.26 Five-Group LADDER.



A1.6.6.7 **Anchoring the Picture.** In a labeled picture, the groups closest to the fighters will be anchored first. If groups are equidistant from the fighters, anchor the nearest group to bullseye. In RANGE or VIC presentations, anchor the lead group. In a WALL or CHAMPAGNE, anchor the outside group closest to the fighters, or bullseye if equidistant. The anchoring point is the center of the leading edge of the anchored group.

A1.6.6.8 **Naming the Groups.** Within a labeled picture, each group will have an established name, IAW the figures in this section and in **paragraph A1.1**, General. AZIMUTH.

A1.6.6.9 **Specific Picture Labeling Contracts.**

A1.6.6.9.1 **Single Group.** When only one known BOGEY/BANDIT/HOSTILE group exists, the label is SINGLE GROUP, and all information is passed in core.

- "CHALICE, SINGLE GROUP BULLSEYE 360/20, 20 THOUSAND, SPADES."

A1.6.6.9.2 **Two Groups.** There are two primary ways to describe two-group pictures: AZIMUTH and RANGE. If the groups are in an AZIMUTH relationship, name the groups within the picture using the four cardinal directions (i.e., "north group" or "south group"). If the groups are in a RANGE relationship, name the groups using "lead group" and "trail group."

A1.6.6.9.3 **ECHELON.** Echelon is used to describe a two groups or greater presentation along a single axis where one or more groups are not in a true azimuth or range relationship to the others. To describe the distance, ABM/WDs will measure the

slant range between the groups. In an echelon, if groups are wider than they are long, it will be called azimuth. As a ROT for calling azimuth or range, use a 45-degree line from the closest group.

- (See **Figure A1.22**, ECHELON Fill-In.)
- "DARKSTAR, TWO GROUP, AZIMUTH 10, ECHELON NORTHEAST, SOUTH GROUP BULLSEYE 110/25, 15 THOUSAND, HOSTILE, NORTH GROUP, 12 THOUSAND, BOGEY."
- "FOCUS, THREE GROUP LADDER, 15 DEEP, ECHELON SOUTHWEST, LEAD GROUP OVER BULLSEYE, 22 THOUSAND, HOSTILE, MIDDILE GROUP, 15 THOUSAND, SPADES, TRAIL GROUP, 35 THOUSAND, HOSTILE."
- "DRAGNET, THREE GROUP LADDER, 12 DEEP, LEAD GROUP BULLSEYE 340/4, 25 THOUSAND HOSTILE, MIDDLE GROUP RANGE 7 ECHELON NORTWEST, 15 THOUSAND, BOGEY, TRAIL GROUP 19 THOUSAND, HOSTILE."

A1.6.6.9.4 **Three or More Groups.** The five other labels that may be used to describe pictures with three or more groups are WALL, LADDER, CHAMPAGNE, BOX, and VIC.

A1.6.6.9.4.1 **CHAMPAGNE and VIC.**

A1.6.6.9.4.1.1 **CHAMPAGNE Labels.** CHAMPAGNE is a label describing three distinct groups with two in front and one behind. In a CHAMPAGNE, the two groups closest to the fighters will be named lead groups (north lead group and south lead group in a CHAMPAGNE headed east towards the fighters) and the lead group closest to the fighters will be anchored off bullseye. The third group in the CHAMPAGNE will be named the trail group. When calling the distances between groups in a CHAMPAGNE, the azimuth and then the range will be called. However, if it looks only slightly like a CHAMPAGNE, it will be called a three-group WALL. As a ROT, the trail group should be swept back approximately 45 degrees or more from the lead groups to be considered a CHAMPAGNE. (See **Figure A1.23**, CHAMPAGNE.)

A1.6.6.9.4.1.2 **VIC Labels.** A VIC label describes three groups with a single group closest in range and two trail groups, separated in azimuth. In a VIC, the group closest to the fighters will be named the lead group; the other two are trail groups. When calling the distances between groups in a VIC, the range and azimuth will be called. However, if it looks only slightly like a VIC, it will be called a three-group WALL. As a rule of thumb, the trail groups should be swept back approximately 45 degrees or more from the lead group to be considered a VIC. (See **Figure A1.24**, VIC.)

A1.6.6.9.4.2 **WALL and LADDER.**

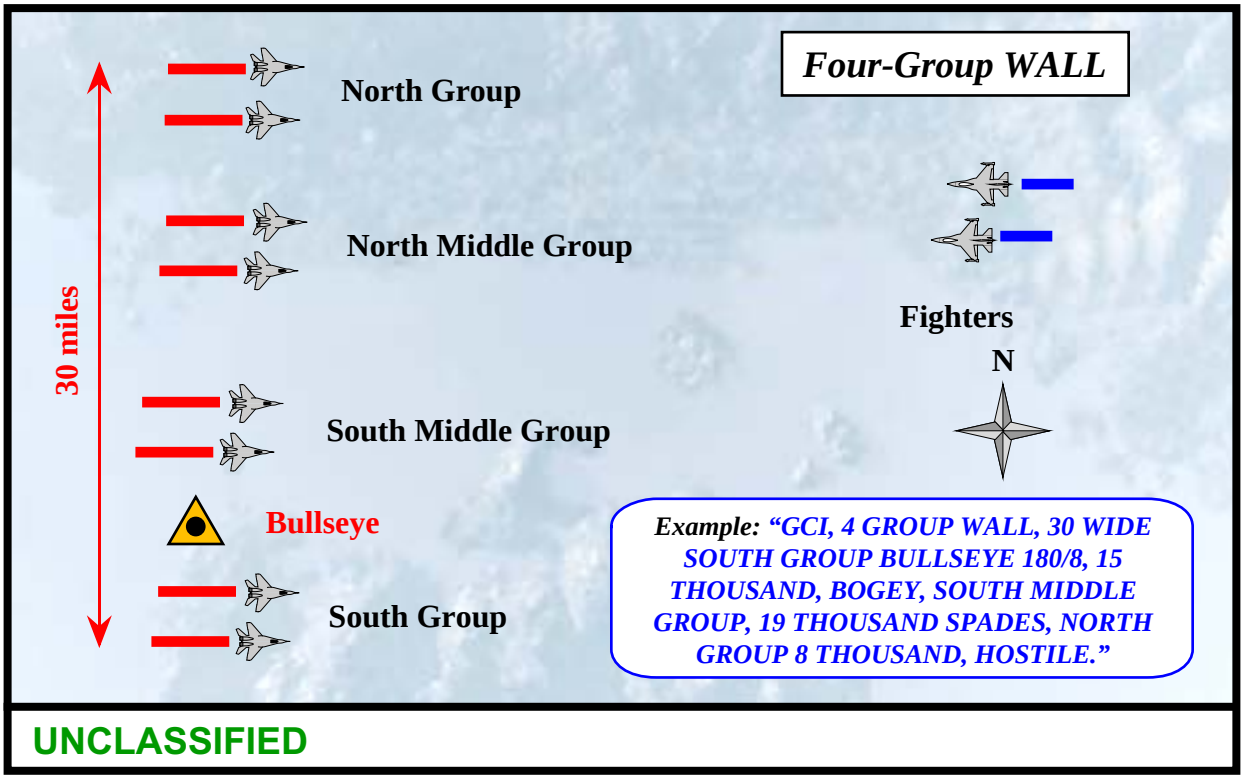
A1.6.6.9.4.2.1 **Three-Group WALL or LADDER.** In a three-group WALL or LADDER, call the group in the middle the "middle group." In a three-group LADDER, the last group will be called the "trail group." The range between the

"lead group" and the "middle group" in a three-group LADDER will be provided in a second transmission. The azimuth from the anchor to the middle group in a WALL will only be provided if the distance is drastic or the tactical situation warrants. (See **Figure A1.25**, WALL and LADDER Presentations.)

A1.6.6.9.4.2.2 **Four or More Group LADDER.** In a range problem with four or more groups (four-group LADDER), name the groups after the lead group as "second, third, and so on," but the last group in the LADDER will always be named the "trail group." (See **Figure A1.26**, Five-Group LADDER.)

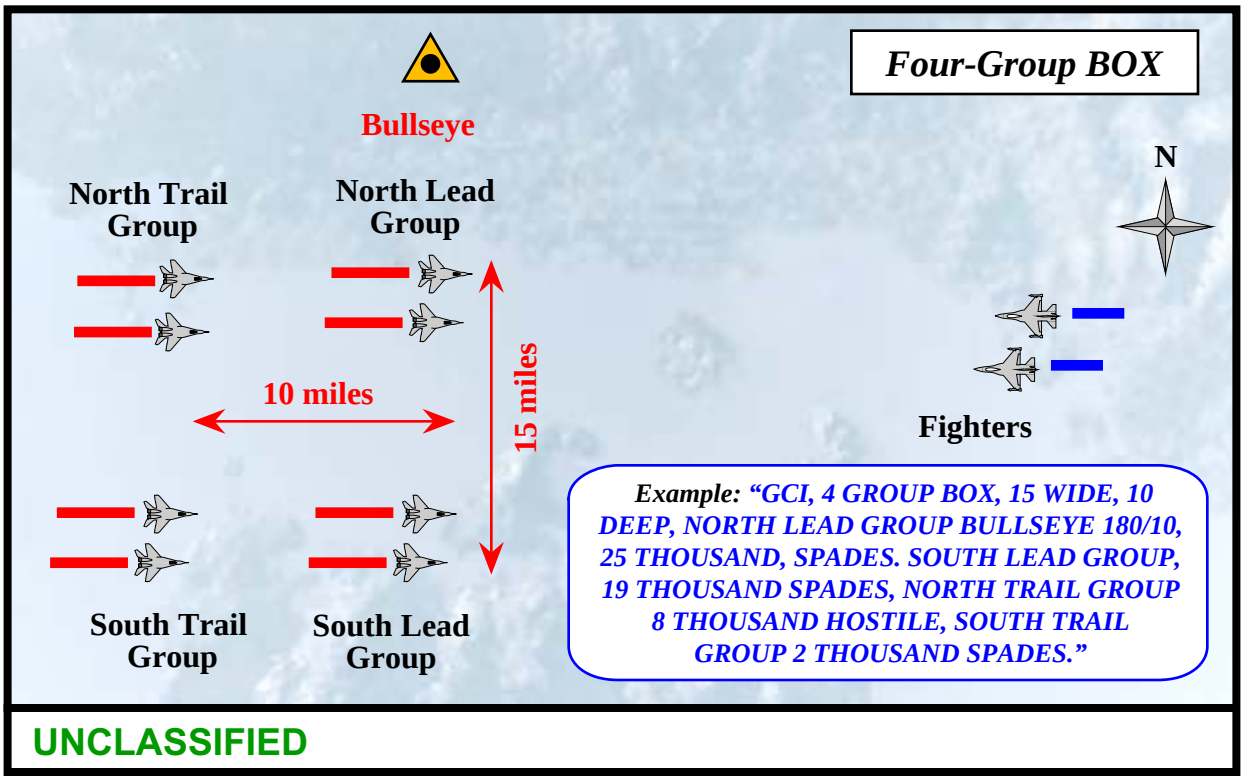
A1.6.6.9.4.2.3 **Four-Group WALL.** In a four-group WALL, name the outside groups with the cardinal directions, like in a two-group azimuth, "north group" and "south group." The other groups inside the WALL will be named "south middle group" and "north middle group." (See **Figure A1.27**, Four-Group WALL.) For example, "EAGLE 1 LOCKED BULLSEYE 270/10, 25 THOUSAND." By using the names mentioned above, the ABM/WD could respond, "EAGLE 1, LOCKED NORTH GROUP, NORTH MIDDLE GROUP BULLSEYE 230/14, 28 THOUSAND HOSTILE."

Figure A1.27 Four-Group WALL.



A1.6.6.9.4.3 **Four-Group BOX.** A four-group BOX presentation is initially labeled in the same manner as a three-group CHAMPAGNE. The azimuth spacing between the trail groups will be filled in with a subsequent transmission, as comm pacing permits. (See **Figure A1.28**, Four-Group BOX.)

Figure A1.28 Four-Group BOX.



A1.6.6.10 **PICTURE.** ABM/WD/fighters will not transmit the word "picture" when describing a presentation. Fighters can request PICTURE at any time and the ABM/WD response can be in the form of CAP comm, core information, or a labeled picture, depending on the phase of the mission and situation, but it will be communicated relative to bullseye location.

A1.6.6.11 .**Opening and Closing Groups.** Labeled groups whose separation is increasing or decreasing to the extent that it will impact the briefed or planned intercept flow or targeting plan, but whose aspect remains greater than 16 AA, can be described using the terms "OPENING" or "CLOSING." An update of the separation (range, azimuth, or altitude) should be included as part of the transmission.

- "BANDSAW, GROUPS OPENING, RANGE 16."

A1.6.7 Bounding.

A1.6.7.1 Bounding limits the use of group labels to situations where the group picture is related. Unless briefed otherwise, use a bounding range of 30 miles. Individual groups (or CAPs) operating no closer than bounding range are not considered as orchestrating one specific tactic and will not be described using group labels; they will be called "packages." To describe groups outside of bounding range, use core information.

- "DARKSTAR, TWO PACKAGES, PACKAGE BULLSEYE 360/45, PACKAGE BULLSEYE 270/10."

A1.6.7.2 Packages can be labeled with a cardinal direction if doing so will help facilitate targeting.

- "DARKSTAR, TWO PACKAGES, NORTH PACKAGE BULLSEYE 030/45, SOUTH PACKAGE BULLSEYE 110/55."

A1.6.7.3 If a common sense relationship between the packages exists that will aid in targeting the packages, then it can be used.

- "DARKSTAR, TWO PACKAGES, NORTH-SOUTH 35, NORTH PACKAGE BULLSEYE 360/45 . . ."

A1.6.7.4 Azimuth and range should not be used to describe groups outside of the briefed bounding range.

A1.6.7.5 Within these packages, there may be a group picture that can be labeled.

- "CHALICE, NORTH PACKAGE, TWO GROUP RANGE 10, LEAD GROUP BULLSEYE 045/35, 25 THOUSAND, HOSTILE, 2 CONTACTS. TRAIL GROUP 15 THOUSAND, HOSTILE, HEAVY 4 CONTACTS."

A1.6.7.6 After the "inner package" picture has been labeled, both the group name and package name will be used when referencing groups. This is to avoid confusion as there might be two or more groups with the same group name.

- "VIPER 2 TARGET LEAD GROUP NORTH PACKAGE."

NOTE: The shortest distance between groups must be greater than bounding range in order to meet package criteria. (See **Figure A1.29**, Bounding.)

A1.6.8 Weighted. "Weighted" is a fill-in for a CHAMPAGNE, VIC, or WALL when one or more groups are out of position or offset from the standard picture label. (See **Figure A1.30**, Weighted CHAMPAGNE, **Figure A1.31**, Weighted VIC, and **Figure A1.32**, Weighted WALL.)

A1.6.9 Inner-Group Formation. ABM/WDs and aircrews should label the inner-group formation when this call will enhance mission success. This is particularly important when fighters are committed to a visual merge. Fighters should not attempt to label the inner-group formation at ranges beyond the reasonable expectations of accurate inner-group radar resolution nor at times when higher priority radio calls should take precedence.

A1.6.9.1 Since the inner-group label will be used to primarily to define sort priorities and build a mental picture of the group's formation for WVR employment, it will be called in god's eye view format, based on the actual formation the targets are flying, not their radar-apparent orientation.

A1.6.9.2 When describing an inner-group formation, use the labels LINE ABREAST, LEAD-TRAIL, SWEPT, WEDGE, STINGER, or CONTAINER.

Figure A1.29 Bounding.

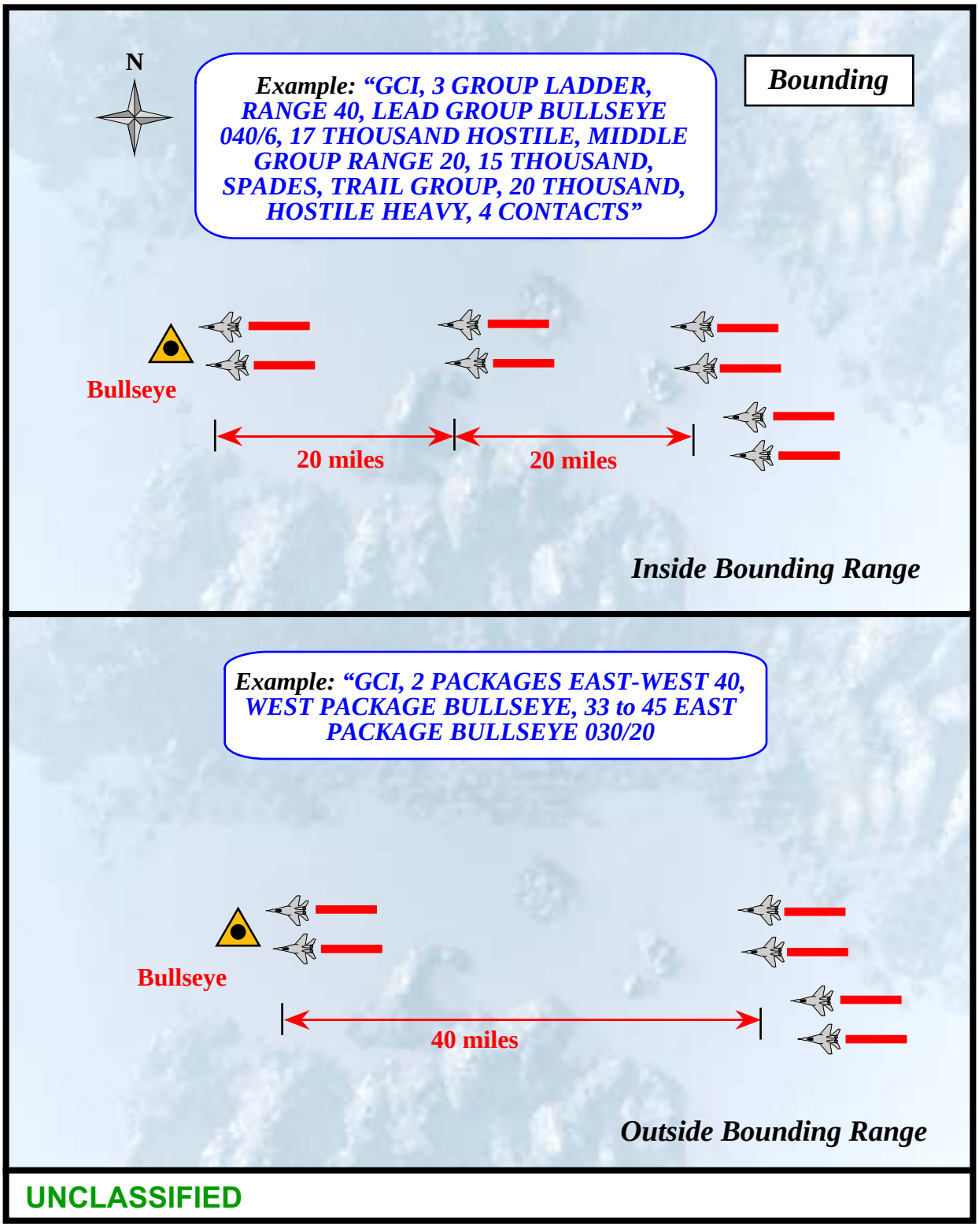


Figure A1.30 Weighted CHAMPAGNE.

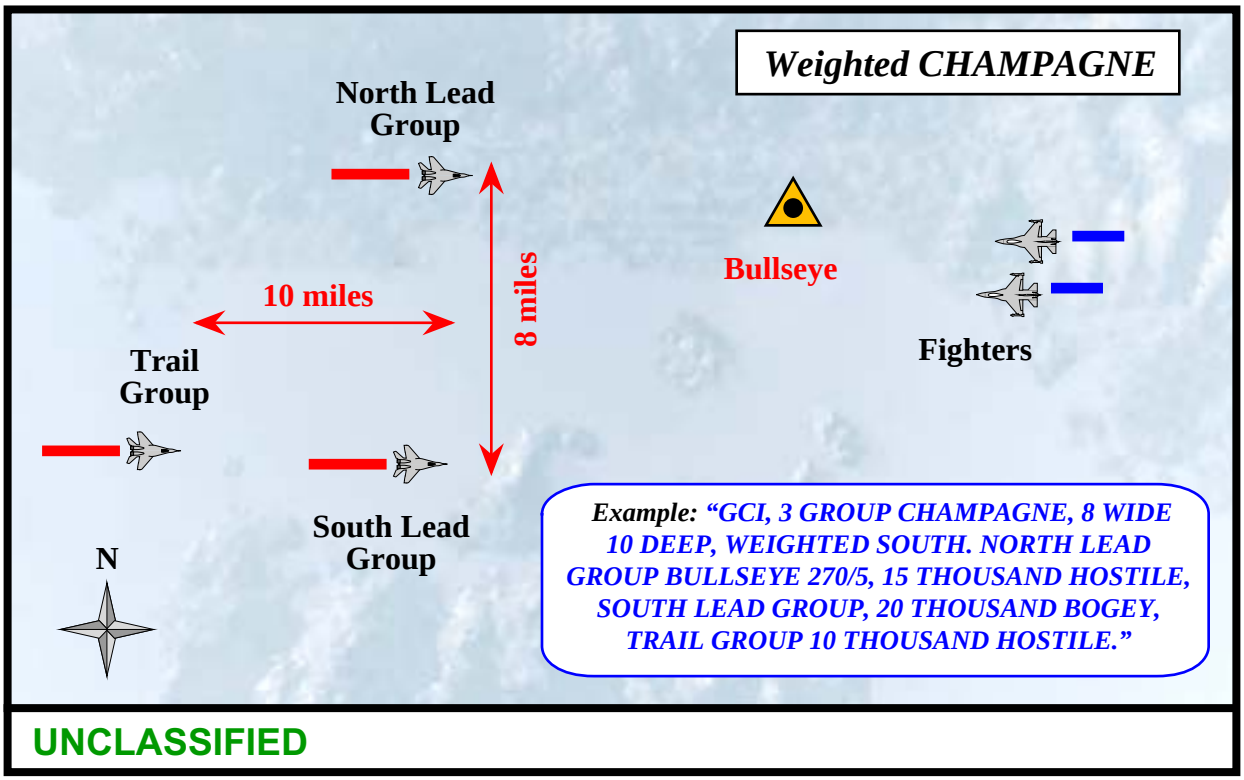


Figure A1.31 Weighted VIC.

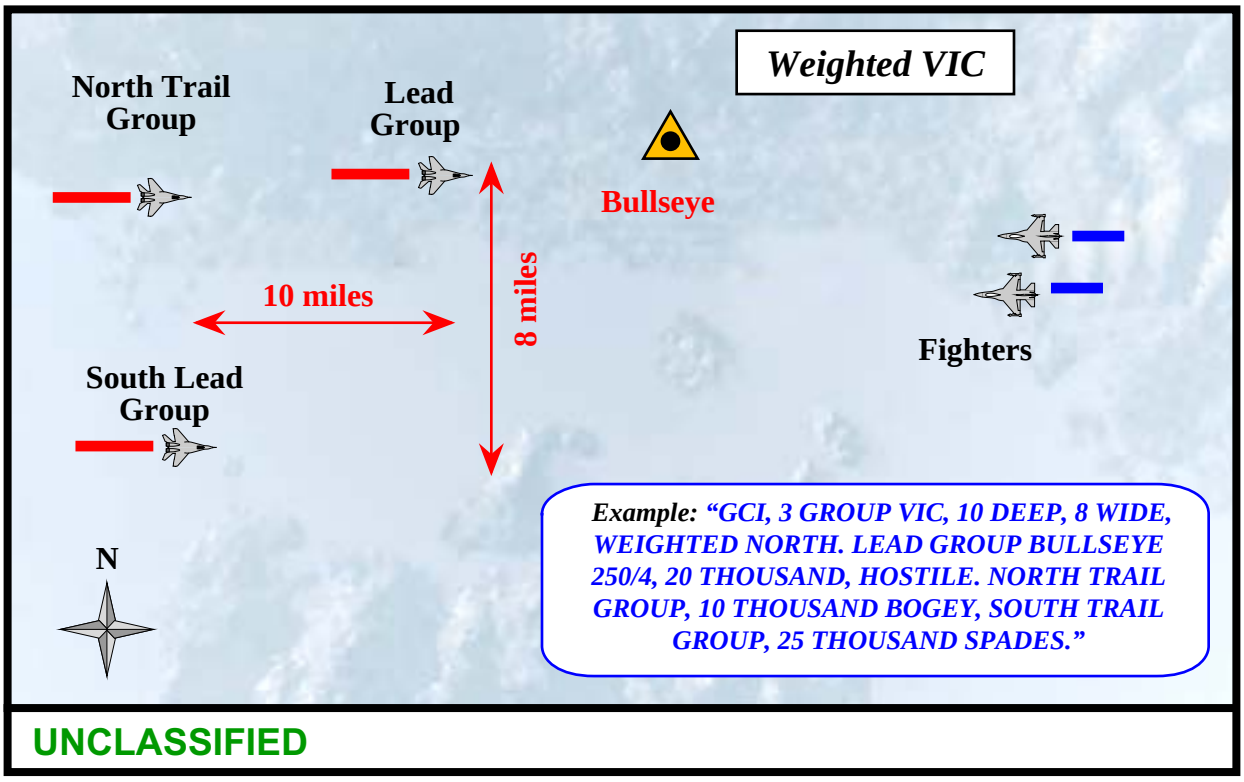
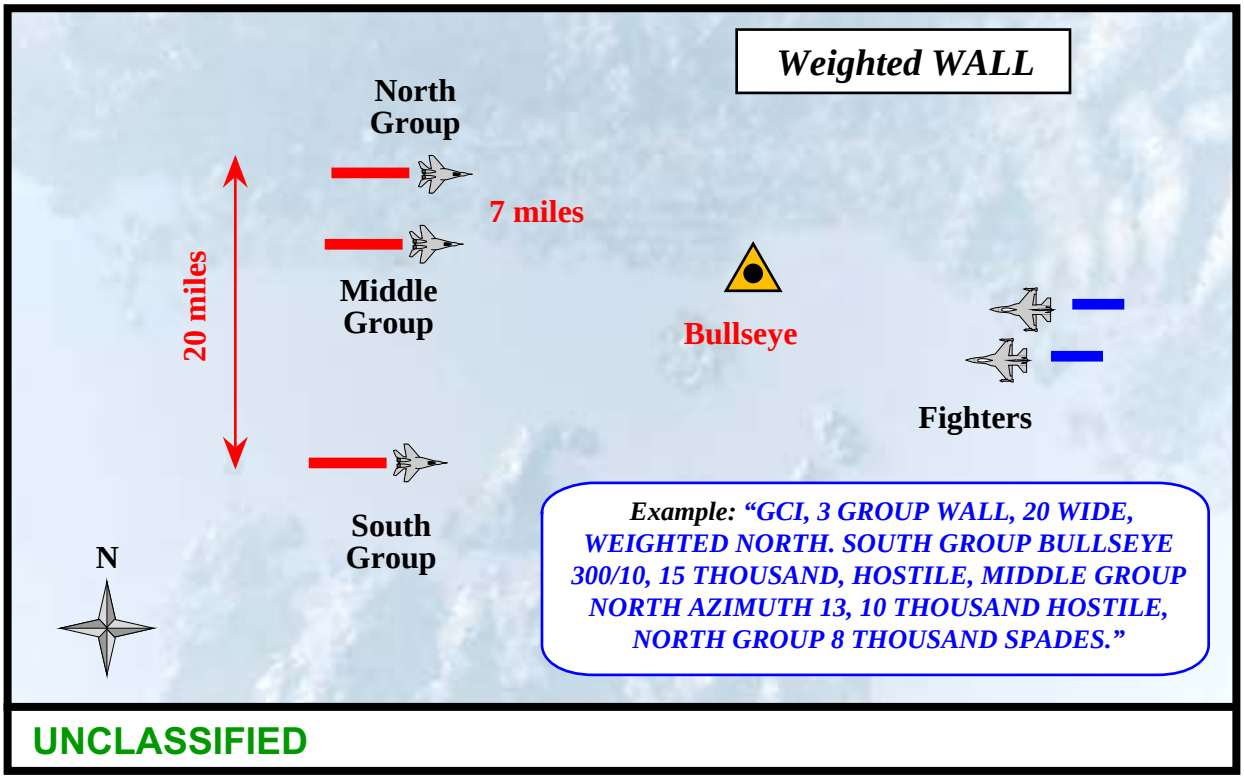


Figure A1.32 Weighted WALL.



A1.6.9.2.1 If the fighters need a radar-apparent label to facilitate a sort for BVR ordnance employment, fighters can use the terms NEAR/FAR or SIDE/SIDE. However, ABM/WDs will use the god's eye view labeling contract.

A1.6.9.3 If an ABM/WD determines through comm or radar that a group has an altitude stack of at least 10,000 feet, the ABM/WD will communicate it using the term "STACK," stating the higher altitude first then the lower altitude.

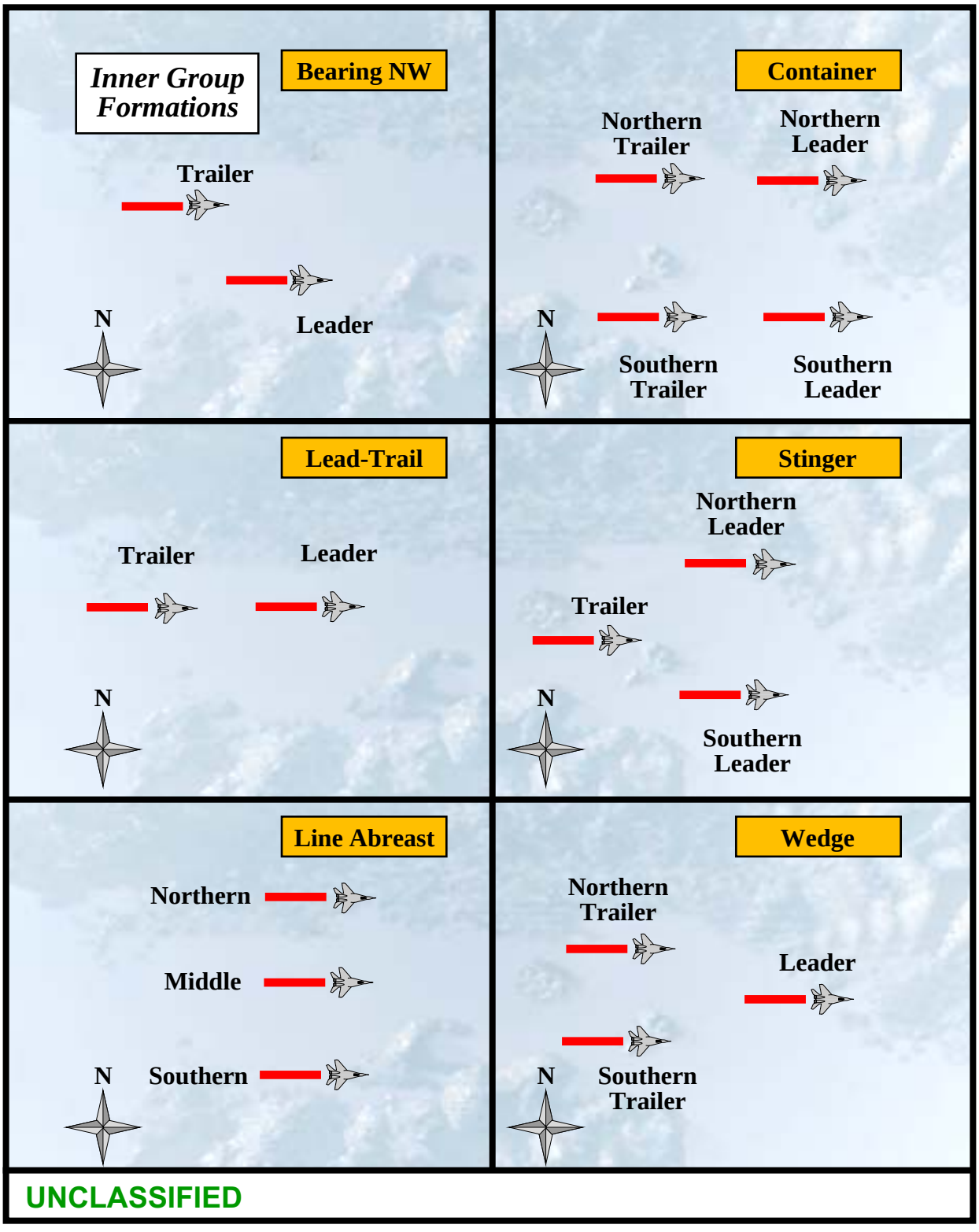
- "DARKSTAR, NORTH GROUP BULLSEYE 250/17 STACK 30 THOUSAND, 10 THOUSAND, HOSTILE."

A1.6.9.4 When naming individual contacts within the groups, use combinations of leader, trailer, western, eastern, and so on (do not use the word "contact"). (See **Figure A1.33**, Inner Group Formations.)

A1.6.9.5 **Heavy.** A group is "heavy" if it contains at least three contacts. If the number of contacts in a group can be accurately determined, the group will be called heavy and the number of contacts provided.

- "LUGER, WEST GROUP BULLSEYE 190/15, 35 THOUSAND, HOSTILE, HEAVY, FOUR CONTACTS, CONTAINER."

Figure A1.33 Inner Group Formations.



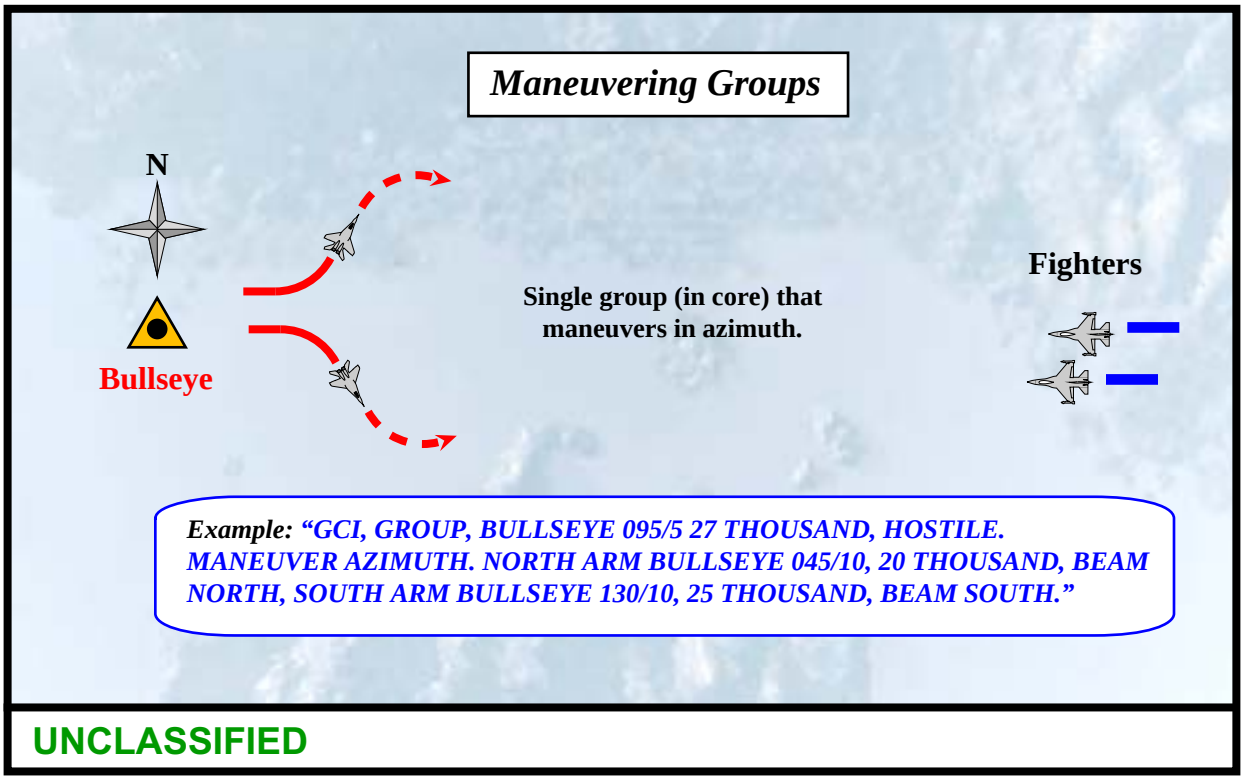
A1.6.10 Maneuvering Groups.

A1.6.10.1 As a ROT, after two returns, the ABM/WD recognize and call "MANEUVER" only and wait for the next sweep/cycle/hit to add amplifying information such as "MANEUVER AZIMUTH," "MANEUVER RANGE," MANEUVER [cardinal direction]," if the group is continuing to split and has not settled on a steady flank, beam, or drag. (See **Figure A1.34**, Maneuvering Groups.)

- (Using Group Name) "DARKSTAR LEAD GROUP, 030/12, 25 THOUSAND, HOSTILE, MANEUVER."
- (Using Core Information) "DARKSTAR GROUP BULLSEYE 270/15, 15 THOUSAND, HOSTILE, MANEUVER."
- (Assuming flight member or ABM/WD recently voice group ID) "CHALICE, GROUP BULLSEYE 270/15, 15 THOUSAND MANEUVER AZIMUTH."
- "BANYARD, NORTH GROUP BULLSEYE 190/15, 15 THOUSAND MANEUVER NORTH."

NOTE: These calls may be followed with a new picture in core information or a picture label.

Figure A1.34 Maneuvering Groups.



A1.6.10.2 Once the true nature of the maneuver is determined, the terms "MANEUVER AZIMUTH" and "MANEUVER RANGE" will be used if the group continues to separate and has not settled.

- (Using Group Name) "DARKSTAR LEAD GROUP MANEUVER RANGE."

- (In Core Information) “DARKSTAR, GROUP BULLSEYE 270/15, MANEUVER AZIMUTH.”

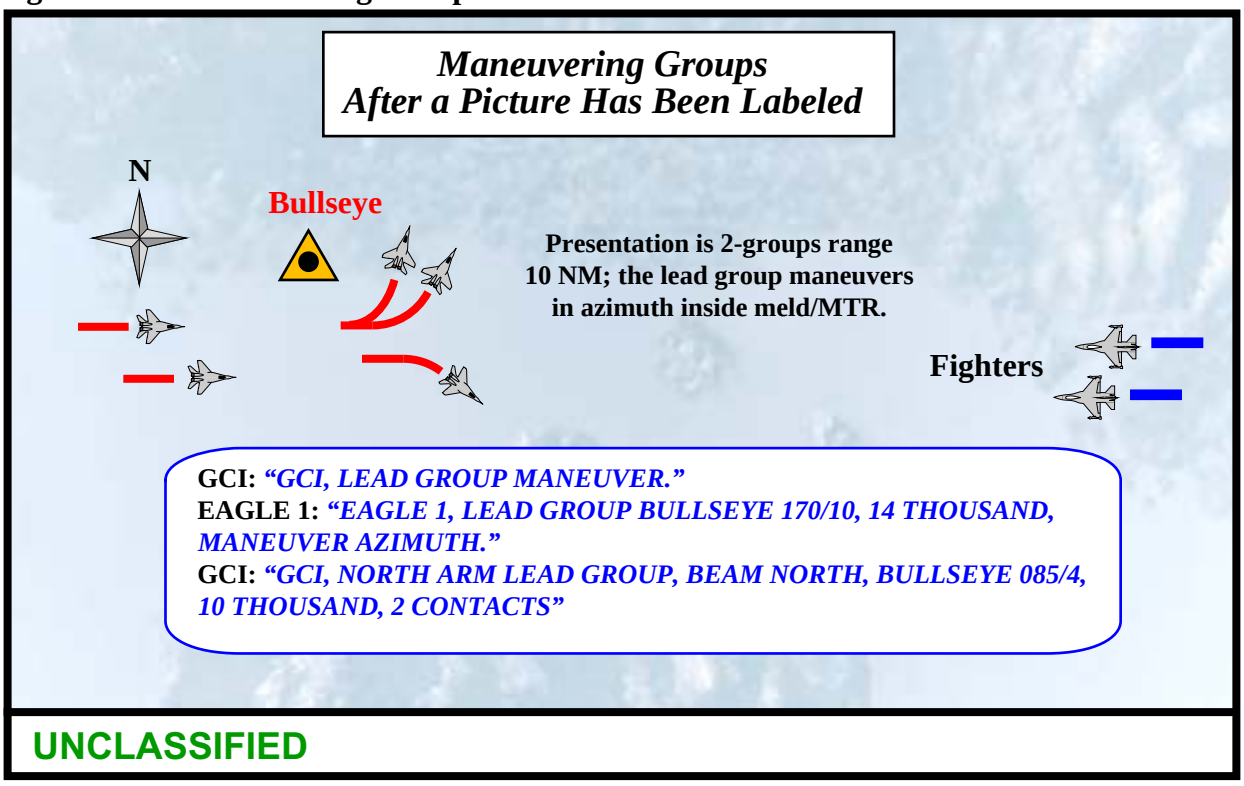
A1.6.10.3 When the maneuvering appears to have ceased and the group is on a steady heading, it may be described with flank, beam, drag, heading, or tracking direction. This scenario may be followed with a “NEW PICTURE” call in core information or labeled picture format.

A1.6.10.4 **Maneuvering Groups After a Picture has been Applied.**

A1.6.10.4.1 **Arms.** For groups that maneuver after picture labels have been applied **paragraph A1.6.10**, Maneuvering Groups, an additional label “ARMS” may be used to discriminate between different entities of a maneuvering group. Arm names will include cardinal directions or lead/trail (do not include ERNS/ERS). (See **Figure A1.35**, Maneuvering Groups After a Picture has been Applied.)

- “RAMBO 1, LEAD GROUP MANEUVER AZIMUTH.”
- “DARKSTAR, NORTH ARM LEAD GROUP, BULLSEYE 090/6, 10 THOUSAND, HOSTILE, BEAM NORTH.”

Figure A1.35 Maneuvering Groups After a Picture has been Labeled.



A1.6.10.4.1.1 Once the maneuver has been completed and comm time/priority exists, the relationship of the maneuvering group can be provided. For example, if the arms from the lead group maneuvered and then continued east, the call could be: “BARNYARD, LEAD GROUP LINE ABREAST 6.” AZIMUTH and RANGE will not be used to describe the resulting formation when the maneuver occurs

inside of meld/MTR/NNP. If the maneuver has occurred and does not appear to be complete, a relationship can still be provided as long as it makes sense, builds SA, and will aid in the targeting/sort decision process.

A1.6.10.4.1.2 Should "arms" subsequently split or maneuver, they can be referenced as "NORTH CONTACT LEAD ARM," and "SOUTH CONTACT LEAD ARM."

A1.6.11 Faded Comm and Techniques.

A1.6.11.1 In general, if a previously reported group is not processed for two consecutive sweeps/cycles, it will be reported by the ABM/WD as FADED. The faded call's bullseye location will be anchored at the position of the last contact with a last known heading given (even if greater than 16 AA and if known) and number of contacts (single contact is not assumed). ID will not be given on a FADED call from the ABM/WD.

- "BANDSAW, NORTH GROUP FADED, BULLSEYE 270/27, TRACK NORTH TWO CONTACTS."

A1.6.11.2 By calling the group FADED, the ABM/WD is informing the fighters C^2 can no longer accept targeting responsibility on that group. The ABM/WD will attempt to dead reckon (DR) the FADED group's location for SA but will make no calls based on DR location. If the fighter subsequently acquires the faded group and calls its location with a heading, the ABM/WD will update the DR process again. After the initial FADED call, the ABM/WD will not reference the FADED group unless specifically requested to do so or if a PICTURE/NEW PICTURE call is made. In this instance, the group will be called FADED with its "last known" radar contact location, anchored off bullseye. If the contact was continuously tracked by a fighter after the ABM/WD lost contact on the group, the last fighter location will be used in the "faded...last known" call.

- "BARNYARD, PYTHON 1, STATUS NORTH GROUP."
- "BARNYARD, NORTH GROUP FADED, LAST KNOWN BULLSEYE 270/27."
- "DARKSTAR, PYTHON 1, PICTURE."
- "DARKSTAR, 4 GROUPS, 2 GROUPS AZIMUTH 10, NORTH GROUP OVER BULLSEYE, 30 THOUSAND, HOSTILE, SOUTH GROUP 10 THOUSAND, HOSTILE, 2 GROUPS FADED."

A1.6.11.3 ABM/WDs will use "negative contact" to report a friendly aircraft that is not displayed on a scope. For example, "EAGLE 1, DARKSTAR, NEGATIVE CONTACT."

A1.6.12 Electronic Attack.

A1.6.12.1 C^2 will respond to STROBE calls with: (1) Range, (2) bullseye location, altitude, and ID, and (3) GROUP label (if applicable) to the closest group along that azimuth and any follow-on groups along that azimuth. If C^2 is clean along that azimuth, then that should be reported for SA. This may indicate that the contact may be below C^2's coverage or may be a ground-based jammer.

- "RAMBO 1, STROBE 360."

- "RAMBO 1, STROBE RANGE 37, BULLSEYE 241/14, 25 THOUSAND, HOSTILE, LEAD GROUP."

A1.6.12.2 MUSIC calls will be answered with (1) bullseye location with altitude and ID, (2) number of contacts in that group, if able, (3) any detected maneuvers and track direction.

- "SNAKE 1, MUSIC EAST GROUP."
- "SNAKE 1, EAST GROUP, B/E 210/15, 25 THOUSAND, HOSTILE, 2 CONTACTS LINE-ABREAST TRACK EAST."

A1.6.13 New Groups.

A1.6.13.1 Prior to a fighter reaching meld/MTR/NNP range, any group previously undetected/unreported will be referred to as a "new group." If either a fighter or ABM/WD is describing a picture in core information and someone else detects a subsequent group, that group will be called a "new group" and anchored off bullseye—usually with the next comm call.

- "CHALICE, TWO GROUPS, GROUP BULLSEYE 360/10 32 THOUSAND, HOSTILE, GROUP OVER BULLSEYE, 8 THOUSAND, BOGEY" and then "EAGLE 1, NEW GROUP BULLSEYE 190/7, HITS 5 THOUSAND."

A1.6.13.2 If the "new group" is detected/reported after labels have been applied, the priority is to first anchor that group off the bullseye, then if it makes sense, make a new picture call. Anchor the new picture using standard anchoring criteria.

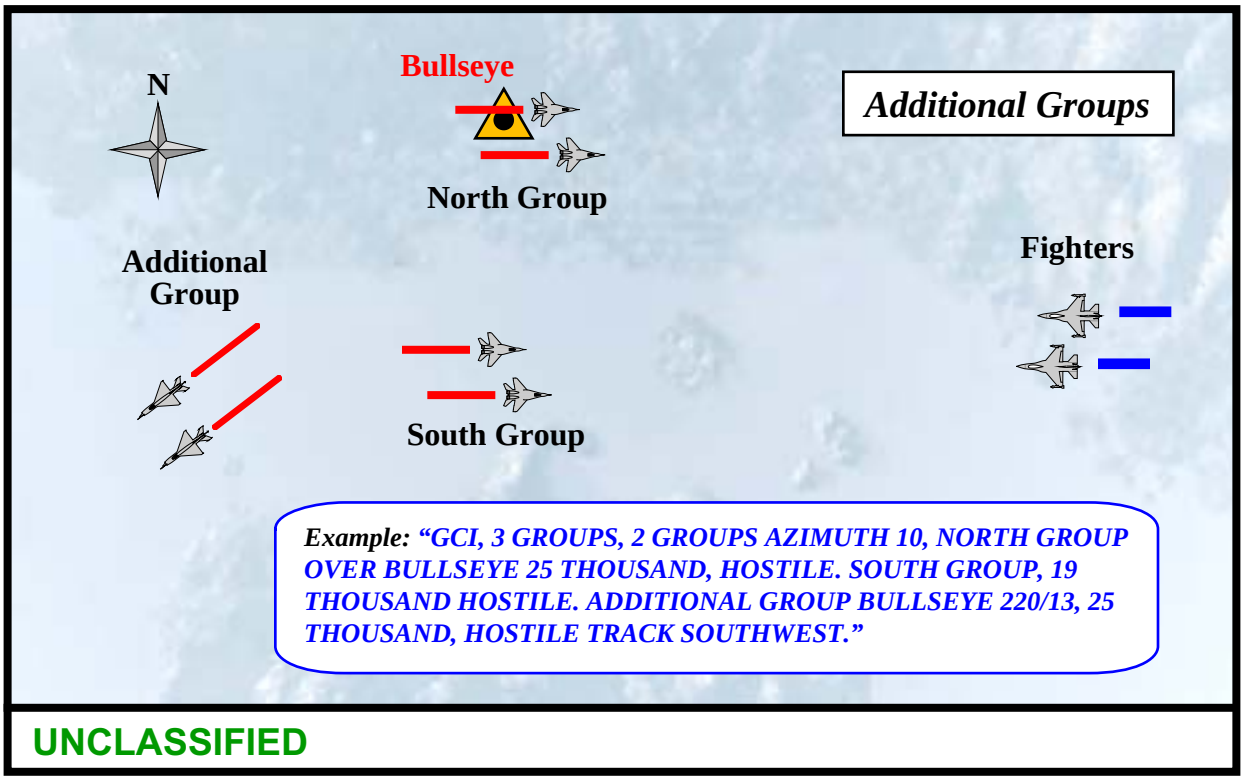
- "VIPER 1 NEW GROUP BULLSEYE 275/15, 5 THOUSAND."
- "DRAGNET, NEW PICTURE, THREE-GROUP LADDER, 20 DEEP, LEAD GROUP BULLSEYE 275/15 5 THOUSAND, LAST, BOGEY, MIDDLE GROUP RANGE 6, 20 THOUSAND, SPADES, TRAIL GROUP 15 THOUSAND, HOSTILE."

A1.6.13.3 If a "new group" appears within 5 NM of meld/MTR/NNP range and time does not allow the normal "new group," "new picture" progression, then a new picture can be labeled using the "new group" as the anchor.

A1.6.14 Additional Groups. "Additional group" is used only when applying labels to a presentation when there is at least one group, within bounding range, that does not fit within the previously discussed group labels. It does not matter whether this group is a factor for targeting. The fighter/ABM/WD will first state the total number of groups, provide the presentation label, and finally in the next transmission anchor the "additional group" off bullseye. (See **Figure A1.36**, Additional Group.)

- "BARNYARD, 3 GROUPS, 2 GROUPS AZIMUTH 10, NORTH GROUP OVER BULLSEYE 15 THOUSAND HOSTILE, SOUTH GROUP, 12 THOUSAND, BOGEY, ADDITIONAL GROUP BULLSEYE 240/14, 12 THOUSAND, BOGEY."

Figure A1.36 Additional Group.



A1.6.15 Pop-Up Groups.

A1.6.15.1 After meld/MTR/NNP range, any previously undetected/unreported group detected inside of meld/MTR will be called a "pop-up group," anchored off bullseye followed by range to the closest fighter.

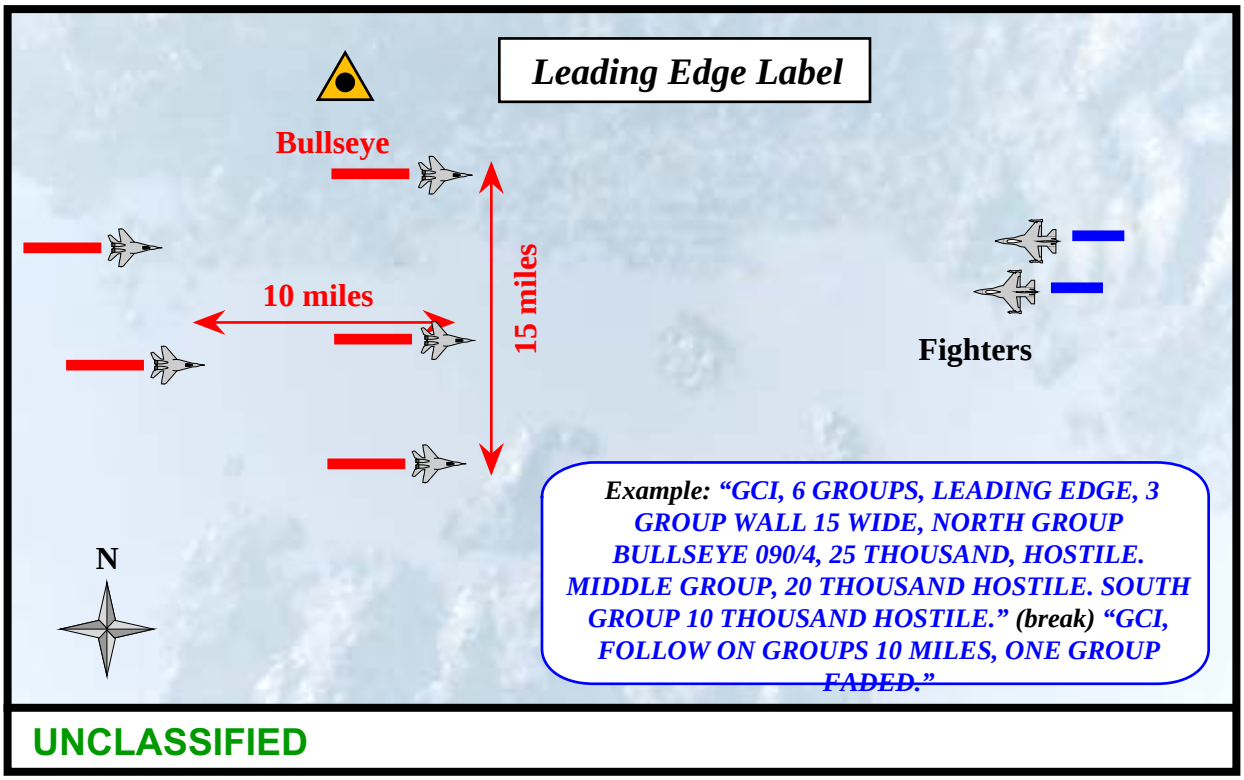
- "DARKSTAR, POP-UP GROUP BULLSEYE 270/15, 5 THOUSAND, BOGEY, HOSS 1, 22 MILES."

A1.6.15.2 If the previously undetected/unreported group meets threat criteria, it will be called a "pop-up threat" with BRAA from the closest fighter.

- "RAMBO 2, POP-UP THREAT BRAA 270/13, ALTITUDE UNKNOWN, BOGEY."

A1.6.16 Leading Edge Label. If all groups cannot be included using a traditional label or label with an additional group, but the groups closest to the fighters meet labeling criteria, the ABM/WD will voice the total number of groups, label, and anchor only the leading edge. The ABM/WD will then provide the range back (not slant range) to the remaining groups using the term "FOLLOW-ON." The term "RANGE" will not be used when referencing follow-on groups. Default leading edge will be 15 NM deep. (See **Figure A1.37**, Leading Edge Label.)

Figure A1.37 Leading Edge Label.



A1.6.17 Fighter Cold Ops. This applies when all elements are cold to the threat after executing an "out" or "abort" maneuver; all communications will comply with the briefed priorities and occur on the primary frequency.

A1.6.17.1 Unless briefed otherwise, the comm priorities are as follows:

- Spikes/threats within a stern WEZ.
- Two-ship mutual support.
- Four-ship mutual support.
- Picture.

A1.6.17.2 When all elements are cold, the ABM/WD will minimize comm. Until a picture is requested, the only comm from the ABM/WD should be responses to spikes and threat calls on either threat groups stabilized or approaching briefed A stern WEZ (altitude dependent) or previously unreported/undetected groups inside of briefed threat criteria. When cold, one fighter per element (or four-ship) will call a spike on the primary frequency if the spike cannot be correlated to a previously targeted group. As a ROT, if the adversary's range is closing and approaching a stern WEZ, the ABM/WD will add 2 NM to the briefed stern WEZ threat criteria. When a picture is requested, the ABM/WD will describe the relationship of all the groups behind the elements in accordance with the picture labeling methods described earlier. Bounding range and aspect angle labeling criteria are unchanged. Any changes to the briefed targeting or flow plan will be transmitted on the primary frequency.

A1.6.18 New Picture Comm.

A1.6.18.1 Once labels have been put on the groups, they may only be changed by use of a "NEW PICTURE" call. "NEW PICTURE" calls will not normally be made inside a briefed MTR or meld range. A new picture should be called if the picture labeling criteria discussed earlier have been met and the fighters have not closed inside of the briefed MTR or meld range. The things that can cause a new picture are as follows:

- Groups maneuver/split.
- Additional group turns hot.
- A group is destroyed.
- A previously undetected group appears (i.e., a new group).

A1.6.18.2 New picture calls should be prefaced with the words "NEW PICTURE" and then follow standard bounding and anchoring rules. If no such range is briefed, use the briefed meld/MTR as the cutoff. The ABM/WD will wait until the flight requests a "PICTURE" before giving the new picture in core information or IAW the labeled presentation format. This allows ABM/WDs to prioritize comm and control to the flight in the following priority:

- Spike ranges/threats within a stern WEZ to the element calling OUT.
- Provide the picture or bogey dope to the flight.
- Assist in gaining mutual support (as required).

A1.6.19 Untargeted Group. If any group is recognized to be (or perceived to be) untargeted inside the briefed targeting range, use "UNTARGETED GROUP" followed by core information. When the group is part of a labeled picture, use the group name, followed by "UNTARGETED," the group location off bullseye, and fill-ins.

- "CHALICE, UNTARGETED GROUP, BULLSEYE 270/15, 21 THOUSAND, HOSTILE."
- "CHALICE, NORTH GROUP UNTARGETED BULLSEYE 270/15, 20 THOUSAND, HOSTILE."

A1.6.20 Final Lock Comm.

A1.6.20.1 **Final Lock Comm Format: Bullseye.** If a fighter is sharing an unsortable group, with a fighter in visual formation then BRAA may be appropriate to resolve a "locked same" condition.

A1.6.20.2 **Locked Calls.** There are four types of locked calls:

A1.6.20.2.1 **First Type.** Fighter is on the correct group and has an inner-group sort. "EAGLE 2 SORTED WESTERN, WEST GROUP, BULLSEYE 270/5, 20 THOUSAND, HOSTILE."

A1.6.20.2.2 **Second Type.** Fighter is on the correct group but has no inner-group breakout. "EAGLE 2 LOCKED WEST GROUP BULLSEYE 270/5, 20 THOUSAND, HOSTILE."

A1.6.20.2.3 **Third Type.** Fighter does not know which group he/she is locked to or targeting is occurring without a labeled picture (i.e.,still in core information). “EAGLE 2 LOCKED GROUP BULLSEYE 270/5, 20 THOUSAND, HOSTILE.”

A1.6.20.2.4 **Fourth Type.** The second fighter to lock into a shared group has an inner-group breakout but is unsure of the first to lock’s sort. “EAGLE 1 LOCKED EASTERN WEST GROUP BULLSEYE 270/5, 20 THOUSAND, HOSTILE.”

A1.6.20.3 **“Locked Same” Resolution.** If two fighters are sharing a group, the following should be the flow of the comm to determine if fighters have a sort based on altitude/range or heading.

A1.6.20.3.1 ROTs for deciding a sorted condition are range, PRF, and aircraft (beam width) dependent and should be covered in MDS-specific standards and/or during the flight/mission/element briefing.

- First to Lock: “EAGLE 2 LOCKED LEAD GROUP BULLSEYE 270/5, 15 THOUSAND.”
- Second to Lock: “EAGLE 1 LOCKED SAME HEADING 180.”
- First to Lock: “EAGLE 2 SORTED HEADING 240” or “EAGLE 2 SAME.”

A1.6.20.3.2 In this case, the flight lead will normally be directive as to who holds or breaks lock unless it is briefed otherwise.

A1.6.20.4 **Comparative Comm Techniques.**

A1.6.20.4.1 If a fighter calls “locked” to a group but does not attach a name, ABM/WDs will respond by attempting to provide the name of the locked group and any available fill-ins.

- “EAGLE 1, LOCKED GROUP BULLSEYE 250/35, 29 THOUSAND.” ABM/WD’s call would be: “EAGLE 1 LOCKED NORTH GROUP, BOGEY, HEAVY, THREE CONTACTS.”

A1.6.20.4.2 If a fighter calls locked with an incorrect group name, the ABM/WD will respond with the correct group name, then provide a point out to the correct targeting responsibility.

A1.6.21 Clean Comm. Clean at meld/targeting range. If a fighter calls “clean” on his/her targeting responsibility, the element leader has first priority to provide SA to the fighter. If no fighter response is provided, the ABM/WD will point out the appropriate target per the briefed targeting plan (or respond with CLEAN or FADED).

A1.6.22 Engaged Comm. When an aircraft calls engaged, it is maneuvering WVR. The call should anchor the group engaged by the fighter to bullseye to allow appropriate deconfliction and increase the overall SA of other package aircraft. For example, “VIPER 1, ENGAGED SOUTH GROUP, BULLSEYE 180/20, 25 THOUSAND, BOGEY.”

A1.6.23 Threat Calls. When aircraft position is known, threat information will be provided to a specific aircraft either in BRAA or cardinal/sub-cardinal direction (if threat group is within 5 NM), followed by range, ID, and group name (if picture label has been applied) to untargeted groups meeting specified threat criteria. Hot aspect is assumed for all threat calls,

unless an aspect is provided. Threat information called in a BRAA format will include "BRAA" in the transmission.

- "COBRA 1, THREAT BRAA 340/14, 15 THOUSAND, HOSTILE, EAST GROUP."

A1.6.23.1 If exact fighter location is not known, threat information may be provided using a bullseye reference, but the word "bullseye" will immediately follow the word "threat." If a specific fighter receives a "threat bullseye…" call, the fighter should respond with call sign and posit so the threat call can be upgraded to BRAA.

- "COBRA 1, THREAT BULLSEYE 295/26, 20 THOUSAND, HOSTILE."
- "COBRA 1 IS BULLSEYE 280/10, 5 THOUSAND."
- "COBRA 1 THREAT BRAA 260/15, 20 THOUSAND HOSTILE."

A1.6.23.2 When a group meets "any aspect" criteria, the ABM/WD will provide an aspect with the threat call to prevent aircrews from making significant changes to intercept options/engagement decisions.

- (Versus a long radar threat) "RAMBO 1, THREAT BRAA 260/10, 20 THOUSAND, HOSTILE, DRAG [or "TRACK _____]."

A1.6.23.3 Standard Threat Criteria.

- Heat threat—10 NM hot aspect; 5 NM any aspect.
- Short radar threat—15 NM hot aspect; 10 NM any aspect.
- Long radar threat—20 NM hot aspect; 15 NM any aspect.

NOTE: When an F-16 is in position to employ ordnance on a threat, the ABM/WD will also provide the bullseye position of the threat group in the same threat call.

- "SNAKE 1, THREAT BRAA 090/10, 20 THOUSAND, BULLSEYE 100/15, HOSTILE"

A1.6.24 BOGEY DOPE. In the postmerge environment, if the fighter is within a pre-briefed radar blind zone, the fighter will preface all BOGEY DOPE or SPIKE calls with bullseye position and altitude.

- "BARNYARD, RAMBO 1, BULLSEYE 110/22, ANGELS 5, WESTBOUND, BOGEY DOPE SOUTH GROUP"

A1.6.24.1 The ABM/WD will respond with a BRAA formatted call from the requesting fighter's position to the requested group or nearest HOSTILE, BANDIT, or BOGEY aircraft. If a specific fighter requests BOGEY DOPE to a group and the fighter's location is not known or is not given as part of the BOGEY DOPE request, the ABM/WD will request the fighter's position ("posit"). Posit responses will be in digital bullseye or in pre-coordinated GEOREFs.

A1.6.25 ABM/WD Request for Status. When a controller requests "status" of a group, the pilot will respond with either a plain language description of the group or with one of the following descriptors: TARGETED, HUSKY, PITBULL, LOCKED, WORKING, or CLEAN

.

A1.6.26 SPIKE Comm.

A1.6.26.1 **SPIKE Responses.** If a fighter calls "SPIKED" with a magnetic bearing or with a sub-cardinal direction, the ABM/WD will attempt to correlate the SPIKE to a detected group and call the range, altitude, ID, group label (if applicable), and fill-ins.

- "RAMBO 1, SPIKED 270, (CLOSE/MEDIUM/FAR), NOTCH NORTH."
- "SNAKE 1, SPIKED WEST, NOTCH 360."
- "RAMBO 1, SPIKE RANGE 17, 30 THOUSAND, HOSTILE EAST GROUP, 2 CONTACTS."

NOTE: (1) If no azimuth or cardinal direction is provided by the fighter, no response from the ABM/WD is required. (2) If the group spiking the fighter is within threat range, the ABM/WD will respond with a standard spike response. (3) If group location is ambiguous (i.e., a group is not along that azimuth but another group is nearby), the ABM/WD will respond with "CLEAN (with azimuth or cardinal direction)" and BRAA to the nearest group to that azimuth. The bearing and range to that group will be prefaced with "THREAT" or "NEAREST GROUP" as appropriate.

- "RAMBO 1, SPIKED 240, CLOSE."
- "RAMBO 1, CLEAN 240, THREAT BRAA 280/15, 20 THOUSAND, HOSTILE, EAST GROUP, HEAVY 3 CONTACTS."

A1.6.27 Dirt/Mud/Singer Comm. These are informative calls on the primary frequency notifying all players of an active surface-to-air threat. Fighters will communicate an active surface-to-air threat with the term "DIRT X," "MUD X," or "SINGER X" followed by the estimated range to the threat (near/medium/far) and cardinal direction. When defending against a surface-to-air threat, fighters will transmit "defending (magnetic heading)" and their current bullseye position. Fighters employing HARMs will anchor "Magnum" calls with a bullseye location to the threat they are shooting.

- "RAMBO 1, MUD 6, NORTH, MEDIUM, DEFENDING 270, BULLSEYE 240/15."
- "COBRA 1, SINGER 6, SOUTH, DEFENDING 090, BULLSEYE 040/20."

A1.7 Air-to-Ground Standard.

A1.7.1 Terms and Definitions.

A1.7.1.1 **Kill Box.** A kill box is a 3-dimensional fire support coordinating measure used to facilitate the expeditious air-to-surface lethal attack of targets, which may be augmented by or integrated with surface-to-surface fires. Kill boxes should be defined using the common geographic reference system (CGRS) and may include altitude and/or weapons restrictions; however they may follow other boundaries (e.g., terrain features). Kill boxes will be further defined as blue or purple. Applicable ROE, collateral damage restrictions, and positive identification requirements must be followed and engagements must meet the commander's targeting priorities.

A1.7.1.1.1 **Blue Kill Box.** A blue kill box permits air-to-surface fires in the kill box without further coordination or deconfliction with establishing headquarters. All aircraft not assigned to the blue kill box will not enter or drop weapons through the confines of the kill box without coordination with the kill box coordinator or

appropriate C^2 agency. When reporting kill box status on the tactical frequency, blue is assumed.

A1.7.1.1.2 **Purple Kill Box.** A purple kill box permits the integration of surface-to-surface fires with air-to-surface fires into the kill box without further coordination or deconfliction with establishing headquarters. Altitude separation is the preferred method for deconflicting fires in a purple kill box and will be published in the ACO. All aircraft employing ordnance inside a purple kill box will adhere to published altitude and/or time restrictions. All aircraft not assigned to the purple kill box will not enter or drop weapons through the confines of the kill box without coordination with the kill box coordinator or appropriate C^2 agency.

A1.7.1.2 **Kill Box Terminology.** C^2 agencies will transmit the status of established kill boxes to all affected aircraft using open, closed, active, cold, or cancelled.

A1.7.1.2.1 **Established—**Term used to described a kill box that is in effect. Either planned via the joint targeting cycle or immediate during execution.

A1.7.1.2.1.1 **Open—**Term used to describe a portion of a kill box that was previously closed but now is open to fires.

A1.7.1.2.1.2 **Closed—**Term used to describe a portion or portions of an established kill box in which fires or effects of fires are not allowed without further coordination. Closed will primarily be used to restrict fires inside a previously open kill box. Aircraft assigned to an established kill box that is closed are authorized to fly inside the confines of the closed kill box.

A1.7.1.2.1.3 **Active—**An established kill box that has aircraft flying in the space defined by the kill box or other joint fires within the boundaries of the kill box. The call sign of the aircraft operating inside the kill box will be included in the transmission along with any restrictions (e.g., altitude blocks).

A1.7.1.2.1.4 **Cold.** An established kill box that is not active. All portions of the kill box are open to fires unless identified as closed. Kill box is assumed Cold and will only be transmitted by C^2 agencies on previously active kill boxes.

A1.7.1.2.2 **Cancelled.** The kill box is no longer in effect.

A1.7.1.3 **Kill Box Coordination and Deconfliction.** Kill box coordination is required when multiple flights are operating within the same kill box. If possible, a FAC (A) or SCAR-trained flight will perform kill box coordinator duties. If a FAC (A) or SCAR asset is not available, the first flight to enter a given kill box will be responsible for kill box deconfliction.

A1.7.1.4 **Air-to-Surface Tasking.** INVESTIGATE, TARGET, or SMACK will preface all dynamic air-to-surface tasking not covered by JP 3-09.3. Investigate, target, and smack are directive and imply different levels of ROE fulfillment.

A1.7.1.5 **Investigate—**Directive to verify specified elements of ROE, PID, CDE, and/or coordination of forces on the referenced target/track. Aircrew may employ ordnance/fires

provided all elements of ROE (which should include PID, commander's, and commanders's guidance at a minimum) are fulfilled.

A1.7.1.6 **Target—**ROE, PID, coordination of forces, and commander's guidance requirements on the referenced target/track have been satisfied. Target/track association or correlation and CDE must be accomplished prior to employing ordnance/fires.

A1.7.1.7 **Smack—**Clearance to employ ordnance/fires on surface target coordinates. ROE, PID, CDE, coordination of forces, and commander's guidance requirements on the referenced target/track have been satisfied and coordinate accuracy is sufficient for GPS weapon employment.

A1.7.2 Tasking Communications. Air-to-surface tasking is prefaced with the mission type, bullseye location, and track number. Taskings will be passed using the modified J-Fire 9-Line format (lines 4, 5, 6, and remarks). Line 4, target elevation, will be measured in feet (MSL). Line 5, target description, and Line 6, target location, will be passed using WGS-84 lat/long decimal minutes format unless otherwise briefed. Remarks will include enhanced target description, restrictions, and unbriefed threats in the target area as appropriate. Read back requirements include tasking type, Lines 4 and 6, and restrictions.

- "SNAKE 31, NIGHTSTAR, TARGET BULLSEYE 150/10, TN 12421, CALL READY DETAILS."
- "SNAKE 31, READY DETAILS."
- "SNAKE 31, NIGHTSTAR, TARGET 6210 FEET, SCUD TEL, N 3734.153 W 11630.221, CATEGORY 2, CALL READY REMARKS."
- "SNAKE 31, READY REMARKS."
- "SNAKE 31, SCUD TEL NORTH SIDE OF GOLD MOUNTAIN ROAD, NO CBU."
- "SNAKE 31, TARGET 6210 FEET, N 3734.153 W 11630.221, NO CBU."

A1.7.3 Time over Target/Battle Damage Assessment. As soon as information is practical and available, tasked aircraft will provide C^2 agency with estimated time over target and ingress and egress track direction. Once the target is engaged and aircraft are outside of the threat, initial battle damage assessment will be passed to C^2 agencies who will relay this information to the CAOC and all other pertinent players. C^2 agency will pass the call sign of the attacking flight, the track number of the target, ID, BULLSEYE location, TOT, and attack heading. BDA format will be IAW JCAS in-flight report guidelines.

- "CHALICE, SNAKE 01 TARGETING, TRACK 22401, SA-3 BULLSEYE 180/15, MED, TWELVE-TWENTY, ATTACK HEADING 240, EGRESS HEADING 150."

A1.8 Surface Threat Passage

A1.8.1 SITREP. SIGINT, IMINT, and MTI information on surface emitters is passed on the voice product net (VPN). The SITREP will be passed 5 minutes prior to the package lowdown. Emitters will be passed using the following priority: (1) active threats, (2) previously active threats, and (3) EW/GCI radars. Emitters will be passed using system type, digital bullseye location, and operating frequency.

A1.8.2 Lowdown. Lowdown is a request to provide tactical ground information pertinent to the mission in digital bullseye format. The lowdown will be prefaced with "LOWDOWN" and passed at pre-briefed times, upon initial check-in for those aircraft not airborne during pre-briefed lowdown, and upon request. The lowdown will include, in priority order: (1) previously unlocated or unreported active strategic SAMs, (2) all active tactical SAMs, and (3) previously active SAMs. The mission commander should determine priorities within each of these categories. Additional information (e.g., movers, rotators, and IMINT reports) can be added based on mission requirements. Prior to the fragged lowdown, pilots may request any updates from tactical C^2 and/or SIGINT ID authority (SIA) on the frequency established during mission planning. The SIA is responsible for maintaining accuracy of the common tactical picture based on emitter/ROTATOR information as well as resolving any emitter ID ambiguities.

A1.8.3 Combat Advisory Broadcast. Active surface-to-air threat emitters are passed on the tactical frequency using pre-briefed labels or digital bullseye format. C^2 agencies will relay threat information received from VPN to the strike frequency.

- "BARNYARD, ROLAND ACTIVE BULLSEYE 205/13."
- "BARNYARD, NORTH SA-2 ACTIVE."

A1.8.4 Imminent Threat Warning (ITW). ITW is a surface-to-air threat warning from a C^2ISR platform to a friendly asset. ITW will be passed when a friendly aircraft is within 5 NM of the briefed, maximum effective range of any active threat. ITW will be prefaced with the aircraft call sign or the bullseye position of the friendly aircraft and use pre-briefed labels or digital bullseye format for description of the threat. If a fighter has reported MUD, DEFENDING, or SINGER to a specified threat, no ITW is required to that threat.

- "HOG 1, SA-8 ACTIVE BULLSEYE 015/9."
- "AIRCRAFT BULLSEYE 020/15, SA-8 ACTIVE, BRAA 180/10."

A1.8.5 TACREP. Tactical reports are given on VPN indicating the collection of tactical intelligence. TACREPs will be assigned an alphanumeric designator indicating the type of activity and serialization. (Alphanumeric designators are IAW **Table A1.13**, TACREP Alphanumeric Designators.)

- "AGENT, TACREP E-04, SA-6 TARGET ACQUISITION ACTIVE, BULLSEYE 235/18, FREQ. XXXXX, TRACK NUMBER 13207."

Table A1.13 TACREP Alphanumeric Designators.

Alphanumeric	INT
A-##	COMINT (air activity)
E-##	ELINT
G-##	COMINT (ground activity)
H-##	HUMINT
I-##	IMINT or non-imaging IR
J-##	Radar MTI
R-##	CAOC

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