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BY ORDER OF THE SECRETARY OF THE AIR FORCE

19 October 2004

AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-3.18

COMBAT AIRCRAFT FUNDAMENTALS

F-117 (U)

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BY ORDER OF THE SECRETARY OF THE AIR FORCE	***AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-3.18***
	21 December 2004
	Tactical Doctrine
	COMBAT AIRCRAFT FUNDAMENTALS—F117

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PURPOSE: The Air Force Tactics, Techniques, and Procedures (AFTTP) 3-3 series publications are the primary aircraft fundamental reference document for the USAF. 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. All echelons of the USAF are challenged to build and expand on these fundamentals.

APPLICATION: This publication applies to all active duty, Air Force Reserve, and Air National Guard personnel. The doctrine in this document is authoritative but not directive. This publication applies when published in ANGIND2 for Air National Guard and AFRESIND2 for United States Air Force Reserve.

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. AFTTP 3-3 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.

SERIES: The series of AFTTP 3-3 volumes includes the following:

Volume 3	*Combat Aircraft Fundamentals—A/OA-10*
Volume 4	*Combat Aircraft Fundamentals—F-15A/B/C/D*
Volume 5	*Combat Aircraft Fundamentals—F-16C/D*
Volume 18	*Combat Aircraft Fundamentals—F-117*
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CHAPTER 1

INTRODUCTION

1.1 Overview. Aerial warfare is still a relatively new form of combat, spanning a period of only 90 years. During that time, rapid technological developments have spurred progress from very primitive weapons systems to the inclusion of stealth into modern fighters. The unmatched precision and low observable (LO) characteristics of the F-117 are primarily the result of these recent advancements. Nevertheless, the basic principles of aerial combat have remained virtually unchanged. These fundamentals or standards form the foundation of training for tactical employment. This document provides guidance to these fundamentals as they apply to employment of the F-117 weapons system.

1.2 Purpose. This manual supplements both formal and continuation training (CT) programs and, with AFTTP 3-1, provides aircrew the information needed to make the right decisions during any phase of a tactical mission. AFTTP 3-3 provides no authority or sanctions to depart from established training procedures and directives; nor is it directive in nature.

1.3 Change Procedures. Aircraft modification, operational and training experience dictate changes to this volume. Old procedures and tactics are never disregarded simply because they have been around for a while. At the same time, new and better ways of accomplishing the mission evolve and need to be incorporated into this volume. Safety of flight changes are incorporated as soon as possible. Other inputs are included during the biannual update cycle. Suggested changes are to be forwarded from any level of command to: Headquarters (HQ) ACC/DOT, 205 Dodd Blvd, Suite 101, Langley AFB, Virginia 23665-2789.

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CHAPTER 2

MISSION PREPARATION

2.1 Introduction. Mission preparation is a key to success in training and combat. The success of all that follows (e.g., briefing, execution, and debriefing) is directly related to the amount and quality of preparation. First, determine mission objectives in terms of the desired improvement in measurable combat capability and related basic aircrew skills. Second, prepare yourself for the mission. Finally, decide how to brief and execute the mission. This chapter addresses several planning considerations.

2.2 Establishing Priorities and Situational Awareness.

2.2.1 General. Task prioritization during the heat of the mission is paramount. There are occasions when not all tasks can be done at once; prioritizing the tasks is required to ensure mission accomplishment.

2.2.2 Fundamental Tasks. Know the following fundamental tasks:

- Maintain aircraft control.
- Do not hit the ground or anything attached to it.
- Do not hit anything in the air (e.g., lead or wingman).
- Do not run out of fuel.
- Do not let anything shot from the ground or air hit the aircraft.

2.2.3 Changes in Priorities. There may be shifts in fundamental task priorities, but they are never completely removed. For example, at 20,000 feet in close formation in the weather, avoiding a midair collision is a bigger concern than hitting the ground.

2.2.4 Mission Accomplishment. This task has a high priority; however, in peacetime there is no mission more important than safe recovery of the flight. The aircrew cannot afford to exceed personal limits in the desire for mission accomplishment. Aircrew limits vary from day-to-day, based on psychological and physical preparation.

2.3 Mental and Physical Considerations. A fighter mission demands total involvement, whether it is actual combat or continuation training (CT). This means being mentally and physically prepared for the mission. Mental preparation requires setting aside outside stresses to allow for total concentration on the mission. Physical preparation means conditioning the body for the extraordinary demands of aerial combat and adopting a healthy lifestyle. ***This is an attitude***. The fighter pilot's attitude is a proper blend of pride, desire, aggressiveness, and knowledge.

2.3.1 G-Induced Loss of Consciousness. USAF fighter aircraft can currently exceed pilot tolerance for sustained high gravitational load factors (G). This capability often allows pilots to apply more Gs than their bodies can tolerate; after a "short grace period," oxygen available to the brain is depleted and consciousness is lost. Pilots must anticipate G onset, control the G onset rate, and coordinate their G straining maneuver. This takes physical preparedness, mental discipline, and practice to master. Failure to do so could spell disaster. G-induced loss of consciousness (GLOC) has two serious traits. First, it is more dangerous than other pilot stresses because it is not possible for pilots to accurately and reliably know how close they are to the GLOC threshold. Second, since amnesia (of the incident) is a characteristic of GLOC, a pilot may not remember a loss of consciousness and, therefore, may not be cognizant of any "close calls" the pilot was lucky enough to have survived. The best solution to the GLOC problem is pilot awareness. The pilot has ultimate control over G stress factors. The F-117 is potentially more dangerous than other aircraft as far as Gs are concerned. In most fighter aircraft, pilots expect to pull Gs commensurate with aircraft performance. In the F-117, pilots normally do not expect to pull more than 3 Gs. This sets up the potential for GLOC if sudden abrupt maneuvers are made far exceeding the pilot's expectation of Gs during a sortie. Pilots must always use caution when applying Gs to the aircraft.

2.3.2 Mental Considerations. Layoffs such as a long leave, duties not including flying (DNIF), or even just coming out of a low G flying phase can have an impact on the pilot's mental preparedness and requires a build-up of mission tasking 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 bodily warning signs of fatigue and stress. Pilots need to be aware of these factors and be on guard for signs of stress limits. An individual's tolerance and warning signs can vary significantly from day-to-day. The following can help pilots stay mentally fit for the mission.

2.3.2.1 **Avoiding Unnecessary Risk.** Identify high-stress situations and maneuvers in the briefing for each mission and the proper techniques for avoiding or mitigating risk.

2.3.2.2 **Flight Lead Considerations.** Flight leads should exercise strong control and monitor the flight members. Consider coming home early if any flight member demonstrates fatigue.

2.3.3 Physical Considerations. The fighter crew member on a good diet, with proper physical conditioning, and adequate rest is physically prepared to meet demanding mission tasks. There is a negatively synergistic effect when more than one of these factors is below standard. Proper physical conditioning involving anaerobic training (e.g., free weights, Nautilus, Universal Gym, and Hydra-Fitness) and aerobic training (e.g., running, racquetball, and cycling) play an important role in improved mission success. Proper mission planning begins with good physical preparedness.

2.4 Misprioritization and Basic Situational Awareness. Misprioritization during any mission will result in channelized attention and can have disastrous results. By professionally preparing for each mission and defining objectives accounting for the lowest common denominator, you can delay or deny task saturation factors. Each member of the team must mentally fly the mission before strapping on the jet (chair fly/hangar fly). Search for situations that are most critical and mentally address what would happen in the cockpit: instrument cross-check, change switches, conduct visual search, audibilize a "surprise," have an emergency. Stress basic situational awareness (SA). Fighter pilots are not born with it; it must be developed and kept "current."

2.5 Objectives.

2.5.1 Mission Objectives. Mission objectives should be the basis for mission preparation. The mission objectives give the "big picture" of what is happening. Examples of mission objectives are "Destroy the assigned targets on time, with no losses." The specific or "training" objectives are performance statements used to measure individual and team success during the mission.

2.5.2 Training Objective Components. A valid objective has three parts: performance, conditions, and standards. They must be measurable and achievable.

2.5.2.1 **Performance.** This is what each pilot or the flight does during the mission. It describes action and is not vague. Use action verbs such as: employ, practice, negate, etc.

2.5.2.2 **Conditions.** These are starting parameters such as "with no GPS" or "on a controlled range with BDU-33 practice ordnance."

2.5.2.3 **Standards.** They state how well the task must be performed, and is categorized by time limits, accuracy, and quality (e.g., "meeting valid attack criteria" or "tracking within 1 mil").

2.5.3 Defined Objectives. Define objectives with contingencies and other planning considerations such as weather, sun position, day or night, the threat, or the air tasking order (ATO) in mind. Well-defined objectives are based on the mission requirements and the particular mission's most limiting factor (e.g., weather, wingman experience, and so forth). Clear objectives limit the impact of distractions and focus attention on mission accomplishment.

2.6 Mission Preparation. From a basic student upgrade sortie to a complex combat scenario, the success of any F-117 mission demands thorough preparation. This preparation consists of two phases: mission planning and mission briefing. Incomplete preparation in either area degrades mission accomplishment.

2.6.1 Mission Planning Accomplishment. 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. All flight members, as well as intelligence, targeteers and weather, should be involved in the mission preparation. 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. There are many factors which must be considered to ensure preparation is thorough.

2.6.1.1 **Main Factors.** Two main factors which determine the direction of mission preparation are the role of the F-117 for the particular mission (e.g., deep strike, interdiction, time-sensitive targeting [TST]) and the overall mission objective (e.g., student training, syllabus objectives, CT, visual bombing, or combat target destruction).

2.6.1.2 **Additional Factors.** Additional factors which must be addressed during mission preparation, depending on the role and overall objective, include:

- Flight size.
- Experience level of flight members.

- Higher headquarters (HQ) guidance—syllabus, air force instructions (AFI), and ATO (frag).
- Support assets.
- Controlling agencies.
- Communications.
- Fuel considerations and refueling.
- Rules of engagement (ROE)/Special instructions (SPINS).
- Target.
- Routing.
- Threats.
- Weather.
- Aircraft stores configuration.
- Weapons delivery options.

2.6.2 Briefing.

2.6.2.1 **Mission Briefing.** The briefing sets the tone for the entire mission. Establish goals and have a plan to accomplish them. Write the mission objectives on the board. Outline the standard that measures successful performance.

2.6.2.2 **Standard Briefing Items.** Cover start, taxi, takeoff, recovery, and relevant special subjects in an efficient manner. Elements of the mission which are standard are briefed as "Standard." Spend most of the time describing the "what" and "how to" of the mission.

2.6.2.3 **Mission Support Briefs.** If support assets, friendly players, intelligence (Intel), or other mission personnel are present, brief them first on the pertinent information and the mission. However, ground-controlled intercept (GCI)/airborne warning and control system (AWACS) controllers need to receive the entire tactical briefing. Alternate missions will be less complex but also have specific objectives.

2.6.2.4 **Briefing Technique.** The flight lead needs to be dynamic and enthusiastic. He motivates and challenges the flight to perform to planned expectations, asking questions to involve flight members and determine briefing effectiveness. If other flight members are involved in the briefing process, keep the number of speakers to a minimum to avoid duplication or contradiction of information and to control brevity.

2.7 Mission Execution.

2.7.1 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 member of the team. Once airborne, they have 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.

2.7.2 Wingman Responsibilities. Wingmen have the supporting role in the flight. They help the leader plan and organize the mission. They have visual lookout and deconfliction responsibilities, perform back-up navigation tasks, and are essential to target destruction objectives in a surface attack role. It is essential wingmen understand their briefed responsibilities and execute their contract in a disciplined manner.

2.7.3 Flight Discipline. Discipline is perhaps the most important element for success in any aspect of aerial combat. On an individual basis, it consists of self-control, maturity, and judgment in a high-stress, emotionally charged environment. Teamwork is an integral part of discipline; individuals evaluate their own actions and how they affect the flight and mission accomplishment. If all flight members know their respective duties, they work together as a team. Experience and realistic training leads to solid and professional discipline in the air.

2.8 Debriefing.

2.8.1 Purpose. The objective of the debrief is twofold. First, was the mission accomplished? If not, then find out why not, and determine if it needs to be repeated. Second, were the mission objectives achieved? What aspects of the mission (good and bad) can be used as learning points to improve mission accomplishment?

2.8.2 Preparation. Reconstruction of the mission objectives occupies much of the debriefing. Before the debriefing, use everything available (e.g., videotape recorder [VTR], notes, and range scores) to reconstruct the mission and develop the evaluation. Preparation before the debrief with flight members and support assets provides for a well-controlled, effective debriefing. An honest assessment of accomplishments is more important than "winning the debrief." Be alert for training rule violations and fix any deviations to regulations or safety immediately.

2.8.3 Debriefing Techniques.

2.8.3.1 **General.** Get the small items (administrative details) out of the way first. 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. Begin any debriefing discussion by first deciding if the mission objective was met. If not, the primary focus should be on finding out "why" and then discovering the reason. Lessons learned and points to ponder should be passed on to other flights or could be used to update tactics in the future.

2.8.3.2 **Complex Missions.** Some missions do not lend themselves to detailed reconstruction. Choose only the significant events that impacted the objectives of the ride. The final summary includes an assessment of strong and weak points and the required corrections.

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CHAPTER 3

FORMATION

3.1 General Tasks.

3.1.1 Introduction. Formation discipline is essential for the safe and efficient employment of the F-117. During combat operations, formation may be required to coordinate offensive weapons effects, mutual support, and survivability. The integrity of a formation is maintained only when the leader has complete knowledge and control of the actions of each flight member. The flight leader briefs the formations to be flown and formation responsibilities. Wingmen maintain assigned formation position until a change is ordered or approved by the Flight Lead.

3.1.2 Communication. Discipline within a formation is immediately evident in its communications, whether by radio or visual signals. Regardless of the method, all communications must be clearly understood by every flight member. Radio discipline requires not only clarity and brevity in the message itself, but limiting unnecessary transmissions as well.

3.1.2.1 **Call Sign Usage.** Always use the complete assigned call sign for flight transmissions. Radio calls are prefaced by the flight call sign to alert wingmen that a message is directed to the flight. Wingmen acknowledge all radio calls unless briefed otherwise, with their position number ("STEALTH 2," "STEALTH 3," or "STEALTH 4"). Reliance on voice recognition or inflection to identify other aircraft is a poor peacetime practice and intolerable in combat. In exercises or combat, situational awareness (SA) is the key to success, and disciplined call sign use is required. Poor radio discipline quickly degrades SA.

3.1.2.2 **Visual Signals.** To keep radio transmissions to a minimum, use visual signals during the daytime whenever practical. Unless the flight leader specifically briefs nonstandard or unit specific signals, use only standard AFI 11-205, *Aircraft Cockpit and Formation Signals*.

3.1.3 Lead Changes.

3.1.3.1 **Transfer of Role.** Lead changes require a clear transfer of roles and deconfliction responsibilities from one flight member to another. Lead changes are initiated and acknowledged with either a radio call or visual signal. Obtain visual contact with the new lead before initiating a lead change. The lead change is effective upon acknowledgement. All flight members continue to ensure aircraft separation during position changes. The new leader continues to monitor the new wingman's position.

3.1.3.2 **Lead Change Acknowledgement.** If using the radio to initiate or acknowledge the lead change, use call signs and be specific. An example is: "STEALTH 2, TAKE THE LEAD ON THE LEFT." The acknowledgement is: "STEALTH 2 HAS THE LEAD ON THE LEFT." Lead changes using visual signals may be preferred during the daytime.

3.2 Basic Formation.

3.2.1 Ground Operations. The leader will brief the flight procedures, but taxi will normally be 20 minutes prior to takeoff, rather than 15, to ensure the two-ship can get through quick-check in time.

3.2.2 Runway Lineup. The flight lead will determine which side of the runway to take after considering departure route, wind direction, runway conditions, and runway width.

3.2.2.1 **Two-Ship Lineup.** Flight lead will normally take the middle of the assigned side of the runway. Number Two pulls forward to align the gear of lead. Usually 10 feet between wingtips is sufficient. A technique to ensure wingtip spacing is for Number Two to take the center of the assigned side of the runway (depending on runway width). (See **Figure 3.1**, Two-Ship Runway Lineup.)

3.2.2.2 **Three-Ship Lineup.** Flight lead will line up near the edge of the side of the runway. Number Two pulls forward on the runway centerline to align the gear of lead. Number Three lines up towards the edge of the assigned side of the runway, aligned on the gear of Number Two. All aircraft should have a minimum of 10-foot wingtip spacing. (See **Figure 3.2**, Three-Ship Runway Lineup.)

3.2.2.3 **Four-Ship Lineup.** During daytime operations only, the Flight lead will line up 500 feet down on the appropriate side near the edge of the runway. Number Two lines up with the wingtip on the centerline on the opposite side of the runway. Number Three lines up with a wingtip on the centerline lined up centered behind Numbers One and Two. Number Four lines up near the edge of the opposite side of the runway, lining up Number Three's gear. (See **Figure 3.3**, Four-Ship Runway Lineup.)

3.2.3 Engine Run-Up. During daytime, the wingman will turn on the landing light when cleared for takeoff. For two-ships lead will signify engine run-up by visual signal and the wingman will respond with a head nod when ready. At night, for two-ship flights the wingman will turn off the taxi light to signify readiness for engine run-up. When lead turns on his landing light the wingman then performs the run-up checks and signifies ready for takeoff by turning the landing light on. For four-ship flights, Number Three calls ready when Number Four signals ready through a head nod or taxi light off. Lead will signal run-up by radio call or landing light on at night.

3.2.4 Trail Departure. The purpose of a trail departure is to get a flight of two or more aircraft airborne when conditions do not permit a visual formation Rejoin out of traffic. Wet runways, crosswind limits, stores configuration differences, low ceilings, or poor visibility are normally the deciding factors. The flight lead's responsibility is to fly the published departure as briefed. The wingman's overriding priority is to maintain aircraft control. The pilot should concentrate on instrument flying during the departure.

Figure 3.1 Two-Ship Runway Lineup.

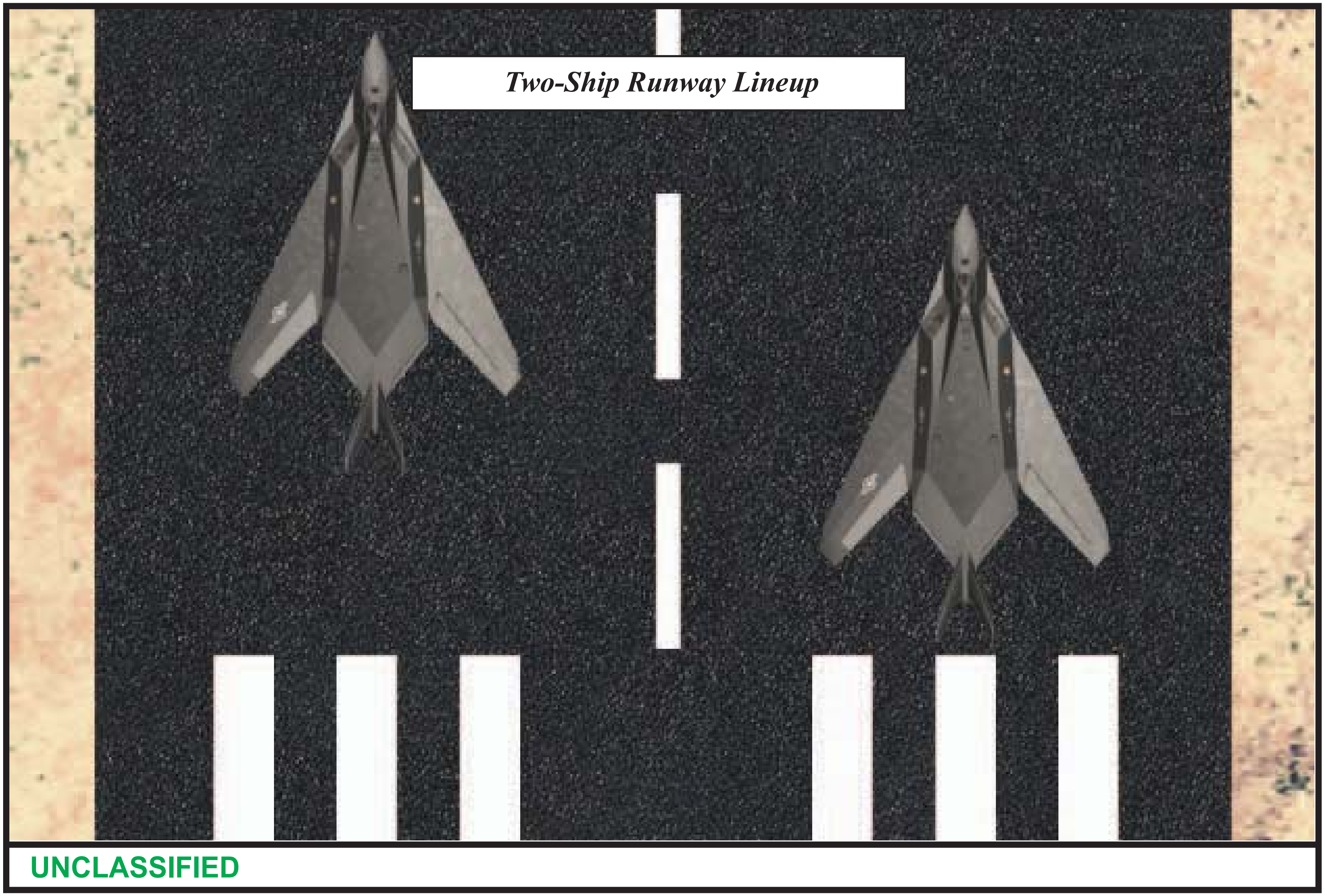


Figure 3.2 Three-Ship Runway Lineup.

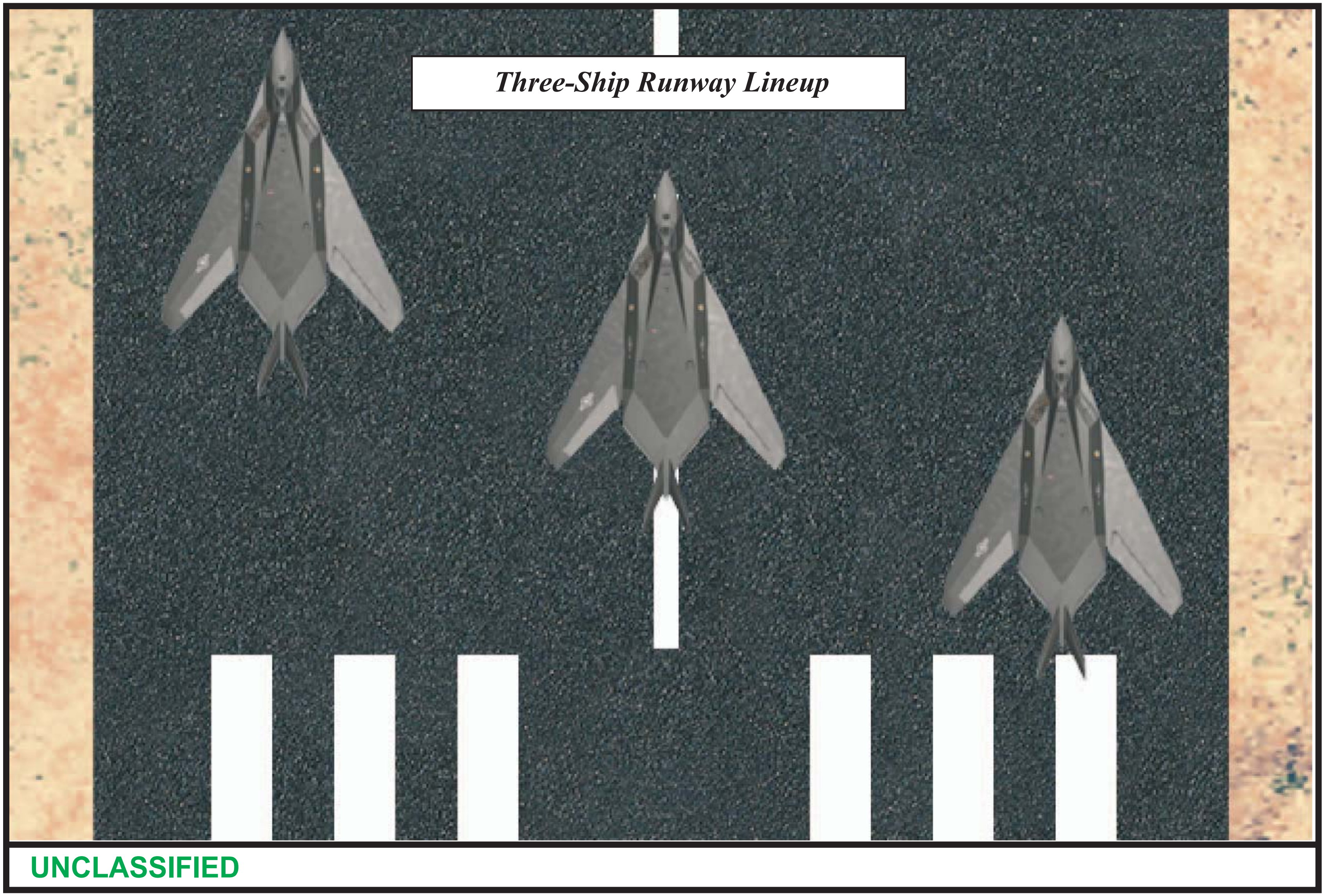
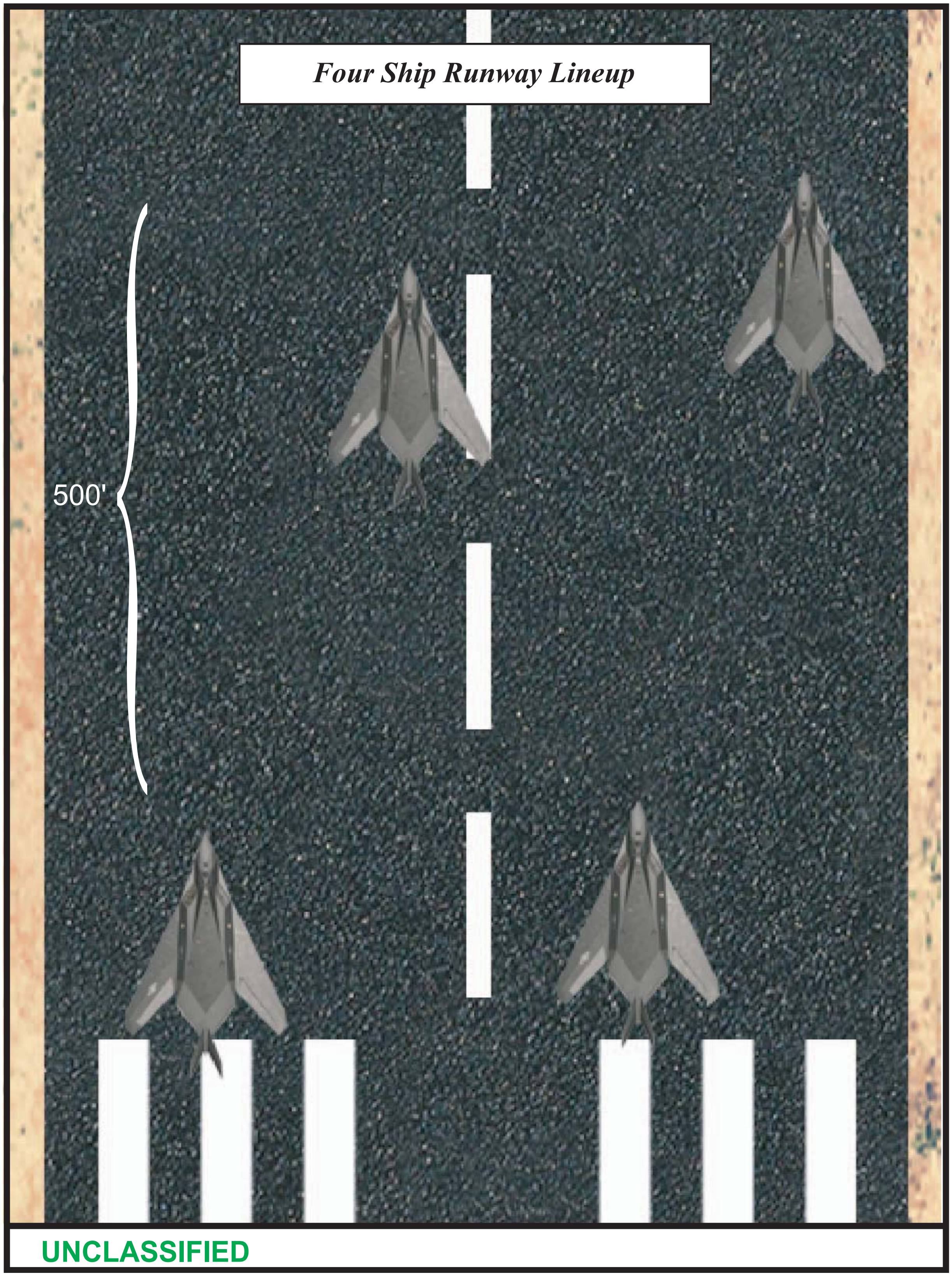


Figure 3.3 Four-Ship Runway Lineup.



3.2.4.1 **Before Takeoff.**

3.2.4.1.1 **Review the Departure.** As a technique, set the FLIR in SRCH, WFOV and slew the infrared acquisition and detection system (IRADS) cursor to approximately 3 degrees above the horizon. This will assist in eyeballing Lead (and/or Number Two) when safely airborne and climbing on the departure. Have the departure plate out and the navigation displays set up properly prior to takeoff.

3.2.4.1.2 **Clearance.** All flight members should listen carefully to the clearance and controlling agencies for nonstandard or unpublished restrictions.

3.2.4.2 **After Takeoff.**

3.2.4.2.1 **FLIR Assist.** With SRCH and WFOV selected, Lead (and/or Number Two) will normally show up in the center of the screen. After establishing a safe climb rate, adjust as required for additional SA. (See **Figure 3.4**, FLIR Assisted Trail Departure.)

3.2.4.2.2 **Fly the Departure.** Do not sacrifice aircraft control and basic instrument procedures while flying the departure. Proper execution of the departure procedure will ensure proper separation throughout the procedure. Flight leads will call out any unbriefed changes. Accelerate to the briefed climb airspeed, then climb out at the pre-briefed power setting, normally military power. Do not accelerate to closing airspeed until leveled off, unless otherwise briefed.

3.2.4.2.3 **Maintaining Track.** During constant heading segments of the standard instrument departure, use small heading changes to maintain track behind Lead. Wingmen may offset the preceding aircraft slightly to avoid jet wash. Strong crosswinds may cause the aircraft in front to be offset from the expected no-wind position.

3.2.4.2.4 **Turns.** Anticipate Lead's turns on the situation display (SID). To maintain trail in turns, the rule of thumb is for 30 degrees of bank; delay the turn 10 seconds for each mile in trail.

3.2.4.2.5 **Spacing.** To maintain the briefed spacing, comply with the SID routing and restrictions. Power and airspeed can be used, but is the least desirable means of maintaining spacing because of the accordion effect on Number Three.

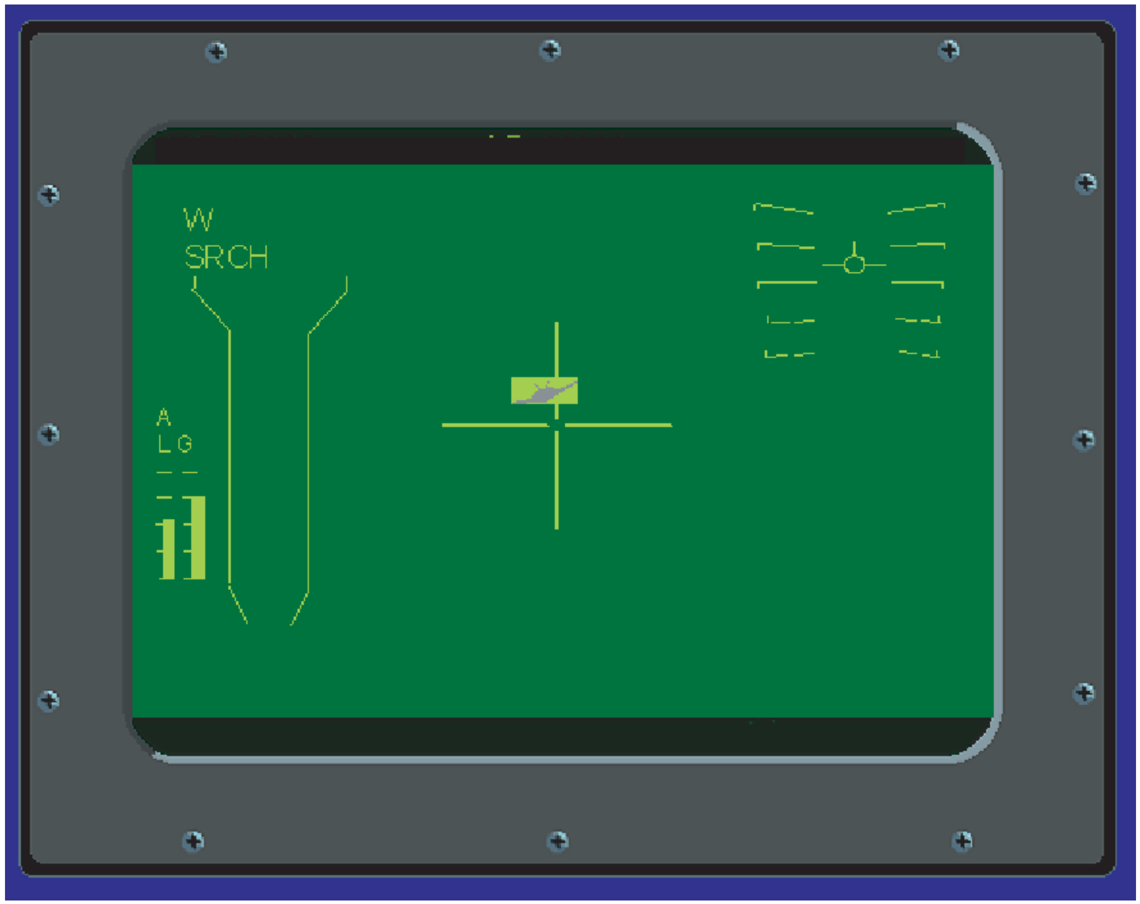
3.2.4.2.6 **Altitude.** Fly the SID precisely and maintain appropriate altitude separation Make all appropriate SID turns, level-offs, and course changes. Fly precise instruments, maintain airspeed, follow the SID, and there will not be a conflict. Even without a FLIR eyeball, lead should be within a few degrees and 2 to 3 NM of the nose when breaking out on top of the clouds.

3.2.4.2.7 **Errors.** The most common cause of error during the trail departure is not flying the SID.

3.2.5 Climb Out. Both aircraft climb at 300 KCAS in mil power. Using 30 degrees of bank, fly the published DP or the ATC departure clearance. Maintain the navigational routing to the first steer point. TACAN air-to-air in the "X" or "Y" channel (as briefed) is used to set the flight spacing at 1 NM trail or as briefed. The wingman should initially level off 1,000 feet below the leader, then close to the briefed position for station-keeping. Ensure the altimeter is set at 29.92, passing FL180.

Figure 3.4 FLIR Assisted Trail Departure Setup.

FLIR Assisted Trail Departure



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3.3 Basic Formations.

3.3.1 Fingertip Formation. When flying Close Formation with another F-117, align the tip of the lead aircraft's wing with the midpoint of the engine exhaust (fore and aft) and align the aft tips of the vertical stabilizers (in and out). Another set of references for fore and aft is setting the wingtip light (position light) at the intersection of the fins and the fuselage. A small portion of the inlet grid should be visible. Roll outs from turns require more forward stick pressure than most aircraft. The wingman will stack just low enough to see the wingtip position light on the underside of the wing. (See **Figure 3.5**, Fingertip [Close] Position.)

3.3.2 Route Formation. Route is an extension (up to 500 feet) of the Close Formation references. The wingtip light in the intersection of the fin and fuselage is probably easiest to see from farther distances. The position allows wingmen to comfortably check cockpit instruments, provide visual lookout and still be close enough to move into Close Formation if weather or other circumstances dictate. During turns, the element or aircraft turned into stacks down only as necessary to keep Lead in sight and stay below Lead's plane of maneuver. When turned away, the element or wingman executes an Echelon Turn. (See **paragraph 3.3.6**, Echelon.) Crossunders may be directed as in Close Formation using a wing flash.

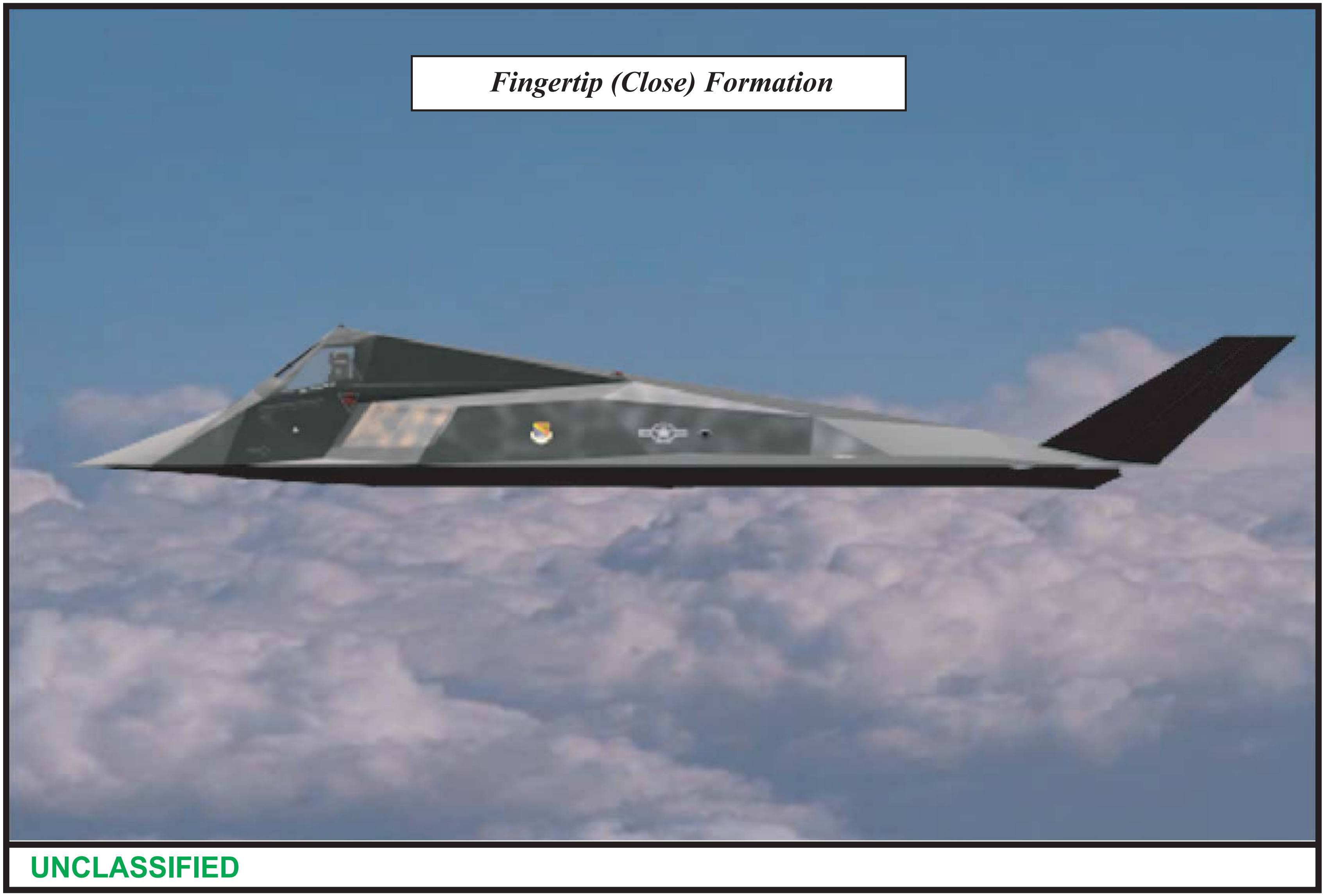
3.3.3 Day Three-Ship Close/Route Formation. Under instrument meteorological conditions (IMC), Lead should not exceed 30 degrees of bank. Number Two should stack slightly low while in echelon so Number Three can see through Number Two to align canopies with Lead.

3.3.4 Crossunders. The F-117 canopy structure restricts visibility during crossunders and in banks in excess of 60 degrees. During crossunders, reduce power to drift aft and low of the lead aircraft, ensuring nose/tail separation. Drop far enough aft to ensure visual contact is maintained without restriction from the canopy structure. Cross to the opposite side and move back to the original position.

3.3.5 Element Crossunders. When an element crosses under, the element drops below and behind the Lead (element) maintaining nose-tail and vertical clearance, crosses to the opposite side, then moves up into position. Number Four changes position during the crossunder when Number Three passes behind Lead. To return to Fingertip Formation, the leader makes a radio call.

3.3.6 Echelon. In Echelon Turns, maintain the same relative position as Fingertip for turns into the echelon. For turns away, the fuselage of all aircraft will be maintained in the same horizontal plane. Lead aircraft should attempt to maintain 45 degrees of bank and will not exceed 60 degrees of bank. The common tendency is to drop aft. This is due to blockage of visual references by the top of the canopy. As long as 45 degrees of bank is not exceeded, this is not a problem. Route echelon is an Echelon Formation with route spacing between aircraft.

Figure 3.5 Fingertip (Close) Position.



3.3.7 Pitchouts and Rejoins.

3.3.7.1 **Pitchouts.** During the pitchout, use 2 Gs and 60 degrees angle of bank unless lead briefs otherwise. Sight will probably be lost during the first part of the turn, so a uniform pitchout will ensure aircraft separation and make it easier to regain visual as during roll out. Ideally, lead will pitch out with approximately 350 KCAS so there is energy through the turn and roll out with 300 KCAS or better. Do not take more than five seconds spacing to avoid the increased probability of losing sight of Lead. If ever blind, let lead know immediately. With lead in sight, call "TWO'S VISUAL." Lead will give a wing rock beginning in the direction of the planned turn to direct the Rejoin. If it is straight ahead, the Rejoin will be directed on the radio.

3.3.7.2 **Turning Rejoins.** During the initial portion of the Rejoin, the wingman should maneuver to place the lead aircraft in the forward portion of the side window. After closing to within 6,000 to 8,000 feet, the wingman should then maneuver to place lead on the line for the final portion of the Rejoin. The rejoin line is defined as the vertical stabilizer halfway through the upper wing during the Rejoin. Exercise caution during the final portion of the join up since speed brakes are not available to control closure rates. Also, it is not a good idea to cross control (slip/skid) the aircraft in an attempt to slow down. A good technique to control closure during the Rejoin is to reduce overtake to 10 knots for each 1,000 feet of closure (i.e., when 3,000 feet back, have 30 knots closure, at 2,000 feet, 20 knots, and so forth). Once proficient, modify these parameters as necessary to expedite the Rejoin. Rejoins require a continuous cross-check of airspeed, position, and relative closure to the lead aircraft. If not performed correctly, a Rejoin can become hazardous. Aircraft always rejoin in sequential order. Number Two rejoins to the inside of turns, Numbers Three and Four go to the outside. If overtake is excessive approaching the route position, initiate a controlled overshoot. Reduce bank angle to maintain sight of Lead and ensure nose-tail separation passing behind and below lead's aircraft. Stabilize on the outside of the turn, then smoothly cross back under and complete the Rejoin to Fingertip. Standard rejoin airspeed is 300 KCAS. During Turning Rejoins, lead will use 30 degrees of bank, unless otherwise briefed.

3.3.7.3 **Straight Ahead Rejoin.** While rejoining straight ahead, it may be difficult to gauge distance and rate of closure without using air-to-air TACAN. This may be attributed to the flat color and basic odd shape of the jet. A conservative rule of thumb is 350 KCAS until inside 3,000 feet, then 320 until approaching route. As a technique, use the flight vector in the head-up display (HUD) to assist in estimating the distance. At about 3,000 feet, the F-117 should be the same size as the interior of the flight vector circle and two vertical fins can be identified. At about 2,000 feet, the F-117 is approximately 2/3 the size of the flight vector. At approximately 1,000 feet, aspect angle begins to become clearly visible and the F-117 is the same size as the flight vector. A modification to this technique is to look for approximately 50 KCAS of overtake airspeed at 3,000 feet, then reduce speed by 10 knots per 1,000 feet. At this point, make a bid to the appropriate side to complete the Rejoin. Number Two normally joins to the left side with Number Three and Number Four joining to the right of lead. Velocity vector control is extremely important during the rejoin phase. For a Straight Ahead Rejoin, fly the aircraft to a route position and once stabilized, transition to Close Formation. Use the velocity vector by placing it just to the left or right of Lead. Obviously the velocity vector is only an aid and is not used as the sole reference. Basic pilotage always applies, and a “bad” velocity vector does not mean much if the wingman hits the lead.

3.3.7.4 **Beacon Out Rejoins.**

3.3.7.4.1 **Purpose.** In real-world contingency operations, the F-117 will fly without the rotating beacon. Beacon out training may be practiced with a two-ship in restricted or warning areas. See AFI 11-2F-117, Vol 3, *Lost Wingman Procedures*, for a list of applicable restrictions.

3.3.7.4.2 **Visual Cues.** The obvious lack of visual cues from the lead aircraft makes it imperative to cross-check altitude and lateral separation during the Rejoin. Monitor closure using air-to-air TACAN and airspeed. Even though lead will have the navigation lights on bright, the aft-facing white lights on the wingtips tend to blend in with stars and ground lights. If spatial disorientation is encountered, inform lead and transition to instruments, while maintaining altitude separation.

3.3.8 Formation Approach and Landing.

3.3.8.1 **Approach Speed.** Lead establishes an approach speed consistent with the heaviest aircraft. The wingman is positioned on the upwind side if the crosswind component exceeds 5 knots. Lead ensures sufficient runway width is available for the element. After configuring, the F-117 is extremely stable to fly on the wing throughout the approach, go-around, and missed approach.

3.3.8.2 **Stack Level.** As the wingman, maintain at least 10 feet of lateral wingtip spacing. Stack level with the lead aircraft after clear of IMC, configured and established in a descent on final. While stacking level on an approach (at glideslope intercept), the mountains in the local area can create a false horizon. This tends to make wingmen stack low. Be aware of this tendency and stack high enough to see the opposite wing on approaches.

3.3.8.3 **Missed Approach and Climb Out.** During Climb Out, a technique is to have lead set one of the throttles one knob width short of max. This gives the wingman some power advantage for maintaining position and/or rejoining the flight.

3.3.9 Lost Wingman. Consider the following guidelines:

3.3.9.1 **Procedures.** Review AFI 11-2F-117, Vol 3, *Lost Wingman Procedures*, before any mission involving night air refueling or IMC.

3.3.9.2 **Execution.** When executing lost wingman procedures, smoothly transition to instruments. Execute the appropriate lost wingman procedure in a prompt but controlled manner while making a radio call to lead. Smooth application of control inputs is imperative to minimize the effects of spatial disorientation. Concentrate on the instrument references and stabilize the aircraft. Once the pilot initiates the procedure, the pilot should carry it through until confirming flight path deconfliction (visually, radios, air traffic control [ATC]), and correct orientation. Do not attempt to rejoin without clearance from the flight lead.

3.4 Tactical Formations. In the F-117, station-keeping is normally used during night/visual meteorological condition (VMC) operations. Trail Formation is normally used during night/IMC operations. Both require an air route traffic control center (ARTCC)-assigned altitude block when operating in controlled airspace.

3.4.1 Formation Considerations. Several criteria, such as the following, are addressed when selecting the best tactical formation for a given mission:

- Role and mission objectives.
- Threats (air and surface).
- Flight size.
- Flight leader and wingman capabilities.
- Ordnance and fuel load-maneuvering capability.
- Tactics (low or medium altitude).
- Surface attack tactics and timing.
- Terrain.
- Weather (ceiling and visibility).
- Support assets (ground-controlled intercept [GCI], electronic warfare [EW], suppression of enemy air defenses [SEAD], and so forth).
- Communication rules of engagement (ROE) (comm out, comm jamming).

3.4.2 Collision Avoidance.

3.4.2.1 **Responsibility.** Collision avoidance is the responsibility of the wingman during formation maneuvering. Unless directed otherwise by the flight lead, wingmen maneuver to keep Lead in sight and normally deconflict high and to the outside.

3.4.2.2 **Transfer of Responsibility.** The following are examples of times when the primary responsibility for deconfliction transfers to the flight lead:

- Turn Geometry—when turn geometry forces a wingman to lose visual contact.
- Blind—when a wingman calls "BLIND."
- Padlocked—when a wingman calls "PADLOCKED."

3.4.2.3 **Wingman Resumption of Responsibility.** Primary responsibility for deconfliction transfers back to the wingman after the wingman regains a visual on Lead. Although F-117 tactical formations generally allow flexibility of wingman maneuvers, the differences in responsibilities between the leader and the wingman demand there be no confusion between roles. Lead changes are usually made using the radio. The fundamentals of radio discipline described in **paragraph 3.1.2**, Communication, are especially critical to tactical formations.

3.4.3 Two-Ship Formations.

3.4.3.1 **Station Keeping (VMC).**

3.4.3.1.1 **Position.** For Two-Ship Formations, wingman maintains a position 500 feet below and a 0.2 to 0.5 NM cone behind the 3/9 line of lead.

3.4.3.1.2 **Techniques.** Station-Keeping Formation will be maintained using a combination of visual references and the air-to-air TACAN. The IRADS will not be used to achieve or maintain Station-Keeping Formation. If heavy maneuvering is required, the best position may be low at 6 o'clock. This will allow easy visibility of both wingtip lights and any change in their relationship indicating a turn.

3.4.3.2 **Trail Formation (VMC or IMC).**

3.4.3.2.1 **Position.** For Two-Ship Formations, wingman maintains a position 1,000 feet below and 1.0 NM (± 0.2) behind lead.

3.4.3.2.2 **Techniques.** Trail Formation will be maintained using a combination of visual references and the air-to-air TACAN. The IRADS will not be used to achieve or maintain trail formation.

3.4.4 Multi-Ship Formations. Three-ship operations should emphasize altitude separation due to altimeter error problems, limited visibility, and poor lighting references for the F-117.

3.4.4.1 **Restrictions.** The following applies to the use of Three-Ship Formations.

3.4.4.1.1 **Night.** Close/Route will not be flown at night on another F-117, except during tanker operations or if the situation dictates (e.g., emergencies).

3.4.4.1.2 **Three-Ship Formations.** Three-Ship Formations will be limited to day formation departures or night trail departures.

3.4.4.2 **Station-Keeping Formation (VMC).** Two maintains 0.2 to 0.5 NM and a minimum of 500 feet vertical separation. Three should maintain 0.7 to 1.0 NM and 1,000 feet vertical separation at all times.

3.4.4.3 **Trail Formation (VMC or IMC).** Two maintains 1,000 feet below and 1 NM (± 0.2 NM) behind Lead. Three maintains 2,000 feet below and 2 NM (± 0.2 NM) behind Lead.

3.4.5 Climbs and Descents.

3.4.5.1 **Climbs.** For climbs, the wingmen will acknowledge the altitude change, and the Flight Lead will immediately start the climb. The wingmen will start the climb 10 seconds later per aircraft.

3.4.5.2 **Descents.** For descents, the wingmen will acknowledge the altitude change. The highest number wingman immediately begins the descent. The remaining wingman or Flight Lead will begin descent 10 seconds later per aircraft. Because the wingman has limited drag authority, it is important for lead to maintain power above 75 percent during descents.

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CHAPTER 4

AIRCRAFT BASICS AND INSTRUMENTS

4.1 Aircraft Basics and Navigation. This chapter discusses techniques and procedures for basic aircraft operation. It then discusses aircraft handling maneuvers, instruments, spatial disorientation, and abnormal operations.

4.1.1 Aircraft Preflight. Accomplish weapons and aircraft preflight IAW the Dash 1 and Dash 34 checklists. If any problems develop, request a Red Ball as early as possible through the crew chief or squadron ops.

4.1.1.1 **VTR Tape.** Give the VTR tape to the crew chief before entering the cockpit. He will insert it in the recorder and close the access panel.

4.1.1.2 **Forms.** There are two 781A sections; one regular and one for the radar absorbent material (RAM). Be vigilant for K entries in small print that can potentially ruin one's day (e.g., do not use feed source to correct fuel imbalance). There may also be limitations or mods printed on the outside of the forms. The RAM A section indicates missing or non-radar cross section (RCS) RAM.

4.1.1.3 **Exterior Preflight.** Weapons and aircraft preflight will be accomplished IAW the Dash 1 and Dash 34 checklists. Check the weapon bays, weapons load panel (WLP), and weapons at the start of the exterior walk-around so the load crew can complete its job and move to the next aircraft. If any weapon does not match the respective WLP code, get a weapons troop to set the correct code.

WARNING: On the exterior preflight, be careful to avoid injury from extended antennas, gear doors, and such.

4.1.1.4 **Brake Accumulator (in the right wheelwell).** Quantity may read high (3,000 pounds per square inch [psi]) if the brakes have not been pumped down after a previous flight. To properly check the precharge, have the crew chief pump down the brakes.

4.1.1.5 **PASS and Tailhook.** A flashlight is needed to see the PASS bottle and hook accumulator pressure gages. The PASS gage is the upper of the two gages. Both should indicate approximately 1,000 psi.

4.1.1.6 **Drag Chute Pin.** Ensure the drag chute pin is removed. A good place to check this visually is from dead 6 o'clock. From any other angle, the pin and streamer may not be visible when installed. Check the end of the pin to ensure it is rounded; if it is not, part of it may have broken off inside the jet. If the pin is removed prior to arrival at the aircraft, an entry verifying removal should be in the forms. Although the pin may not be next to the forms, the end of the pin should still be checked.

4.1.2 Before Engine Start. When entering the cockpit, be careful not to kick the clock, clock knobs, throttles, or inertia reel lock handle. Use only the handgrip on the glareshield when entering the cockpit. Do not use the glareshield or the head-up display (HUD) combining glass for support.

WARNING: The canopy/seat alternate jettison T-handle requires a 50-pound pull to actuate; however, use caution as the handle has a short actuation stroke. Be sure the handle is pinned before getting into and out of the cockpit. Ensure the ejection seat safety lever is SAFE (up) when entering and exiting the cockpit.

4.1.2.1 **Organization.** Establish the habit of using the same cockpit organization for every flight, according to personal preference. This will make cockpit management easier, especially in an emergency and something must be found quickly. Ensure all required publications are readily available.

4.1.2.2 **Before Start Procedures.** The cockpit interior check will be accomplished before power is applied to the aircraft. Check for proper switch settings, primarily in the OFF, Safe, Normal, or Caged position. The exceptions are the UHF radio, generator switches, and bleed air switches. Placing these switches on prior to start enables normal operation during the start sequence.

4.1.2.3 **Verify Checklist.** Completing the verify checklist prior to engine start is a ***must*** to ensure safety and prevent system damage.

4.1.2.4 **Battery Engine Start.** A battery start is the primary method for starting engines. If you are going to perform an external power engine start, use the appropriate checklist found at the end of the normal pages of the Dash 1 checklist.

4.1.2.4.1 **Throttles.** Ensure throttles are off. A positive check is to push forward on the throttles to see if they move.

4.1.2.4.2 **Emergency Gear Handle.** If the emergency landing gear release T-handle is not fully stowed (as little as 3/8 of an inch extension), it prevents hydraulic pressure from reaching the gear down actuator, leading to loss of nosewheel steering without any associated caution light during taxi.

4.1.2.4.3 **Bleed Air Switches.** If an engine will not crank, the most likely cause is that the engine bleed air switches are off or the throttle is not in OFF. Re-accomplish the verify checklist prior to further actions.

4.1.2.4.4 **Battery ON.** Check that the BAT light is extinguished. APU start should be initiated within 1 minute after the battery switch is turned on. This will require expeditious checking of the critical lights (e.g., airframe mounted accessory drive [AMAD], uncouple [UNCPL], and ready to couple [RDY to CPL], master test of the fire and overheat detect circuits, APU fire switchlight, and tailhook switchlight).

4.1.2.4.5 **KY-58.** If the power switch is ON, The KY-58 will cause static and beeping when initially powered. Ensure that the DI Phase/Base Band switch is in the Base Band position and key the mike once. This initializes the KY-58 usually corrects the static or beeping. If it does not, ensure that the antennas are extended.

4.1.2.4.6 **"ANTENNAS CLEAR!"** Advise the crew chief before extending antennas.

WARNING: Always clear any configuration changes or control movements with the crew chief. This includes antennas, flight control checks, flight control system (FCS) built-in test (BIT) checks, and AUX GEN/EPU operation.

4.1.2.4.7 **Radios.** All aircraft have a LOCOMM antenna. The AUTO position should select the antenna with the best reception, but either Top (UHF upper antenna) or Bottom (LOCOMM antenna) may have to be selected if reception problems are encountered. Note that the lower retractable UHF antenna is not connected and does not transmit.

4.1.2.4.8 **Master Volume Knob.** If communication with both the crew chief and outside agencies over the radio is too low in volume, check the Master Volume knob at your left heel. A good setting for this hard-to-find/-reach knob is all the way forward (clockwise), and then back a touch. (It is extremely difficult to check this switch after strapping in.) If it is adjusted too high, the ICS will feedback into UHF transmissions. The squeal will render the F-117 radio unreadable to outside agencies.

4.1.2.4.9 **Solenoid Switches.** The APU, AUX GEN, START/AMAD RUN, and EMER HYD switches must be held in the ON position for approximately 5 seconds before the switch is held electrically. For the AUX GEN and EMER HYD switches, release the switch when the proper light indications are observed (i.e., AUX GEN or EMER HYD ON lights illuminate). For the APU and the START/AMAD RUN switches, holding the switch on for an excessive amount of time with a malfunctioning system may damage the system. Release the switch after the 5-second minimum time for the solenoid to engage and hold.

4.1.2.4.10 **APU Start.** To avoid setting off the sprinkler system, ensure the front and rear hangar doors are open before starting the APU. Occasionally the battery has insufficient power to start the APU. This could result from maintenance working on the aircraft or working a Red Ball with the battery on prior to engine start. Whatever the reason, remember that during a battery start, the APU must be started within 1 minute after turning the battery switch on. If this time limit has passed, or if the battery power is drained, have the crew chief connect external power. On the electrical control panel, the external power AVAIL light should be illuminated. Momentarily place the external power switch to Reset, then NORM. Observe that the ON portion of the external power available/ON light illuminates.

4.1.2.4.11 **APU Limits.** If the aircraft battery is allowed to drain excessively, the APU will automatically shut off. Always check the electrical fault panel to determine the cause of any automatic APU shut down. Delay emergency power unit (EPU) start a minimum of 3 seconds after the APU OFF light extinguishes to ensure the APU reaches normal output pressure. There is an audible acceleration of the APU when this occurs. Turn the AUX GEN switch ON. This will reduce battery drain, but not eliminate it since the battery is not being charged at this time. Ensure that the AUX GEN ON light on the EPU/APU panel and the EMER HYD ON light on the annunciator panel illuminate. Check the EPU Emergency Hydraulic pump output at 3,000 ± 200 psi, as shown on the Flight Hydraulic pressure gage. The crew chief may tell you that six flight control surfaces are up and centered and often requests a flight control reset. Operation of the AUX GEN/EPU should be limited to 4 minutes to minimize APU oil temperature build up. During successive APU starts, pooled fuel may cause a loud bang on the restart. During an APU start with battery power only, environmental control switch (ECS) air will not be available and the fan caution light on the ECS panel will remain on until after an engine is started.

4.1.3 Battery Power Engine Start. The start switch will not hold in the start position with the respective throttle out of the OFF position.

4.1.3.1 **Engine Start Indications.** Normally, the exhaust gas temperature (EGT) accelerates rapidly until around 570 to 590 degrees, peak out around 610 to 630 degrees, then decrease rapidly to idle indications of 350 to 450. As the EGT and RPM rise, a good check for proper operation is to see if the EGT is approximately 10 times the RPM (i.e., 30-percent RPM should show 300C EGT). Ensure EGT decreases after peaking. If not, a hung start may result.

4.1.3.1.1 **Abnormal Starts.** The following are abnormal start indications:

- Negative ignition—engine rotates normally, but fails to ignite within 20 seconds.
- Hung start—engine start begins normally, but core RPM stagnates around 54 percent.
- Hot start—engine starts normally, but the EGT rises out of limits (i.e., above 700 degrees C).

4.1.3.1.2 **Corrective Action.** For any of the above, corrective action is the same. Abort the start and continue to motor the engine. If the starter disengaged, reengage it when the core RPM is below 30 percent. If the EGT did not exceed 815 degrees C, a restart may be accomplished once the EGT is below 200 degrees and the tailpipe is clear of fuel. If the 815-degree limit was exceeded, abort the aircraft, write it up, and get a structural tracking and engine monitoring system (STEMS) reading.

4.1.3.2 **After First Engine Start.** Check the annunciator panel lights. Ensure the generator is on-line and the AUX GEN has turned itself off. If the AUX GEN does not turn off automatically, turn it off manually. Write up the malfunction in the 781s after the sortie.

4.1.3.3 **EDTM Insertion.** Do not insert the expanded data transfer module (EDTM) until after the first engine is started. Gently place EDTM into the receptacle such that the handle moves down toward the center of the cockpit. The handle should be at about a 45-degree angle as it is gently set in (do not force the EDTM and avoid banging the receptor clips). Press the EDTM down and lower the handle. There should be a click as it snaps into place. Ensure proper insertion by checking that the EDTM Fail light, which is on the right side of the EDTM interface unit (IU) panel just in front of the receptacle, blinks on and then extinguishes. If the EDTM is bad, have the expediter get a new one before starting the left engine.

4.1.3.4 **FCS BIT.** Accomplish the FCS BIT through step five. With power to the main AC buses established, aircraft nose heating begins. If start of the FCS BIT through step five is delayed, false FCS transducer failures will most likely result due to uneven heating in the nose compartment.

4.1.3.5 **Infrared Acquisition/Detection System (IRADS).** Ensure the LASER mode switch and the BRSGT-OFF-TEST switches are off. Turn the forward looking infrared (FLIR) and downward looking infrared (DLIR) to STBY to initiate the cooling period, which may take up to 15 minutes.

4.1.3.6 **Seat Adjust.** Sitting height is personal preference. One technique for initial sitting height is to adjust the seat so the entire HUD is in view with NORM symbology selected. Another is to sit with normal posture and move the seat until the -5 pitch mark is aligned with the bottom of the front combining glass. Height can be adjusted for different phases of flight (e.g., air refueling, weapons delivery, and recovery).

4.1.3.7 **Other Engine Start.** Use the same procedures to start the other engine. With both engines started and on internal power, you can now turn on and initialize the aircraft systems.

4.1.4 External Power Engine Start. A checklist exists for engine start with external power. Normally, this procedure is not used locally. The checklist is significantly different than the Battery Start Check. Since power and cooling air are used in this procedure, systems are turned on and checked for proper function before starting the engines. Follow the checklist explicitly when performing this procedure.

4.1.4.1 **Power ON.** Turn the battery switch ON and check that the BAT light extinguishes. Check the AVAIL light is illuminated. Place the EXT PWR switch momentarily to RESET, then to NORM. The EXT PWR ON light should illuminate. Place the electrically held AVIONICS GND PWR switch to the A position. This will allow external power to be applied to all avionic systems. Note that cooling air must be available in order for the AVIONICS GND PWR switch to electrically hold in any position other than NORM.

4.1.4.1.1 **INU/GPS.** Turn on the inertial navigation unit (INU), global positioning system (GPS), and control display navigation unit (CDNU). While the checklist does not call for it here, now is a good time to turn on both CMDIs, HUD, and sensor display (SD).

4.1.4.1.2 **Master Test.** Complete the entire master test and turn it off.

4.1.4.1.3 **INS/GPS.** Start the inertial navigation system (INS) alignment and GPS initialization prior to engine start.

4.1.4.1.4 **Verify Checklist.** Completing the verify checklist prior to engine start is a ***must*** to ensure safety and prevent system damage.

4.1.4.1.5 **Switches.** Reconfirm that the battery switch is on and the BAT light is extinguished. Perform the FCS prestart BIT. Unlike in the battery start check, there are no deviations in the FCS prestart BIT steps. Ensure the FLIR/DLIR mode switches are off to prevent damage from power surges as the generators come online during the engine start sequence.

4.1.4.1.6 **Disconnect Power.** After both engines are started, disconnect external power. Ensure external power is not removed until you are ready. The litany can be modified as follows: cleared on the power and air; traps and doors are clear; rails and ears clear; canopy coming down.

4.1.5 Before Taxi.

4.1.5.1 **Canopy.** Ensure the ECS mode selector switch is in CKPT OFF to prevent the canopy seal from inflating prematurely, thereby making it difficult to close and lock the canopy. Clear the crew chief to close the traps and doors. A good litany to use is: "CLEAR ON TRAPS AND DOORS; RAILS AND EARS CLEAR; CANOPY COMING DOWN." Add "CLEARED TO DISCONNECT POWER" if external power was used. Ensure the "elephant ears" are down and the canopy rail guard is removed. Closing the canopy on the guard will damage the canopy rigging.

4.1.5.1.1 **The Canopy Handle.** Ensure the canopy handle is in the AFT position and not stowed prior to lowering the canopy. It should be about 1.5 inches from the canopy rail and should not be able to move any farther outboard. If the canopy stops while raising or lowering, check to see if anything is physically keeping it from moving. If not, the canopy power drive unit (PDU) circuit breaker may have popped. It is located in the PDU above your right shoulder. It may be necessary to unstrap and turn around to reset it.

4.1.5.1.2 **Lock and Stow.** The canopy handle requires a strong push forward to latch it. This is normal. After the canopy is closed and latched, the canopy lock handle must be stowed completely (seated against the small microswitch in the indentation in the canopy rail) to enable cabin pressurization. Use the Velcro modification to ensure the handle stays in the fully stowed position. Ensure the canopy unsafe light is extinguished. Place the ECS mode switch to NORM.

4.1.5.2 **Computers.** Raise the guard on the Load/Run/Reset switch and select the Load position. Turn the three computer switches to ON. There is no need to wait 15 seconds before placing the computer mode switch to Run. The EDTMIU has already completed its BIT check. A flashing STANDBY in the HUD and the color multipurpose display indictors (CMDI) will be displayed until the computers are up and running.

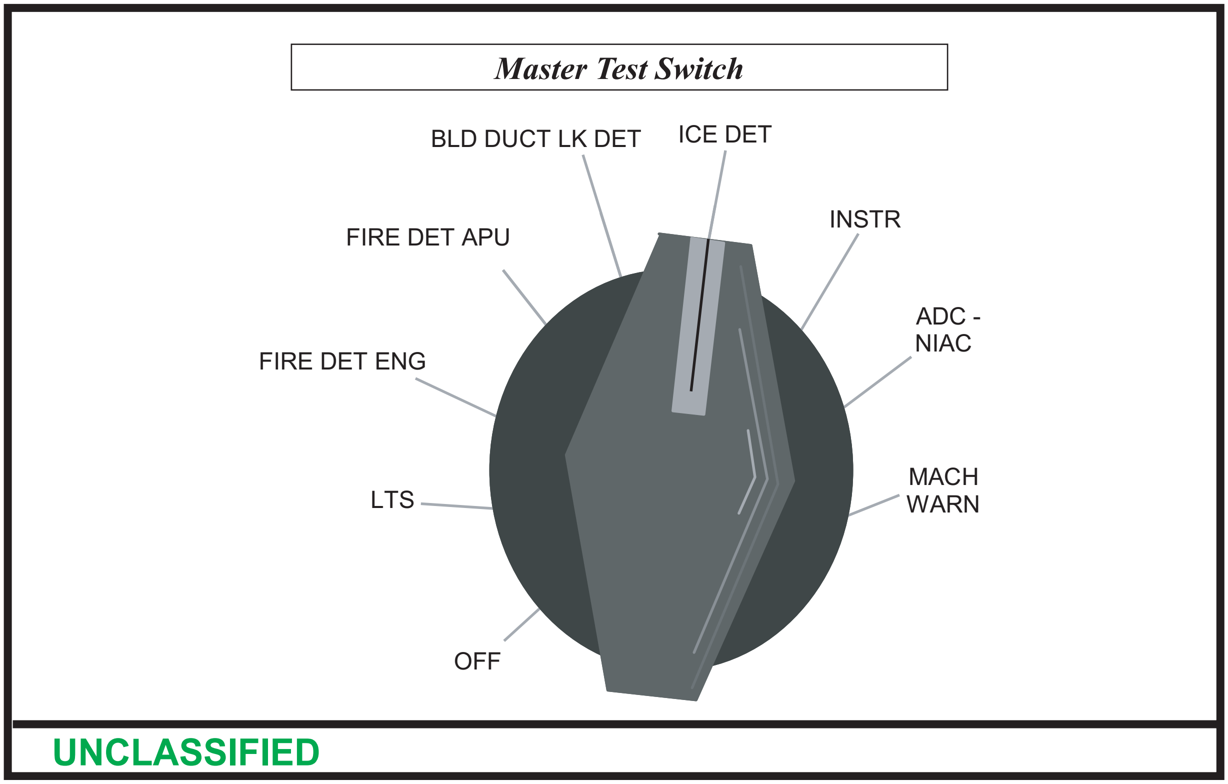
4.1.5.3 **INS/GPS.** Turn the INU and GPS switches on.

4.1.5.4 **Master Test Panel.** The Dash 1 states to perform the master test, turn the switch off. (See **Figure 4.1**, Master Test Switch.)

4.1.5.4.1 **ICE DET.** Press the test switchlight for 5 seconds and then release. Check the four ice detect lights in the electrical fault indicator panel. They should illuminate for 10 seconds after releasing the test switchlight. The ICING light on the annunciator panel will also illuminate for about 10 seconds. If the Anti Ice switch is in AUTO, the ENG ANTI ICE light will illuminate with the ICING light.

4.1.5.4.2 **Air Data Computer (ADC)-Navigation Interface and Autopilot Computer (NIAC).** Inadvertently leaving the master test in the ADC-NIAC position will cause the HUD and CMDI airspeed and altitude indications to remain on their test indications. Also, do not accomplish the ADC BIT during INS alignment. The input of 2,000 feet MSL from the ADC BIT can induce an elevation error in the INS alignment and force the INS into the NAV mode before being fully aligned.

Figure 4.1 Master Test Switch.



4.1.5.5 **RCS Monitor (Techniques).** Turning the RCS monitor switch on allows monitoring of the blow-in doors, antennas, and such in flight. Another technique is to leave the RCS monitor switch off so as not to become conditioned to seeing these lights illuminated.

4.1.5.6 **INS Alignment.** One of the benefits of using ring laser gyro technology is a significant reduction in alignment time. The Hot Start AIR alignment permits taxiing 90 seconds after initiating the alignment. The alignment is then finished on the move; however, it is not as accurate as a completed full gyrocompass (GC) alignment. GPS aiding will keep the system accurate, but without GPS aiding, the accuracy of the INS will rapidly degrade. Any shortened alignment degrades the system for the next eight alignments since the Kalman Filter has an eight alignment trim cycle. Whenever a full GC alignment is not completed, one can only hope that the previous eight alignments were good alignments, preferably enhanced interrupted alignments (EIA). Full GC alignments are the means the Kalman Filter uses to maintain the health of the INS. Quick alignments should only be used as a back-up.

4.1.5.7 **GPS.** The global positioning system provides highly accurate, three-dimensional position, velocity, and time. There are two levels of accuracy, coarse acquisition (for civilian systems) and precision (for military systems). Crypto keys allow access to the precision signals of the GPS. While the precision signal is not required for a navigation solution, it is necessary for an AIR alignment. If INVALID or NO KEYS is displayed on the GPS display, the crypto keys may need to be reloaded. A quick way to verify that keys are loaded is to check on the CDNU GPS MX page 4. It will say RCVR CONTAINS KEYS if keys are loaded. The GPS may indicate the keys are UNVERIFIED. This is due to the lack of satellite acquisition when inside the hangars. Once you taxi, the GPS should be able to verify the keys. Yearly keys are often loaded and, consequently, verification may take up to 20 minutes from the first satellite acquisition.

4.1.5.8 **FCS BIT Check.** There are instances where the FCS BIT test switch trips off. This is normally caused by: power interruptions when the left generator comes on-line, flight control test panel automatic shut down off after 4 minutes with no activity, and excessive throttle on start (whenever the throttle position exceeds 16 degrees throttle angle). The throttle position is 9 degrees at the IDLE detent.

4.1.5.8.1 **BIT Reset.** If the FCS BIT test switch trips off, the FCS BIT must be started again. Otherwise, advance from step five to resume the test. The display will tell you what to do. Section two of the Dash 1 also contains the FCS test steps. Follow the instructions explicitly. Note that the DUAL FCS fail light will not illuminate during test number 21. Upon reaching BIT number 57, if ground crew slew to 106, advance step by step to BIT number 67, RESET FCS without performing the intervening instructions. By doing this, the automatic BIT steps will be completed automatically and the pilot intervened steps will be omitted. Upon reaching BIT test 67, proceed as directed.

4.1.5.8.2 **Manual Inputs.** Manual control inputs should be held for a minimum of 2 seconds or as directed. When both stick and rudder inputs are requested, the control inputs should be applied separately; otherwise, the BIT may fail. The nosewheel steering (NWS)/air refueling disconnect paddle switch must be held whenever actuating the rudders during the FCS BIT to disconnect the NWS. If not, the nosewheel will follow rudder input and may hang up and not center. The nosewheel will have to be straightened by maintenance personnel for the aircraft to be able to taxi out of the shelter.

4.1.5.8.3 **FCS Failures.** Failures are sometimes encountered in the FCS test. Red Ball is a specialist when this occurs. While waiting for the specialist to arrive, shut the FCS BIT off momentarily then back on and try the test again. Turning the test switch to OFF for a half second will reset the test to the beginning of the current section. Leaving the test switch off for more than half a second will reset to the beginning of the test. If this occurs, simply slew to the appropriate section. Relay the circumstances to the specialists when they arrive, even if the FCS BIT subsequently checks out.

4.1.5.8.4 **Test Delays.** Failures sometimes occur because of an excessive delay in pilot response to commands on the display, or to an improper pilot action. In these cases, cycle the test switch quickly OFF and back ON. The test should reset to its last logical stopping place. The test can either be done again up to the step where the error occurred or slew to that step. Actual malfunctions will require specialist attention—let the specialist do the troubleshooting. (See **Table 4.1**, Common FCS Failure Codes.)

4.1.5.8.5 **FCS Auto Shutoff.** Check the FCS BIT auto shutoff by leaving the FCS test switch on at the conclusion of the test. It should turn off after 18 seconds.

Table 4.1 Common FCS Failure Codes.

Code	Problem	Fix
3	Trim is in backup	Place trim in normal mode
81	AR door is open, reducing flight control computer (FLCC) gains	Close AR door
83, 86, 88 to 91	ISA Failures	Have the crew chief bleed air out of the hydraulic lines
127	Dead flight control battery	Have crew chief replace battery
154	QC transducer failure	Turn on pitot heat

NOTE: The FCS BIT checks must pass prior to taxiing.

4.1.5.9 **IRADS.** Complete the IRADS and sensor display check per the Dash 1 checklist. Turn FLIR/DLIR mode select switches to STBY, then to IR once the cooling lights extinguish. When accomplishing a battery start, it may be necessary to delay the IRADS test until after taxiing for the IRADS to complete its 15-minute cooling cycle. Also, during the poststart FCS BIT, the aircraft shakes enough that the IRADS self test should be delayed until the FCS BIT is complete. Place FLIR/DLIR IBIT switches to TEST and ensure the aircraft remains stationary. The SD screen will display multiple tests for approximately 4 minutes and then show test results in plain text. Prior to calling for a Red Ball, re-accomplish a second test after cycling the FLIR/DLIR to OFF for 30 seconds.

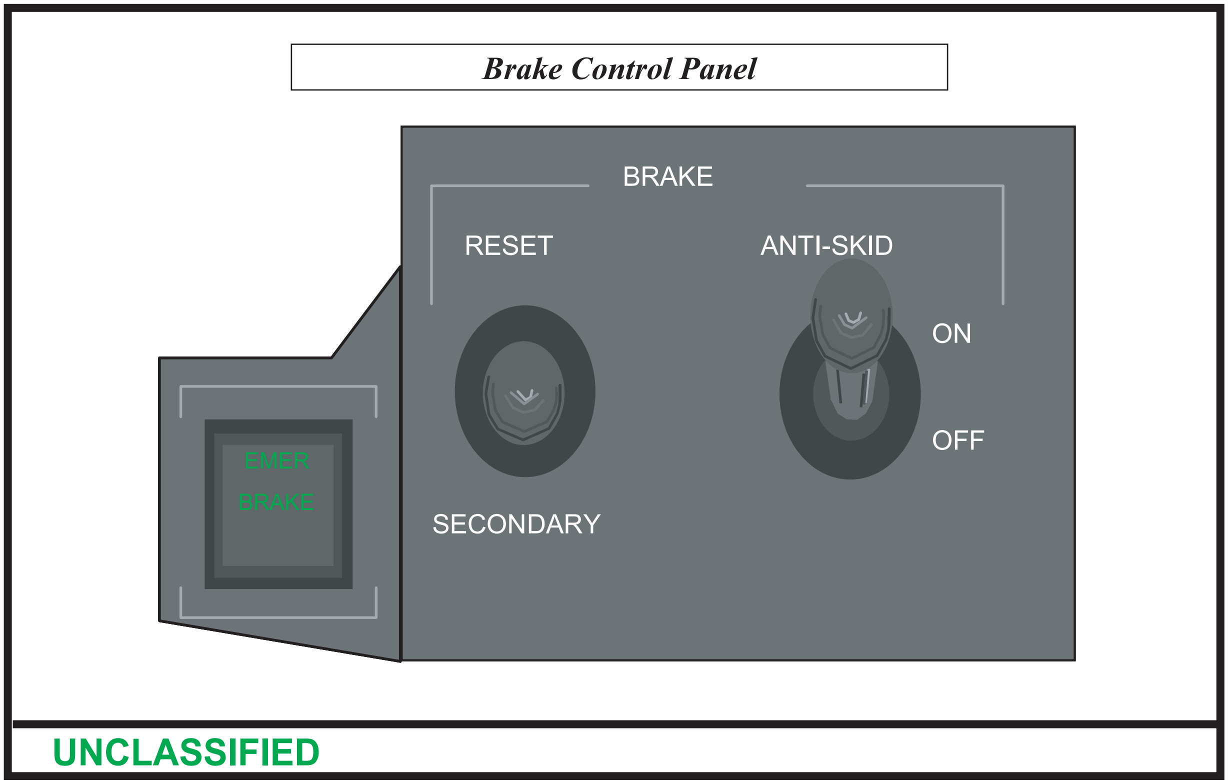
WARNING: Do not initiate the IRADS test when the aircraft is in motion on the ground. However, the IRADS test can be accomplished once airborne.

4.1.5.10 **Brake Check.** Have the crew chief confirm brake movement during this check. The crew chief will confirm left pumping, right pumping as each brake system is tested. Start the check by cycling the brake selector switch to RESET then to NORM and confirm that the PRI BRAKE light is extinguished. This ensures that the brake system is in the normal operating mode. Select Secondary, ensure the PRI BRAKE light illuminates and pump the brakes. Next, select EMER BRAKE PWR. Note that the PRI BRAKE light extinguishes and re-illuminates. Check brake function. Deselect EMER BRAKE PWR and place the brake selector switch back to RESET, then NORM. Observe that the PRI BRAKE light extinguishes. Pump the brakes to confirm that the brakes are working in NORM. Lastly, turn the Park Brake switch on to confirm brake action, and then use as desired. See **Figure 4.2**, Brake Control Panel, for a diagram of the switches.

4.1.5.11 **Radios.** Load the current day HAVE QUICK net, get ATIS initialize the KY-58 prior to check in.

4.1.5.12 **Pins.** After ensuring the tailhook switchlight is not depressed or illuminated, tell the crew chief, “cleared on the pins.” The crew chief will display the pins on the floor of the hangar for you to verify. The pins are then stored in a container in the left wheelwell.

Figure 4.2 Brake Control Panel.



4.1.6 Taxiing. The ground handling characteristics of the aircraft are good. Visibility is adequate, but be aware of blind spots created by the canopy posts, and the lack of aft visibility. Speed cues are poor, and ground speed must be monitored closely to ensure taxi speed limits are not exceeded. The maximum taxi speeds are 20 knots going out, 25 knots coming back (postflight), and 10 knots in turns and in the west area. The aircraft will hold speed, or perhaps accelerate, in idle power on a level surface, especially at low fuel weights. If in a congested area, or you feel you may not have wing tip clearance (less than 25 feet), call for wing walkers. There is a tendency to cut corners because you cannot see the wing tips. Do not do it. Stay on the yellow lines. Under no circumstances, taxi closer than 10 feet to an obstacle. Since the wing tips are behind the main gear, if a turn is started before the wing tip is past the obstacle, the wing tip will swing far enough outside its original path to strike the obstacle.

4.1.6.1 **Brakes.** Use the minimum power necessary to pull out of the chocks. Start with your feet off the brakes and advance both throttles to approximately 70 percent. Let the aircraft start moving before doing an initial check of the brakes. Check the brakes soon after sensing movement. Delay checking the nosewheel steering until out of the hangar where there is room to handle steering problems. Avoid sharp turns above 10 knots ground speed, as it is possible to damage the tires at high gross weights.

4.1.6.1.1 **PRI BRAKE Light.** If the PRI BRAKE light illuminates, reset it once. If it illuminates again, stop the aircraft and call for maintenance.

4.1.6.1.2 **Brake Failure.** If the brakes fail, stopping the aircraft is critical. The brake failure checklist is not boldface, but there is probably no time to refer to it in this situation. Use the EMER BRAKE PWR switchlight for Emergency Brakes or the AUX GEN switch ON for Secondary brake circuit power. As a last resort, use the tailhook.

4.1.6.1.3 **ANTI-SKID Light.** If the anti-skid light illuminates while taxiing, have the anti-skid system checked by maintenance. The mission may be continued if the anti-skid light resets and maintenance clears the aircraft. If the anti-skid light illuminates a second time, the mission must be aborted. Do not taxi after a second anti-skid malfunction.

4.1.6.2 **NWS.** Whenever making a turn using the high gain position (button depressed), apply the rudder smoothly and stay off the brakes. Even at slow speeds, the NWS may disengage when making an abrupt full rudder deflection. This becomes even more likely if differential braking is used for sharp turns. It is possible to lose the brakes in a tight turn if the anti-skid senses too much speed differential between the wheels. If the NWS is inoperative and has no accompanying light, check that the emergency gear T-handle is fully stowed. If there is room to straighten the nosewheel with power and opposite braking, do so. Otherwise, call for a ground crew with a tow bar to straighten the nosewheel to allow re-engagement of the NWS. If the NWS light illuminates during taxi, it can be reset one time. If it illuminates again, contact maintenance to have the aircraft towed back to the hanger per the F-117 In-Flight Guide.

4.1.6.3 **GPS NAV Mode.** The GPS should go to NAV automatically if the almanac is available and the initialization data has been verified. If the GPS indicates INIT during taxi, check the GPS page on the CMDI to see if the GPS is tracking any satellites. If it is tracking one or two satellites, it should quickly initialize and switch to NAV. If it is not tracking any satellite, select Search. This should cause the GPS to return to normal operation.

4.1.6.4 **NIAC Alert.** If a NIAC alert illuminates taxiing out, check the steam gage heading versus the HSD heading. (A 6 fault code will show on the MANT page.) The alert is caused by a mismatch between altitude heading reference system (AHRS) and INS headings and can be resolved by depressing the PUSH TO SYNC button on the AHRS when stopped or while taxiing straight ahead. This fault normally occurs in the hangar and cannot be cleared until outside the hangar.

4.1.6.5 **AHRS.** Because AHRS is dependent on magnetic fields and the INS on gravitational fields, differences in system heading can develop when aligning in a metal hangar. Check INS heading on the CMDI HSD display and compare it to the standby horizontal situation indicator (HSI) display. If a difference exists, or if NIAC illuminates with a 6 on the MANT Page, hold down the PUSH TO SYNC button after exiting the hangar until the headings agree. This should only be done when stopped or while taxiing straight ahead. Ensure the AHRS control panel has the DG/Slave switch in the slave position with the proper magnetic variation (-15), hemisphere (N), and latitude set (32 degrees). If the switch is not in Slave, the autopilot will not work in dual channel.

4.1.7 Marshaling, Arming, and Pre-Takeoff. Ensure the seat is armed, the canopy/seat alternate jettison T-handle pin is removed, and the canopy is locked. A good litany to tell the

EOR crew is, "SEAT IS ARMED, CANOPY JETTISON PIN PULLED, CANOPY IS DOWN AND LOCKED, AND THE LIGHT IS OUT."

4.1.7.1 **Enhanced Interrupted Alignment (EIA).** The INS has the capability of sweetening the alignment by performing an EIA. While this provides a statistical improvement in INS drift rate from 0.3 to 0.2 NM/HR, the operator will probably not be able to tell the difference during operational use. This is because the GPS will keep the system tight throughout the mission. What the EIA does provide is a further tweaking of the INS and Kalman Filter. Also, consider doing an EIA whenever possible. Follow the procedures in the Dash 1 checklist. An EIA cannot be performed when more than 15 minutes in NAV mode (taxi time), heading change of less than 70 degrees, ground speed has exceeded 80 knots, or align quality did not attain 0.30 NM/HR.

4.1.7.2 **IRADS System Check.** To accomplish the IRADS and sensor display check, select SRCH or terrain monitoring (TM) on data entry panel (DEP) to get IRADS looking straight in forward. If the throttle switches do not work, check that the Top Hat switch on the control stick is centered. Check the following.

4.1.7.2.1 **Tracking.** Slew the cursor around to get a feel for slew/track. Slew down through the FLIR/DLIR handoff to ensure there is not an excessive jump on the 3/9 line during handoff. Continue to slew down to check that the DLIR is functioning.

4.1.7.2.2 **Manual Level and Gain (Gray Scales)/Automatic Level and Gain.** On this check, set manual level and gain (MLG) and ensure level and gain are functional. For automatic level and gain (ALG), ensure the level control is still functional. If pressed for time, leave it in ALG.

4.1.7.2.3 **Polarity.** As a general rule, White hot is used for day and Black hot is used for night operations.

4.1.7.2.4 **Narrow and Wide FOV.** Check for smooth transition.

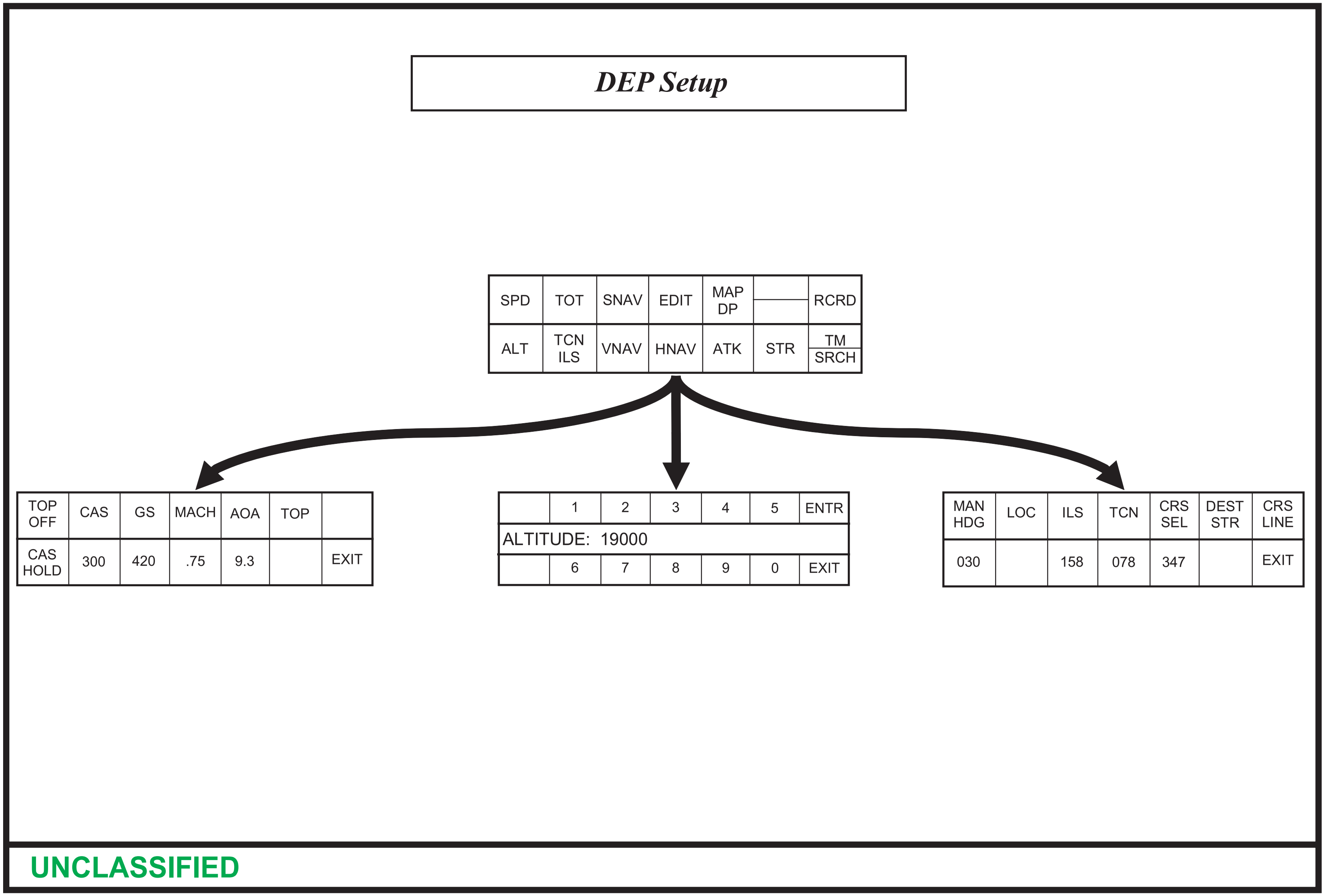
4.1.7.2.5 **Memory Point Track.** Observe M indication in upper left SD, and then hit return.

4.1.7.2.6 **Automatic Video Tracking (AVT)/Refined Point Tracking (RPT).** See how well automatic video tracking locks objects.

4.1.7.3 **Title Tape.** The IRADS test results are a good reminder to title the tape. With test results showing on the SD, select RCRD on the DEP and pause about 7 seconds to ensure the recorder is past the leader and actually recording. Tape title procedures are in the F-117 In-flight Guide or on the lineup card.

4.1.7.4 **DEP Setup.** Set the DEP for the departure, cruise or approach. See **Figure 4.3**, DEP Setup, for more details.

Figure 4.3 DEP Setup.



4.1.7.4.1 **Speed Menu.** Check SPD settings are preset as desired for departure, cruise, or approach. Some techniques are to set the climb schedule CAS and any preplanned ground speed or mach number.

4.1.7.4.2 **Altitude Menu.** Check that the altitude is preset per the departure clearance.

4.1.7.4.3 **Steering Menu.** Another DEP item to check is the steering (STR) function. Ensure instrument landing system (ILS) and TACAN courses are set, as well as any preferences for MAN HDG and CRS SEL.

4.1.7.5 **HSD Page.** Double check ILS and TACAN course settings if not already checked on DEP.

4.1.7.6 **Edit Page.** Checking the Edit Page is similar to reviewing the AF Form 70. The main purpose is to make the EDTM information match the AF Form 70. Check all target, OAP and turnpoint coordinates and elevations. Designate the time on target (TOT) target as a P-point and enter the ETA. See **paragraph 4.1.9.8**, TOT Mode, for more TOT considerations. Altitude and vertical velocity are important if planning to use the vertical navigation (VNAV) profile. Setting proper minimum en route altitude (MEA) will help if current set values are at, or higher, than the planned cruising altitudes. In such cases, the voice altitude warning will become a nuisance. Because altitude affects True Airspeed, it will also affect timing computations. See **paragraph 4.1.9.8**, TOT Mode, for more information. To check the accuracy of any Edit Page inputs, compare what the Edit Page gives as a takeoff time against the AF Form 70 computed takeoff time. They should be within a minute of each other.

4.1.7.7 **Map.** Map settings and functions are mostly a matter of personal preference. Check for overall route in large scale then check target and OAPs in 10 mile scale. Consider a scale that shows restricted airspace and MOA boundaries. By setting 100- or 140-mile scale and DTUP, the aircraft reference symbol is displaced toward the bottom of the screen so the route outline can be observed as far out as the chosen scale will allow. One technique to use when DMAP is inserted is DTUP, 100- or 140-mile scale, FNC 1, BGD 3, and automatic REFEL. This setting places the aircraft reference symbol at the bottom of the screen while highlighting in red any elevation contour band above current aircraft altitude.

4.1.7.8 **IFF.** Expect to get a Mode 4 check. The IFF must be on with Mode 3A and C selected to complete the check. Ensure that Mode 3 is set per clearance and the IFF mode switch in NORM prior to calling number one.

4.1.7.9 **TOLD.** Review takeoff data. As a minimum, review the check speed, rotation speed, lift off speed, takeoff distance, single engine climb, and maximum abort speed with and without a chute. Another number to review is the maximum brake application speed versus gross weight.

4.1.7.10 **Radar Altimeter.** Set the radar altimeter to the desired altitude. One technique is to set 1,000 feet prior to takeoff and then 4,500 feet at level off. During recovery, set 1,000 feet, then 300 feet, pilot minimums or height above ground at minimum descent altitude (MDA).

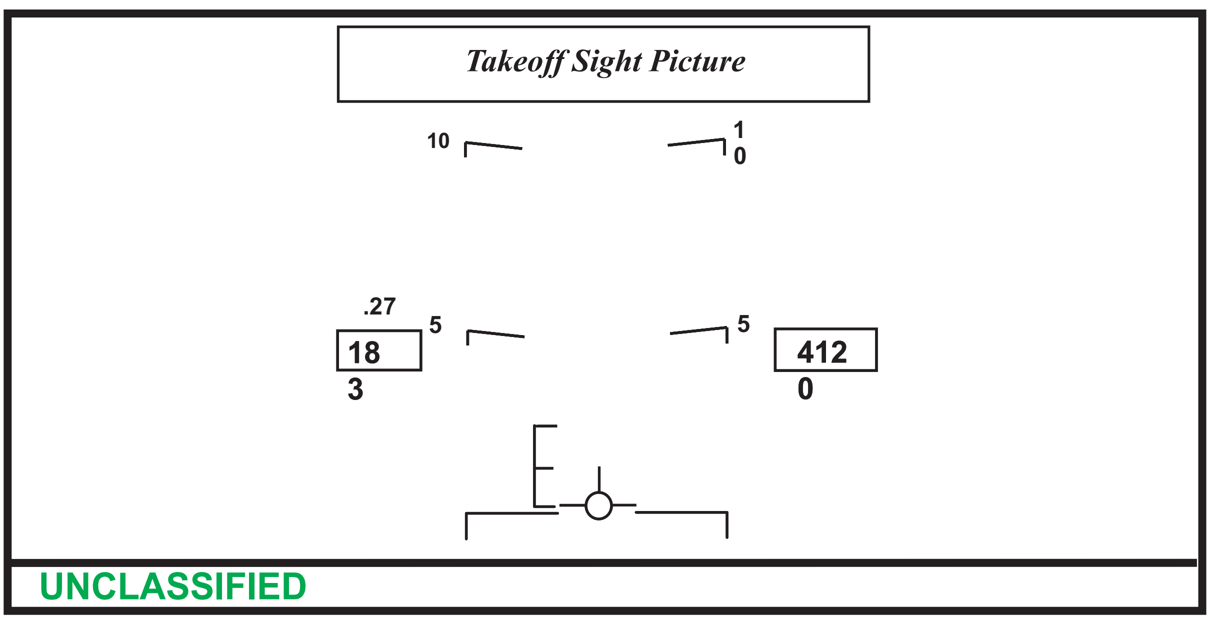
4.1.8 Takeoff.

4.1.8.1 **Brake Light.** The PRI BRAKE light may illuminate just after brake release if the release is particularly abrupt, or if both brakes are not released simultaneously. Cycle the switch to RESET and back to NORM to extinguish the light.

4.1.8.2 **Ground Roll.** Compare the aircraft speed at the 2,000-foot point to the computed check speed. Directional control during the takeoff roll is good. The aircraft will weathervane into the wind and may require significant rudder and aileron inputs with crosswind components over 10 knots.

4.1.8.3 **Rotation.** Rotation requires only a small amount of back pressure and stick travel, but if the pressure is relaxed, the nose drops easily. Maintain initial back pressure until the airspeed reaches about 200 KCAS, then relax it a bit to still maintain the proper attitude. Rotation should be 8 to 10 degrees attitude on the vertical situation display (VSD) (‾W‾) water-line symbol). This initial rotation attitude translates to a 1 to 2 climb angle. The flight path marker is a velocity vector and not an attitude reference. Use of the flight path marker for initial rotation may result in over rotation. A technique to avoid over rotation while still using the flight path marker in the HUD during takeoff is to place the top of the airspeed and altitude containers even with the 5-degree line. (See **Figure 4.4**, Takeoff Sight Picture.)

Figure 4.4 Takeoff Sight Picture.



4.1.8.4 **Gear Up.** Ensure well airborne with two positive rates of climb before raising the gear. Do not let the nose drop when reaching for the handle. Gear retraction takes 6 to 9 seconds. Expect a loud rush of cockpit air as air conditioning source changes from APU to engine bleed air. The nose gear spinning down may cause vibration after raising the gear on departure. Turns prior to spin down aggravate the vibration due to gyroscopic effects.

The vibration should stop within 30 seconds after gear retraction. The PRI BRAKE light may illuminate if wheel spin down control does not stop the main gear in 4 seconds. If this happens, wait 10 to 15 seconds for the wheels to stop, then cycle the brake switch.

4.1.8.5 **Climb Out.** Maintain the 8- to 10-degree climb attitude (1- to 2-degree climb gradient) while the aircraft accelerates from rotation speed to the single-engine climb speed. After achieving single-engine climb speed, a climb-out attitude of 5 on the -○- symbol provides a comfortable climb and allows the aircraft to accelerate to the climb schedule. Depending on the temperature, 8 to 9 degrees with the -○- should hold 300 KCAS during the climb-out.

4.1.8.6 **Departure.** Contact departure control as soon as practical after takeoff. Make sure squawk is on and include altitude passing and altitude cleared to in the call. Departure normally requests an ident so add with a flash to this call. Ensure safe altitude and airspeed before making turns. One technique is to mirror the night/instrument meteorological conditions (IMC) procedure to be at 1,000 feet AGL and 250 knots before making any turns.

4.1.8.6.1 **Autopilot (AP).** If the autopilot will not engage after getting airborne, it is likely that a heading discrepancy between the INS and AHRS is causing the problem. Procedures are the same as on the ground, but until the problem is resolved, only single-channel autopilot is available. The pilot must determine that the single-channel selected is operating properly. Check the slave switch is in the slave position.

4.1.8.6.2 **Blow-In Doors.** The blow-in doors will close with a loud thump at approximately 0.55 Mach during climbout. Their position can be monitored if the RCS MON switch is on.

4.1.8.7 **Autopilot/Autothrottle (AT) Climb.** Turning on AT engages the CAS HOLD mode, which holds the speed at the time of engagement. If another speed mode is desired, it must be specifically selected. Similarly, turning on the AP engages the attitude hold mode. Desired altitude and/or steering modes must be specifically selected. Always double check that the AP/AT modes and values on the DEP are what is actually showing on the VSD and there is a “C” to the left of it! The following are techniques for managing the autopilot and autothrottle during departure.

4.1.8.7.1 **Steering.** Takeoff with steering command preset values set but not selected. This prevents roll commands before they are desired.

4.1.8.7.2 **Engage.** Approaching 300 KCAS, engage autopilot and autothrottle. Note the airspeed at engagement is now commanded in the VSD.

4.1.8.7.3 **Couple.** Command and couple the level-off altitude: ALT–ENTER–Couple. Verify the altitude coupled.

4.1.8.7.4 **Bank.** At appropriate point, manually roll into bank as specified in the departure procedure.

4.1.8.7.5 **Speed.** Select the SPD mode from CAS HOLD to CAS 300 KCAS.

4.1.8.7.6 **Heading.** Command MAN HDG but do not couple until rolling out on the departure heading. SPD, ALT and STR modes should now be coupled.

4.1.8.7.7 **NAV.** Select TACAN preset (TPRE) or horizontal navigation (HNAV) profile to fly remaining portion of departure. See **Figure 4.5**, Departure Autopilot Settings, for an example of DEP settings.

4.1.9 En Route.

4.1.9.1 **Level Off.** The autopilot can be selected and will make altitude changes without autothrottle selected. The catch is that the aircraft must accelerate or decelerate to the airspeed at which the autopilot normally climbs or descends. If autothrottle is engaged at 300 KCAS, for instance, it will use that as its reference for climbs and descents. In the descent, it will try to establish a pitch to hold the reference airspeed. The opposite holds true for climbs. In other words, if cruising at 400 KCAS and a lower altitude is entered, the aircraft will continue at its current altitude until the aircraft slows below its reference of 300 KCAS or a reference airspeed above 400 KCAS is input in the DEP. If the altitude hold function is disengaged by turning off the autopilot, the complete re-engagement procedure must be accomplished. Push ENTER on the DEP and couple the autopilot with NWS button. Merely bumping the stick can be recovered by pressing the NWS button.

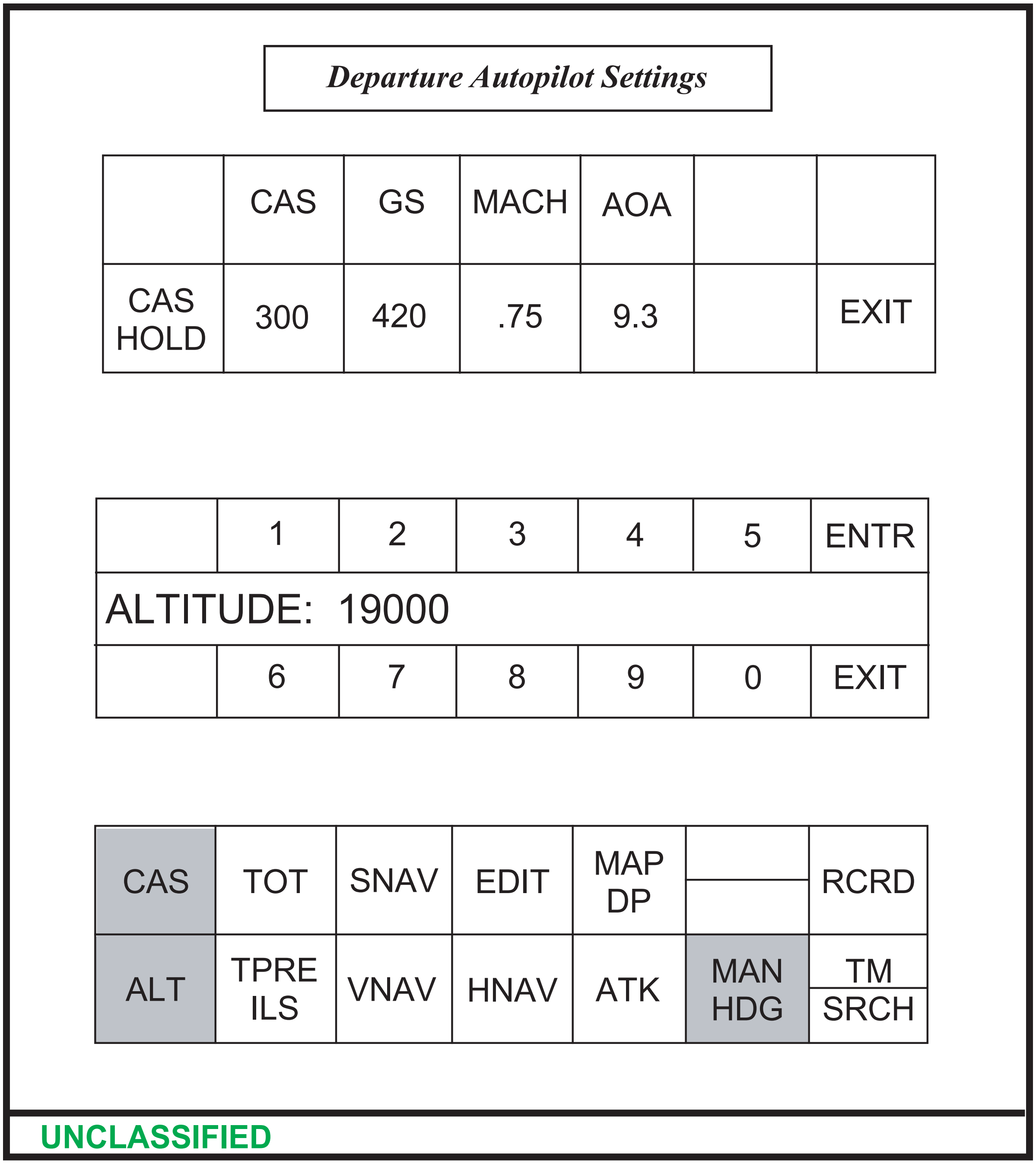
4.1.9.2 **Roll Rates.** When coupled up, roll rates are abrupt, yet comfortable. The autopilot can command turns of up to 50-bank angle. Banks of up to 70 may be made using control stick steering. However, when exercising control stick steering, the A/P ROLL light will illuminate when lateral stick pressure is applied.

4.1.9.3 **Turn Radius Anomalies.** Destination steering is invalid when a nav mode is selected inside two turn radii (e.g., using a 50-bank turn) to the next INS destination point. For example, if the INS auto sequences from point 5 to 6 and the distance between 5 and 6 is less than two turn radii (approximately 10 NM), nav mode steering becomes invalid and the autopilot will drive the aircraft straight ahead from the last destination.

4.1.9.4 **Auto Sequence.** The INS will not auto sequence if station passage occurs outside 3,000 feet horizontally of the desired destination. The INS must see less than 3,000 feet and be increasing before auto sequence occurs. It may also fail to sequence if the pilot switches from LVL ATK to DEST or HNAV after TTI = 0, but before the 5-second over fly or auto sequence.

4.1.9.5 **Speed Adjustment.** When accelerating to a new airspeed, take the time to ensure the speed has stabilized before setting the throttles, or the airspeed can slowly increase out of limits. If setting a mach number or fine tuning a TOT, set the time or mach number first, then reference the ground speed on the left CMDI while zeroing out the acceleration or deceleration. Speed navigation (SNAV) profile flies the programmed speeds set in the Edit Page. If changes from the programmed speed are needed while on autothrottle, switch to SPD mode and set the new values.

Figure 4.5 Departure Autopilot Settings.



4.1.9.5.1 **Speed Cues.** Because there are no good sense of speed cues, particular attention must be paid to airspeed in the cross-check. An overspeed or low speed condition can occur very easily. Airspeed changes of 50 to 75 knots produce no noticeable change in cabin noise, control response, or sense of speed. Also, small changes in the throttles can produce large and insidious changes in airspeed. A rough guide for setting speeds is to take the fuel flow of one engine (assuming both engines are set at the same fuel flow) and divide that by 10 (i.e., 3,100 pph equals 310 KCAS).

4.1.9.5.2 **Sound Cues.** The aircraft lacks good speed cues, but it does make some strange sounds. The blow-in doors closing is one. At high airspeeds, if the throttles are brought to idle, the airplane will shudder and the inlets will have a pronounced duct rumble. This is normal.

4.1.9.6 **Trim.** Trim inputs are minimal. Pitch trim is automatic with the gear up. Auto yaw trim works very well, and major trim changes may only be necessary during single-engine operations. Roll trim is very slow and usually does not need to be changed once set for wings level after takeoff, regardless of airspeed.

4.1.9.7 **Turbulence.** The aircraft reacts differently in turbulence than other aircraft. Instead of being jolted vertically or horizontally by turbulence, the aircraft seems to be on the head of a needle and simply rotates about its center of gravity. Yaw response to turbulence is more pronounced when the autopilot is engaged. Moderate turbulence may cause the autopilot to disengage without a voice warning.

4.1.9.8 **TOT Mode.** This requires VNAV or HNAV and SNAV to engage. There are many different techniques for using the TOT mode. Listed below are just a few good ideas to add to one's bag of tricks. Remember, the AP/AT TOT mode will make a snap adjustment for actual leg winds versus entered leg winds in order to meet the speed and timing requirements for that specific leg. If the difference between actual and entered winds is large, there can be a disconcerting airspeed change with potential problems for overall route timing. If there is time available in, enter the actual winds to help AP/AT timing.

4.1.9.8.1 **Save the Gas.** To avoid wasting fuel and/or setting off speed warnings, it is best not to engage TOT/autothrottles if late. Control the speeds manually to progressively catch-up to the time line, then engage TOT/autothrottle mode.

4.1.9.8.2 **Speed Excursions.** The TOT mode will sometimes command large speed excursions (and associated throttle excursions which can again increase fuel consumption) after track change. These are usually associated with large heading or altitude changes. The airspeed can also increase to greater than 0.8 Mach. Remember to watch the lower airspeed release hit limits; the autothrottle with TOT mode engaged may slow to below OGOI 10-1 minimum weapons release airspeed.

4.1.9.8.3 **Manual Override.** TOT may be over ridden by disengaging the autothrottle and/or turning off TOT mode. If autothrottles are disengaged and TOT mode is selected, manually fly to the correct time while monitoring the TOT speed command caret. When the speed command returns to a reasonable value, re-engage autothrottles.

4.1.9.8.4 **Altitude Changes.** Keep in mind that the aircraft sometimes ignores altitude commands in this mode. For example, if TOT is commanding 250 KCAS and the aircraft is flying faster, after entering a lower altitude, the aircraft will not descend unless the throttles are pulled back and airspeed is 250 KCAS.

4.1.9.8.5 **Manual Track Change.** If a point is designated in the Edit Page as a nav point but LVL ATK is selected to overfly it, the timing will be thrown off because the TOT mode assumes a track change directly over the point as opposed to 5 seconds after TTI = 0+00. Granted, a small heading change to the following point is no big deal, but a 90–degree turn will cause real problems. Be ready to manually track change at TTI = 0+00 if this situation is encountered.

4.1.9.8.6 **Plus or Minus TOT.** Know that big speed changes, delaying turns by a few seconds, control stick steering turns at a shallower angle of bank, cutting corners (either by turning early or cutting out entire legs), or altitude changes, are subtle and not so subtle techniques of gaining or losing time towards a TOT. Also know that good preflight planning is the best solution to a TOT problem since any or all of the above techniques may not always be possible.

4.1.9.9 **VNAV.** In order to work properly, VNAV requires proper Edit Page information (e.g., proper altitude, speed, and climb/descent settings). It requires the aircraft be in special-use airspace (or combat) where random altitude changes are allowed. Otherwise, the "V" in VNAV may stand for "Violation." If VNAV is engaged while outside the safe corridor, the aircraft will not descend more than 200 feet to the AF Form 70 altitude.

4.1.9.10 **Leg Checks.** After rolling out on a new leg, perform checks on flight and mission related items. HATF stands for Heading, Altitude, Timing, and Fuel and reminds the pilot of the major checks that should be accomplished at each turn point. HATF is one technique. Others are Speed, Heading, Altitude, Fuel, Timing, Autopilot (SHAFTA) and Fuel, Altitude, Speed, Timing, Heading (FASTH).

4.1.9.10.1 **Heading.** If set for the follow-on leg, it will only require a quick glance to compare the INS predicted heading with the AF Form 70 predicted heading. Once confirmed, reset for the next leg.

4.1.9.10.2 **Altitude.** Confirm the leg altitude and check the VSD to ensure the autopilot is still coupled to that altitude.

4.1.9.10.3 **Timing.** Cross-check timing by using the ETA display on the lower left side of the VSD. The same information is available on the CDNU progress page but requires head down to view the data.

4.1.9.10.4 **Fuel.** Check the fuel! Imbalances can quickly occur if not paying attention. Be sure to check all tanks for proper fuel sequencing. Some fuel may be trapped (do not count on using it) or slow to feed. Additionally, check continuation and bingo fuel, which may require action.

4.1.9.11 **Turns.** There are different techniques for monitoring route turns. The autopilot turn techniques may seem too involved, but keep in mind the turns deserve special attention, especially at night.

4.1.9.11.1 **Equal to or Less Than 50 Degrees.** Ensure the INS sequences properly (the course arrow moves to the heading set marker), the TO window shows the next destination, and the autopilot turns in the proper direction. There is occasionally a small cranium fake in the opposite direction just as the system sequences. If autothrottle is disengaged, adjust the power to hold the airspeed in the turn. Use the RETURN switch to position the IRADS onto the next destination if it is still looking at the last one. A better technique is to use SRCH or TM mode in turns, particularly those with large heading changes. This is easier on the IRADS servos and gimbals and provides a rough horizon instead of pointing at the ground. Cross-check the performance instruments and autopilot status throughout the turn.

4.1.9.11.2 **Greater Than 50-Degree Bank Turns (Autopilot Off).** If a bank angle of greater than 50 but less than 70 degrees is desired, the autopilot will initially begin the turn up to 50 degrees of bank. By moving the stick laterally, control stick steering overrides the navigation hold submode and will illuminate the A/P ROLL light but does not disengage the autopilot. When the desired bank angle is reached, return the stick to the neutral position and the autopilot will maintain the set attitude. Use the VSD or altitude/direction indicator (ADI) to set the desired bank angle. The HUD lacks bank indications greater than 30 degrees so place the bank arrow in the HUD just below the containerized airspeed or altitude to stay just below the 70-degree limit. Do nothing but fly the aircraft during these turns and remember speed control! This is not the time to be setting weapons switches, working with the CDNU. Remember to recouple the autopilot to the navigation mode as the aircraft approaches the desired heading.

4.1.9.11.3 **Turns with Altitude Changes.** The recommended procedure en route is to do one, then the other. However, if both must be done simultaneously, a good technique is to have the AP/AT fully engaged while focusing completely on this maneuver.

4.1.10 Recovery.

4.1.10.1 **Instrument Approach.** While standard fix-to-fix computations can derive initial heading to the TACAN holding fix or initial approach fix (IAF), RLG navigation improvement program has the capability to enter data by lat/long, radial/DME, or by International Civil Aviation Organization (ICAO) identifier. While a degree of caution is required, no matter which method is used, some attention must be taken whenever working with ICAO databases. Contrary to popular belief, there are Navaids that have the same name/identifier. Consequently, always check and verify ICAO coordinates. Given the accuracy of the INS/GPS, headings to these points may be used as long as they are backed up with TACAN data.

4.1.10.1.1 **Checks.** Accomplish the descent checklist. It is good practice to set courses on the backup HSI. Do not forget the ILS antenna if planning to shoot an ILS! It is a good practice to use the radar altimeter as an instrument approach ground avoidance aid. A technique is to set the maximum setting at the IAF, an intermediate setting during the penetration, and the MDA/decision height (DH) for final approach.

4.1.10.1.2 **Holding.** Establish the Dash 1 holding airspeed of 250 KCAS within 3 minutes of reaching the holding fix. The power setting to hold 250 KCAS is 83 to 85 percent, or 2,500 to 2,700 pph per engine.

4.1.10.1.3 **Penetration.** There are many techniques for penetrations. A clean idle descent requires an 8- to 10-degree nose low pushover to achieve a 250 KCAS descent; a descent gradient of minus 6 to 7 degrees (1 to 2 degrees nose low attitude) should hold the speed and give a 4,500 to 5,000 fpm rate of descent. A gear down approach at idle requires a 10- to 12-degree descent gradient to hold 250 KCAS, giving a 5,500 to 6,000 feet per minute (fpm) rate of descent. The Dash 1 speaks of a 70 to 75 percent power setting, roughly 5 degrees nose low attitude, which yields 250 to 300 KCAS and 3,000 to 4,000 fpm rate of descent. Remember, above approximately 15,000 feet, idle RPM will be higher than 70 percent. If flying penetration at 250 KCAS and configuring at 10 NM on final approach with a normal 3-degree descent gradient, it will take 3 to 4 NM and nearly idle power to slow to final approach airspeed prior to the final approach fix (FAF). One should be on speed (steady angle of attack [AOA] tone) by the FAF. In previewing the penetration, determine the desired descent gradient (and resultant pitch change) using the following formula: Descent Gradient = Altitude Change per 100 feet/Distance in NM. See **Table 4.2**, Penetration Settings, for some typical settings.

Table 4.2 Penetration Settings.

Airspeed	RPM	Descent Rate
250 KCAS	70 percent	3,000 to 4,000 fpm
250 KCAS	77 to 80 percent	2,000 to 3,000 fpm

4.1.10.1.4 **Final Approach.** A normal precision approach glide path will require approximately 82 to 84 percent power to hold approach airspeed (depends on gross weight, altitude, and temperature). If leveling off with landing gear down on approach (for an MDA), approximately 91 to 93 percent power will be required to hold final approach airspeed.

4.1.10.2 **Visual Flight Rules (VFR) Landing Pattern.**

4.1.10.2.1 **Overheads.** Fly initial at 300 KCAS and pattern altitude. Check the winds using the INS. Break over the numbers.

4.1.10.2.2 **Pitchout.** Fly the pitchout with 60 of bank. A slight or no reduction in power is required to slow the aircraft to the desired 220 to 250 KCAS at the initial rollout on downwind. Rudders can aid in moving the nose to maintain pattern altitude.

4.1.10.2.3 **Downwind.** Lower the gear on downwind and be careful not to slow to less than 190 KCAS or 7 AOA maximum, prior to turning base. A good airspeed range to be rolling off the perch is 190 to 200 KCAS. Auto trim terminates with the gear handle down. Manually trim as needed.

4.1.10.2.4 **Final Turn.** Transition to on-speed (9.5 AOA) commencing the final turn. Because of bank and G, on-speed indications will occur between 170 to 185 KCAS (normal gross weights) starting to roll out on final approach. A good initial attitude for the turn off the perch is 45 to 60 degrees of bank and about an 8- to 10-degree descent for a 2,000-foot overhead pattern. Remember the Big E reference in the HUD will not appear until below 200 KCAS. A reduction in power will be required to maintain 9.5 AOA during the turn to final. The desired rollout point is 1 NM at 300 feet AGL. Use the precision approach path indicators to get established on the visual glide path.

4.1.10.2.5 **Final.** A stabilized 2.5- to 3.0-degree glideslope, on speed, gear down approach will require approximately 83 percent to 85 percent power setting. The Dash 1 recommends small power change corrections once established on final to avoid chasing AOA and glideslope. One technique to help assess crosswind effects on final is to have the HUD switch in NORM so you can see how the -○- reacts to the wind. This is not a recommendation to rely on the HUD for landing. If conditions are turbulent, fly an 8 AOA final approach.

4.1.10.2.6 **Closed Pattern.** Delay pull-up to a closed pattern until at least 250 KCAS (AFI 11-2F-117, Volume 3) and comply with local regulations.

4.1.10.3 **Landing.** In a crosswind, fly a crabbed, wings level approach to touchdown. The Dash 1 cautions against a wing-low approach. There is a possibility of dragging an elevon on the runway.

4.1.10.3.1 **Approach Attitude.** The approach attitude is about half the takeoff attitude. The airplane is not held on speed and driven into the ground; it is flared. However, the flare is different from most aircraft because the stick is not brought back continuously until touchdown. Coming over the overrun, the stick should slowly be brought aft to set the landing attitude while retarding the throttles to idle. Maintain the landing attitude as ground effect is entered.

4.1.10.3.2 **Ground Effect.** Ground effect from the delta planform is very pronounced, making smooth touchdown fairly easy, but it also contributes to early flares and long landings. When the airplane gets to about 15 to 20 feet off the ground, the ground effect takes over and the descent rate decreases on its own as the aircraft settles smoothly onto the runway.

4.1.10.3.3 **Pilot Induced Oscillations (PIO).** There is a normal tendency to initially flare too much, then overcorrect and get into a PIO over the overrun. If this happens, freeze the stick momentarily when slightly nose high and let the aircraft settle into the ground effect, bringing the stick aft to arrest any high sink rates that may have developed.

NOTE: At normal landing gross weights, the sink rate at touchdown should not exceed 600 fpm. If the flight path marker gets to level flight or above, the aircraft will float easily in ground effect for 1,000 to 1,500 feet, even when on-speed.

4.1.10.3.4 **Touchdown.** Adjust the pitch only to change the descent rate. If the flare is too high, ease forward slightly on the stick to allow the aircraft to settle through the ground effect. The aircraft is flown onto the runway, not stalled. The planned touchdown speed is 95 percent of the approach speed. At low gross weights, it would be easy to touch down at less than 140 KCAS, but the minimum airspeed is 140 KCAS. DO NOT touch down below 140 KCAS. The aircraft will land with little difficulty at airspeeds 10 to 20 KCAS above on-speed; however, excessive touchdown speeds greatly reduce safety margin for stopping and increase the chances of hot brakes (refer to Dash 1, Section 3).

4.1.10.3.5 **Max Brake Application Speed.** Plan ahead by referencing the in-flight guide to determine the maximum brake application speed. Keep in mind that the in-flight guide lists four different altitudes; be sure to choose the correct one. The intersection of the ambient temperature and current weight of stores plus fuel is the maximum brake application speed.

4.1.10.3.6 **Go-Around.** If a go-around is necessary after touchdown, lower the nose, retrim to 1 unit nose down, advance the power to military, and accelerate to rotation speed (175 KCAS minimum). Without trim input, hold forward stick to keep the aircraft on the runway until rotation speed.

4.1.10.4 **Chuted Rollout.** Once the aircraft is on the ground, it is still at or near flying speed and the nose will want to stay in the landing attitude. Fly the nose smoothly to the runway. Align the aircraft with the runway prior to deploying the drag chute. Establishing a stabilized track along the runway centerline should not take more than 1 to 3 seconds. Do not delay chute deployment unnecessarily. Deploy the chute immediately whenever landing distance is in question. To prevent inadvertent chute jettison, pull the handle to the first detent, and hold it aft until deceleration is felt (about 3 to 5 seconds), then release it gradually until the detent catch. If the handle goes in past the detent even a small amount, the jaws will open and the chute will release. Attempt to minimize rudder inputs during the few seconds between pulling the handle and feeling the deceleration. However, directional control is paramount. Make the appropriate flight control inputs anytime they are required. Deceleration is strong and directional control is good. In a crosswind of 10 knots or more there is a definite tendency to weathervane which becomes more pronounced as speed approaches 100 knots. Consider jettisoning the chute if aircraft control becomes difficult during landing rollout.

4.1.10.4.1 **Braking.** It is not usually necessary to begin braking until decelerating below 100 knots. Because of the significant deceleration caused by the drag chute the aircraft will normally slow to taxi speed within 8,000 feet on rollout with light to moderate use of the brakes. As a technique, slow to below 35 knots prior to passing the last available cable. It is possible to stop in less than 5,000 feet. However, landing must be on-speed (95 percent of approach speed), nose gear to the runway within 3 seconds, chute deployed at nose gear touch down, with a continuous, maximum braking effort. This will probably place the brake energy near the upper limit and hot brakes can be expected. So, do not attempt an early turn off if the intersection is less than 5,000 feet from the approach end of the runway.

4.1.10.4.2 **No Chute.** If deceleration is not felt in 3 to 5 seconds after pulling the chute deploy handle, suspect that the chute has either failed to deploy, has inadvertently jettisoned, or is a streamer, which is the most common chute failure. Another scenario that may cause a no-chute landing would be an excessive crosswind landing. In either case, begin maximum effort braking once the aircraft is below the max braking speed. Monitor speed and runway remaining, and be prepared to use the hook if necessary. A good rule of thumb to judge if the hook will be required is to check speed at 5,000 feet to go. If the speed is greater than 155 KCAS, deploy the hook.

4.1.10.5 **No-Chute Landing.** Normally no-chute landings will be accomplished when crosswinds preclude a chuted landing (refer to latest 49 FW/OG policy). Use of the drag chute is prohibited with crosswinds greater than 15 knots due to directional control problems. Executing a no-chute landing shifts the focus to avoiding hot brakes and being prepared for brake malfunctions. Ensure that the approach speed is less than the maximum brake application speed for the current pressure altitude, temperature, and weight (fuel plus stores). Always be prepared to deploy the chute and/or use the hook if stopping ability is questionable.

4.1.10.6 **Brake Application.** Braking should begin as soon as the nosewheel is on the runway. The best braking technique is to smoothly apply the brakes as required. One technique used to evaluate deceleration performance is to double feet remaining (i.e., at 5,000 feet below 100 knots ground speed [KTGS]; 4,000 feet below 80 KTGS; 3,000 feet below 60 KTGS). Experience shows that the brakes may go all the way to maximum application without anti-skid cycling on a dry runway. Moderate braking should be reached in approximately 3 seconds. Normal distance traveled from initial brake application to taxi speed is approximately 5,000 feet. Expect aircraft with new or little used brakes to smoke. If hot brakes are suspected or they are smoking excessively, pull into the nearest hot brake area and request assistance to check the brakes.

4.1.10.7 **Aerobraking Landing.** Reference current wing procedures for aerobrake landing.

4.1.10.8 **Chute Jettison Maneuver.** This maneuver is designed to minimize the impact chuted landings have on traffic pattern operations by blowing the chute off the runway. Perform the maneuver very deliberately and in accordance with the following guidelines. Listen to the winds and/or check the windsock and maneuver to the downwind side of the runway. At Holloman, the cold side is always the left half of the runway. If a hot side drop is required, coordinate with tower. Initiate the turn maneuver at less than 10 knots ground speed using high-gain nosewheel setting. After turning 30 to 40 degrees, center the rudder pedals. It is critical that the rudders be centered before jettison to prevent damage to the rudder/stub fins. Roll out of the check turn with feet off the rudder pedals to allow the chute to square up behind the jet. Add power to get tension on the chute cords. Use no more than 70 percent RPM. Do not add power until the turn is stopped and the rudder pedals are centered. Delay 3 to 4 seconds before jettisoning the chute. Again, ensure both feet are on the floor when the chute is jettisoned. Another chute jettison technique is to jettison the chute while moving straight ahead on the runway at about 25 to 30 knots ground speed. Coordinate with tower prior to accomplishing a straight-ahead jettison. Use this technique when winds are unpredictably variable and/or gusty, crosswind or headwind component is greater than 15 knots or an excessive tailwind component exists.

4.1.10.8.1 **Jump Back.** If it becomes necessary to add power before jettisoning the chute, the aircraft may decelerate or even try to back up because the large chute acts like a thrust reverser. If this occurs and the aircraft starts to back up, jettison the chute. Applying the brakes before jettison in this situation may cause the aircraft to sit on its tail, damaging the wing tips. The nose may then fall through with enough force to overstress the nose gear.

4.1.10.8.2 **Stowing the Handle.** After jettisoning the chute, hold the handle with the left hand, push the release button with the right hand, and slowly return the handle to the stowed position to keep it from springing back against the instrument panel.

4.1.10.8.3 **Hung Chute.** Do not turn off the runway with the chute attached as it may become entangled in the rudder/stub fins, causing major damage. If the chute will not release, an alternate method to attempt jettison is to push the button and move the handle into the stowed position. If this still does not jettison the chute, stop straight ahead and call for assistance. If there is any question as to the status of the chute, do not move the aircraft until it is resolved or directed to move by the supervisor of flying (SOF) or tower controllers. Major damage to the aircraft can result by taxiing with a hung chute.

4.1.10.9 **Radios.** Clear off the runway with ground, ensure there are no conflicts, and contact Operations with the maintenance code. Operations may also have information on hangar changes for parking.

4.1.11 Shutdown Procedures.

4.1.11.1 **NAV Data.** From time to time, maintenance may request data collection to track the INS performance. Maintenance may want to know the total time in NAV, the alignment error (RER) value, or how much drift there was in the system. Before shutdown, note the INS RER value and time in NAV by pressing INDX, MAINT, INS, and then right arrow three pages on the CDNU and note the time in NAV. Next, right arrow two pages (to page 6). The RER for the current flight is the value next to flight number one. Another place to find RER and time in NAV data all on one page is to look on the ALIGN STAT page on the CMDI.

4.1.11.2 **INS Drift.** Check the amount of drift in the INS by track changing to destination point 00, the alignment point, which should be the same as the parking. On the left CMDI the drift in range and bearing is available.

4.1.11.3 **Canopy.** Open canopy before engine shutdown to prevent excessive drain on the aircraft main battery. Check that all loose items are stowed prior to opening the canopy.

4.1.11.4 **EPU Ground Test.** The flight control surfaces will move during the EPU ground test, so the flight controls should be clear before initiating this test. Look for the following lights on the test: the floodlights on the rear canopy bulkhead will illuminate, AUX GEN will illuminate continuously, EMER HYD will illuminate and indicate normal pressure, APU MODE SEQ lights will illuminate for approximately 5 seconds, and the floodlights will illuminate again when the test is stopped.

4.1.11.5 **Battery.** Ensure the battery is turned off.

4.2 Aircraft Handling.

4.2.1 Engine response. Engine response is excellent for a fan engine. When power is reduced, the engine inlet spillage causes duct rumble and considerable drag. The aircraft can be slowed down fairly rapidly considering there are no speed brakes.

4.2.2 Pitch Response. With the gear down or the AR door open, the pitch response is sluggish compared to the feel when in a clean configuration. This reduction in flight control gains optimizes the responses in the air refueling, approach, and landing phases.

4.2.3 Roll Response. In the clean configuration roll response is crisp, but is decidedly slower with the gear down or the AR door open due to the reduction in gains.

4.2.4 Yaw Response. Yaw response is good, but the aircraft can feel loose in turbulence. Adverse yaw is almost unnoticeable in a normal turn, but can build considerably with large roll inputs. Instantaneous turn rate is very good, but because of the highly swept delta shape, induced drag increases rapidly. Therefore, in high G turns, the airspeed decreases very quickly.

4.3 Instruments.

4.3.1 Basic Instruments. The F-117 has one of the most sophisticated avionics systems in the Air Force inventory, but the cockpit layout, the night environment, and even the displays themselves can induce spatial disorientation very quickly. The pilot has enough information to fly the most precise instrument work ever, but it must be used properly to be effective and safe. In fact, so much information is available from so many sources, it must be correctly prioritized to not become overwhelming. Good, precise instrument flying is the goal and to achieve it F-117 pilots must have solid cross-checks and fly smart.

4.3.1.1 **Set Parameters.** Establish an attitude/power setting that should result in the desired performance. Adjust the attitude/power, if necessary.

4.3.1.2 **Trim.** Trim off the control pressures.

4.3.1.3 **Cross-Check.** Cross-check the performance instruments to confirm desired performance.

4.3.1.4 **Information Management.** If F-117 pilots try to use all the information available from all the displays in the cockpit, it could be overwhelming. The pilot must be able to decide what is needing during each phase of the flight, and how to set up the cockpit. The following is a list of the displays and information available, with suggestions (where applicable) on how and when to use them.

4.3.1.4.1 **Power.** Regardless of whether core RPM, fuel flow, or EGT is used to determine the power setting, they are all presented digitally in the F-117A. This means the pilot must focus on the gages longer to see the information, slowing the cross-check slightly. Also, fan engine characteristics may require the pilot to make more engine adjustments than the pilot may be used to, which will bring these readouts into one's cross-check more often. Know the power setting, airspeed, pitch angle, and descent/climb rate desired for each phase of flight and strive for precision.

4.3.1.4.2 **VSD.** This is a primary attitude indicator for pitch and bank information. This is presented electronically on a CMDI. The VSD should be displayed on the left

CMDI. This will allow rapid cross-check with the main ADI should disorientation become a factor.

4.3.1.4.3 **Main ADI.** This is the secondary source of pitch and bank information on a normal basis, but is the primary source when recovering from an unusual attitude. It is located on the left side of the instrument panel, just left of and below the left CMDI. It may react slowly and precess when the AHRS is driving it.

4.3.1.4.4 **Standby ADI.** This is the emergency source of pitch and bank information. It is very small, low on the right side of the instrument panel, and difficult to see. It is also on the opposite side of the cockpit from the steam gages (e.g., standby altimeter and airspeed), making for a difficult cross-check. One technique to help highlight the standby ADI at night is to set the utility light so that it shines on it.

4.3.1.4.5 **HUD.** This is a secondary source of attitude information under normal conditions, but should not be used for unusual attitude recoveries unless it is the only working attitude reference in the aircraft. It is good for level flight and stable climbs and descents, but its field of view is too small for use in maneuvers using large amounts of pitch and roll, which makes HUD information very dynamic and difficult to interpret.

4.3.1.5 **Performance Instruments.** VSD calibrated airspeed is the primary airspeed reference. HUD calibrated airspeed is the secondary airspeed reference. SD calibrated airspeed repeats the VSD/HUD. It is used to cross-check airspeed during weapons delivery. If recording through the IRADS, make sure the airspeed on the SD indicates what is required because there is some variance between the VSD and HUD.

4.3.1.5.1 **Standby Airspeed Indicator.** This is the normal round gage low on the left side of the instrument panel. It is indicated airspeed and indicates 20 to 50 knots slower (depending on altitude) than the VSD/HUD KCAS (i.e., standby airspeed reads about 200 KIAS when the VSD/HUD reads 250 KCAS). Correction factors are in the Dash 1 checklist.

4.3.1.5.2 **HSD True Airspeed.** This is in the upper left corner of the display. It is used primarily to ensure sufficient airspeed for weapons delivery (i.e., enough for proper GBU guidance). It is also good for calculating turn radii for instruments work.

4.3.1.5.3 **Ground Speed.** This is found in the upper left of the HSD, VSD and HUD displays. It is also shown on the CDNU with GT/GS selected and on the SD. It is used primarily for tactical navigation and timing.

4.3.1.5.4 **VSD/HUD/SD Mach Number.** This is used to monitor aircraft mach.

4.3.1.5.5 **AOA (Gage/VSD/HUD).** This is an excellent airspeed reference when on final approach. It is presented on a gage above the left CMDI as a thermometer-type display in the upper left corner of the VSD display and as a bracket appearing on the HUD. The aural tone associated with AOA is: above 7, low interrupted tone; 9.1 to 9.8, steady medium pitch on speed tone; 9.9 to 11.7, high pitched interrupted tone (the volume cannot be adjusted), above 11.7 high pitched continuous tone.

4.3.1.6 **Vertical Velocity.** The VSD vertical velocity indicator (VVI) is the primary source of vertical velocity information. It is presented as a scale in the upper right-hand corner of each display with a moving arrow and digital readout. It presents instantaneous information and reacts with no lag. It may take awhile to get used to. HUD VVI is a backup to the VSD. The standby VVI is a secondary source of vertical velocity information. It is the normal analog steam gage on the upper left of the instrument panel. Some use it as the primary reference.

4.3.1.7 **Altitude.** VSD altitude is the primary source of altitude information. It has digital readout to tens of feet. If vertical velocity exceeds 2,400 fpm, altitude is displayed to the nearest 100 feet. HUD altitude is the backup to VSD altitude. The standby altimeter is the steam gage on the lower left side of the instrument panel. In the reset mode it repeats the altitude displayed on the CMDI. In STANDBY, or when electrical power has failed, it reads significantly lower than actual altitude (e.g., it says 4,500 feet when altitude is really 5,000 feet). Correction figures in the Dash 1 checklist must be used to determine actual altitude. If the correction factor is not applied, the aircraft will be higher than indicated, which is safe, but it may not be possible to break out on an instrument approach if using uncorrected information.

4.3.1.8 **Heading.** HSD heading is the primary source of heading information. It is electronically displayed on the CMDI. The HSD should be displayed on the right CMDI. VSD/HUD heading is a secondary source of heading information. At the top of each display is a digital readout, accurate to 1 degree, and a 60-degree moving heading scale. The standby HSI is a secondary source of heading information. Under normal circumstances, the heading source is the INS heading. However, in the case of INS or dual generator failure, the AHRS provides backup heading information. The VSD/HSD/HUD drift corrected heading caret shows the magnetic heading to steer to fly a specified course. There is no whiskey compass in the aircraft.

4.3.1.9 **Turn and Slip Indicator.** The normal needle and ball indicator is under the right CMDI. One needle width indicates a 4-minute, 360 turn.

4.3.1.10 **Head-Up Display.** The primary purpose of the HUD is to make the transition to/from instrument/visual conditions much easier. It is excellent for increasing visual lookout, reducing scanning of cockpit instruments, and easing transition to visual references during landing. While the HUD has all the information needed to fly a precision approach, it should be used like any other instrument. Find a place for it in the cross-check, and continue to back it up with information displayed on the CMDIs. Exclusive use of the HUD may lead to varying degrees of disorientation, mainly due to its small field of view. Because of its limitations, it should only be used when situational awareness and conditions allow.

4.3.1.10.1 **Misinterpretation.** Large excursions in pitch and roll are difficult to interpret quickly in the HUD. Therefore, the HUD will not be used for any of the following unless it is the only attitude reference operating: recovery from spatial disorientation, unusual attitude recoveries, and executing lost wingman procedures.

4.3.1.10.2 **Advantage.** The only advantage the HUD has over the VSD is that, while it shows the same information as the VSD, it displays it over the actual terrain. Normally this concerns the flight path marker and where the aircraft is going during landing or during MEA flight when terrain clearance may be questionable.

4.3.2 Instrument Cross-Check. Basic instrument flying involves a thorough, regular cross-check of all performance and control instruments. This normally involves the spoked wheel type of scan, with the attitude indicator at the center, and the other instruments around it. This is impossible in the F-117 due to the physical position of the instruments.

4.3.2.1 **Where to Look.** F-117 pilots have to consciously think about the cross-check, rather than just doing it. The main attitude reference, the VSD, is offset from the center of the aircraft, on the left CMDI. The main heading reference, the HSD, is offset equally far on the right side (the CMDIs are about 20 inches apart.) The engine instruments are even farther to the right, and the needle and ball are under the right CMDI. Essentially, cranium movement is required to do a proper cross-check. This is not only unusual, requiring more thought and work, but can also induce spatial disorientation.

4.3.2.2 **Digital versus Analog.** Thought is required in the cross-check to ensure one is properly interpreting the instruments. The many digital indications give the impression of a lot of swimming numbers. Because the cross-check is spread out and intensive, it can easily lead to channeled attention on one of the instruments, again increasing the chances of spatial disorientation or development of an unusual attitude.

4.3.2.3 **Moving Map.** The moving map display on the right CMDI can also be used to increase situational awareness. The standby HSI can be used to get HSI information. The moving map can be an aid for course guidance, headings, airspace, diverts, weather, and so forth. If the INS fails, the moving map display will be erratic due to the GPS update frequency.

4.3.3 Basic Instrument Approach Procedures.

4.3.3.1 **Precision Approach.** An ILS approach may be selected and flown in a couple of ways.

4.3.3.1.1 **ILS PRE.** When ILS is initially selected, ILS PRE will be displayed on the DEP. The aircraft will continue to follow the current navigation steering mode selected (e.g., MAN HDG) until the localizer is captured. The flight management system (FMS) will then command a 35-degree bank intercept via the bank steering bar. The FMS, however, will not command a turn until within 5 degrees of the localizer. This can lead to a significant overshoot of the ILS localizer course, especially when the intercept angle is great, as in an arc to final. If the FMS is not coupled (hand flying), realize that the bank steering bar may indicate a turn prior to the course deviation indicator (CDI) moving. Use a lead radial or start the turn to final as indicated by the bank steering bar to reduce the overshoot of the localizer. Be aware that if coupled on radar downwind with ILS selected, the aircraft may suddenly turn inbound on an ILS sidelobe. A good technique in this situation is to wait to select ILS until established on base leg.

4.3.3.1.2 **TACAN and ILS PRE.** To reduce the affect of FMS overshoots, the TACAN and ILS may both be preselected. The FMS will command a 30-degree bank intercept to the TACAN final. Once the ILS localizer is intercepted, the FMS steering will revert to the localizer, again flying a 35-degree bank turn, but by then the intercept angle is reduced and the overshoot effects are minimized. A potential problem with this method occurs when the TACAN and ILS final courses differ by a significant amount. If the TACAN course is not within 5.5 degrees of the ILS localizer, the ILS course will not be intercepted. This is especially true for ILS approaches published by Holloman AFB, where the ILS final approach course may be intercepted from an arc and the TACAN final courses are not close to the ILS courses.

4.3.3.1.3 **Glide Path.** Glide Path information will not be reliable until the nose gear is extended, so know what altitude is required and whether intercepting glideslope from above or below.

4.3.3.1.4 **ILS Data.** There are three places to monitor ILS information. The raw ILS information on the CMDIs (HSD/VSD) should be the primary and most reliable source of data. Use the HUD ILS steering bars for basic trend corrections. Glance at the AHRS (HSI/ADI) to ensure backup data is accurate.

4.3.3.1.5 **PAR.** With the deactivation of most PAR systems, chances of flying one are low. However, these procedures are performed in the simulator. Normal radar pattern speed is 250 KCAS. If the pattern is tight, consider lowering the landing gear on base (a good rule of thumb is 14 DME). After lowering the gear, 190 to 220 KCAS is a good maneuvering airspeed until established on final. When configured, straight and level, set throttles at approximately 91 to 93 percent to hold approach speed. When told to begin descent, lower the nose and set the vertical velocity symbol at the glideslope (e.g., 2.5 to 3 degrees). Retard the throttles to approximately 82 to 84 percent (assuming on-speed at the start of the descent). As a rule of thumb, do not exceed 1,500 fpm rate of descent to recapture the glide path from above. If well below the glide path, level off rather than climb back to glideslope. Use the table in the back of the approach book to determine the appropriate VVI to maintain glideslope or use the following rules of thumb: 2.5 degrees ground speed divided by 2, times 10 minus 100 or 3 degrees ground speed divided by 2, times 10.

4.3.3.2 **TACAN Approach.** This approach can be flown coupled all the way to the missed approach point (MAP). However, very close monitoring is strongly recommended for coupled flying between the FAF and MAP, even in day, VFR. The descent from FAF altitude to the MDA is steep since the autothrottle will pull the throttles to idle and make a disconcerting dive to attain the MDA set in the DEP. A 10 degree dive is not unusual. In turbulent or hot weather, the power addition at level off can be slow enough to be eye watering. A better technique is to hand fly the plane to the MDA, then set the MDA in the DEP. Another technique is to initially set an altitude higher than MDA in the DEP, which at least helps if the airplane overshoots the altitude on level off. (This technique may also be too much work, given time from FAF to MAP versus DEP key punches required.) Finally, the same technique for setting airspeed mentioned for ILS applies to TACAN approaches as well.

4.3.3.3 **Backup Approaches.** During training and possible emergency procedures, CMDI-out approaches will be flown. Remember, the standby airspeed indicator reads low, so apply the corrections from the Dash 1 checklist. When practicing these approaches, leave the HSI select switch in BUS and use the DEP to select approach steering modes. If the DEP fails, select TACAN or ILS on the AUX NAV panel, as desired, so the HSI displays the correct CDI displacement.

4.3.4 Instrument Approach Autopilot Use. AP/AT instrument work is a two-edged sword. AP/AT capabilities can ease instrument burden and comfortably deliver the aircraft on-speed, on-altitude to some point on an approach. However, one can easily be lulled into complacency or distracted. The following are some considerations for AP/AT use.

4.3.4.1 **Scan.** Keep the instrument scan going! Since the autopilot is doing all the work, it is easy to become complacent.

4.3.4.2 **DEP Flying.** Do not just fly the DEP! One can become preoccupied with DEP key punching and forget about flying the plane.

4.3.4.3 **Approach to IAF and/or Holding.** Set altitude and desired speed in ALT and SPD on the DEP. Holding procedures mentioned above still apply. Selecting ILS, TACAN, or MAN HDG will provide command steering with a maximum of 30 degrees of bank. For holding, use TACAN steering to the holding fix and then use MAN HDG for the outbound leg. There is a chance that the aircraft will turn in the wrong direction when turning to the outbound heading. One technique is to set the present heading in the MAN HDG course just prior to reaching the fix. When at the holding fix, manually change the heading using the heading set knob on the AUX NAV panel, being sure to turn the knob in the correct direction of turn. At the turn-in point, reselect TACAN to the fix.

4.3.4.4 **Penetration.** The descent altitude and penetration speed can be set in the DEP. Use caution when entering data into the DEP and stay ahead of the aircraft by presetting values. Also, remember that all autothrottle descents use idle.

4.3.4.5 **Intercepting Final.** As you approach the final approach course, recouple ILS and/or TACAN. The Dash 1 states that the autopilot may make a poor capture of the ILS approach course if the intercept angle is 90 degrees. As mentioned before, this situation exists at Holloman when intercepting the ILS from the arc. There are several techniques that may help avoid the problem. Figure out a lead radial and then use MAN HDG or Heading Select knob to start the lead turn. Have the autopilot intercept the TACAN course from the arc, then switch to ILS somewhere during the turn or afterwards. However, due to TACAN and ILS course differences, ILS course capture still may not occur if the TACAN course is closer to one's position than the ILS course. Finally, hand fly the intercept turn until on course, then recouple.

4.3.4.6 **Engagement Limits.** The autopilot should be disengaged prior to landing. Approaching DH or MDA is a good point to deselect autopilot for landing or go-around.

4.3.4.7 **Fully Coupled ILS.** The F-117 is capable of fully-coupled ILS approaches. It will maintain the course and, when approaching the glide path, automatically switch from altitude hold to GSL and start down the glideslope.

4.3.4.8 **Speed.** Although 9.5 AOA is the proper final approach speed, the autothrottle is slow to respond to wind gusts or turbulence. In such cases, the AOA aural warning steady tone will frequently come on when the plane overshoots 9.5. Setting 9.0 AOA is one technique of eliminating this nuisance while still flying reasonably close to the planned AOA. The approach AOA for gusty or turbulent winds is 8 degrees.

4.3.4.9 **Missed Approach.** The missed approach should be hand flown. In the immediate action, low-altitude environment of a missed approach, playing keypunch on the DEP is highly inappropriate. The pilot-activated aircraft recovery system (PAARS) ***should not*** be used for missed approach/go-around. Advance the throttles to maximum and raise the nose to takeoff attitude (8 to 10 pitch attitude or 5–degree pitch line even with the airspeed and altitude boxes in the HUD) and retract the gear with two positive climb indications. The minimum rate of climb should be around 500 to 800 fpm or the climb gradient if published. Once established with the climb gradient at 220 to 250 KCAS, reduce the throttle to 90 to 92 percent. A common error is to accelerate through 250 KCAS.

4.4 Spatial Disorientation. Spatial disorientation may have been the primary cause in three fatal F-117 accidents. All occurred on dark, moonless nights, over sparsely populated, unlit terrain. Investigation findings indicate that when recovery procedures were attempted, they were too late. Better training on night hazards, visual and sensory illusions, and unusual attitudes may have allowed the pilot of each aircraft to recognize the situation before it became unrecoverable. There are two types of spatial disorientation.

4.4.1 Type I Unrecognized Spatial Disorientation. This is the major type of spatial disorientation and the routine cause is loss of situational awareness. This is usually caused by lack of visual cues, which leads to disorientation. Experience shows this type may go totally unrecognized, especially if busy, pressed, stressed, preoccupied, or distracted.

4.4.2 Type II Classic Spatial Disorientation. This is overt and fully recognized by the pilot. It involves a sensory conflict, usually induced by a visual or vestibular illusion. What the pilot sees outside, or feels with the body, conflicts with the aircraft instruments. Symptoms from this vary from mild to incapacitation, depending on the extent of the illusion.

4.4.2.1 **Focal Mode.** This mode operates independently and answers the question, What is the eye (the pilot) looking at? This is the mode used when looking at targets, reading instruments and displays, and essentially provides the brain with detailed information. The focal mode can keep the pilot oriented but requires good lighting, good visual acuity, and active thought. It is the mode we use in the F-117 to maintain orientation.

4.4.2.2 **Ambient Mode.** This mode answers the question, Where am I (the pilot) in space? This is a subconscious function, which analyzes hearing, peripheral vision, muscle sense, and balance, and can be easily deceived. When the visual part of this mode (peripheral vision) is lost, disorientation occurs quickly. Unfortunately, this is the mode most pilots are used to using, as it is fast, automatic, and requires no conscious attention.

4.4.3 How It Relates to the F-117. Because of the lack of cues in the F-117 and night operations, pilots depend on the focal mode for orientation. If forced for some reason to leave the focal mode (e.g., distraction or getting busy), subconsciously pilots return to the ambient mode, which is deficient in the F-117 and can lead to disorientation. Humans cannot tolerate the sensation of getting disoriented. They will seek to orient themselves with whatever cues are available, and accept them with few questions. Without adequate visual cues, the ambient mode takes over, and creates a powerful expectation of orientation that may not be consistent with what is really happening. In a high stress state, we revert to a more firmly established, primitive, fight or flight behavior pattern. We pay more attention to vestibular (inner ear) signals than instruments display. We lose (forget) recently acquired skills. Under severe stress pilots may lose the ability to interpret instruments. Before the ambient mode becomes overwhelming, work to get back to the focal mode as soon as possible. Do this by returning to the basic flight instrument information or disorientation will result (usually in less than 60 seconds when straight and level—less in a turn).

4.4.4 Unusual Attitudes and Spatial Disorientation. Unusual attitudes and spatial disorientation go hand-in-hand. In fact, many of the situations that cause unusual attitudes can also cause spatial disorientation. Usually, spatial disorientation is caused by lack of adequate attention to aircraft attitude.

4.4.4.1 **Spatial Disorientation Accidents.** Normal F-117 flying operations occur in the flight regimes where this is most prevalent—night/IMC. Spatial disorientation is the cause of approximately 9 percent of all Class A accidents. Between 1976 and 1997 there were 81 spatial disorientation mishaps in fighters, with 52 of them flown into the ground. Sixty-seven fighter aircrew members died due to spatial disorientation during this time period. The survivors reported not recognizing their situation until they were too low to attempt recovery, or they recognized their unusual attitude but were unable to make appropriate control inputs.

4.4.4.2 **F-117 Spatial Disorientation.** If an unusual attitude is not recognized early, the disorientation experienced and the accompanying degradation of flying skills become so intense the probability of safe recovery is very low. Hence, the need for early recognition or prevention of unusual attitudes. During takeoff roll at night, F-117 pilots are at risk of developing spatial disorientation. F-117 pilots have decreased visual inputs due to the lack of definable horizon, poor forward cockpit visibility, and most F-117 flying is conducted over sparsely populated terrain with little or no ground lighting. The takeoff leg is especially deceiving. Rolling down a fairly well lit runway, rotating, and climbing out over absolutely black, desert terrain can make the transition to instruments difficult. As a result, most takeoffs will be instrument takeoffs, even in good weather. There are no cues to indicate airspeed from engine RPM sounds, air rushing over the canopy, or airframe rumble/buffet. Interior noise is essentially unchanged from takeoff to landing, regardless of airspeed or angle of attack.

4.4.5 Unusual Attitudes. Night and/or IMC are the situations when pilots are most likely to experience an unusual attitude. Though every aircraft has its pitfalls, the F-117 and the mission it performs seems to provide a disproportionate share of opportunities for unusual attitudes. The SD is very bright and can ruin night vision. The picture it presents is often not the same as aircraft flight path, but instead represents the point where the FLIR/DLIR is cued. Even when TM is selected, the picture gives no sense of depth and is distorted by magnification. For any or all of the above reasons, the SD should be turned down when outside or other reference is essential (i.e., approach and landing). When SD reference is essential, as in weapons delivery, try to scan all available SD information at set intervals during the attack.

The SD provides airspeed, altitude, autopilot and, with the flight attitude awareness display (FAAD), even attitude information. In spite of all this information, it is easy to become channelized in target search and tracking and disregard it. There may be times when the pilot has to turn and look down at the CDNU or concentrate on the right CMDI to glean information from the Edit Page. A couple of examples are checking winds (CDNU) or projected time over a point (EDIT). Cranium movement associated with looking down at the CDNU display can lead to a case of the leans. One can fixate on sorting out Edit Page information. It becomes important to plan moves so tasks are completed efficiently without inducing vertigo or sacrificing instrument scan.

4.4.5.1 **Night Tanker.** Night tanker rendezvous are full of opportunities where channelized attention can occur. Once visual on the tanker, staying visual is important, but fly the aircraft. If hand flying and not referencing the instruments, altitude, attitude, and airspeed can vary widely. To aid the tanker rendezvous, it is possible to reference the autopilot in pitch and maneuver without worrying as much about altitude control. Consider referencing an airspeed. A technique is to use control stick steering. This involves leaving the autothrottle and autopilot on and referenced and bumping off the roll autopilot. This allows steering at less than 50 degrees (autopilot) and gives the wingman more consideration while staying in a separate altitude block.

4.4.5.2 **Multi-Ship.** If doing a 20-second trail departure, there is the added problem of trying to keep lead in sight as well as the tanker. As a wingman, it is easier to keep everything in perspective when lead is not allowed to get too far away. Distance and closure rates on the F-117 are difficult enough to judge during the daylight, let alone a moonless night. Consider pre-briefing set airspeeds and changes, and have the wingman fly a trail position low enough to see both wing tip lights and the rotating beacon.

4.4.5.3 **Weapons Delivery.** On the target run success or failure boils down to actions taken over a very few seconds. Switches for weapons delivery are located in literally every quadrant of the cockpit. Set initial switch settings early and have a well-thought-out plan for quickly checking them. Some people use 3-3-3, others use a Z across the cockpit to ensure they touch each applicable area. The SD contains a wealth of information on the screen including altitude, attitude, airspeed, and autopilot status, but becomes difficult to internalize when the search for a tough desired mean point of impact becomes paramount. Try to keep a cross-check going. In fact, when migration into the SD starts, physically push yourself back in the seat and watch what happens; it may be easier to pick up switch errors, landmarks may appear that were not visible through the soda straw, and the radio may be audible again.

4.4.6 Prevention. Recognize the threat. Think about spatial disorientation when planning and studying the mission, weather, terrain, and maneuvers. Set up the cockpit with the VSD on the left side next to the ADI to quickly compare the most accurate instruments. Set lighting to read instruments at all times, but not so bright that it reflects off the canopy and prevents from seeing outside. The moving map may increase situational awareness. Anticipate. Realize it will probably happen and maintain a good instrument cross-check. Believe the instruments. Review the position of the PAARS button on the stick.

4.4.7 Unusual Attitude Recoveries. In order to initiate actions that may save the aircraft, the situation must be analyzed instantly.

4.4.7.1 **Recognize.** Recognize the unusual attitude, confirm it using all instruments, and use the main ADI as the primary reference for recovery.

4.4.7.2 **Manual Recovery.** If disoriented at night, get control of the aircraft, then concentrate on getting the gyros straight. Concentrate on the instruments, ***but not the HUD***. If still having trouble, fly straight and level for 30 to 60 seconds and concentrate on the ADI. Use the autopilot. Start a good cross-check and do not fixate on any one instrument. Manual recovery by a pilot who has properly determined the situation will probably be quicker than using PAARS. The multicolored VSD display allows a simple snap reference to determine attitude: Lots of brown means nose low, lots of blue means nose high. The VSD will always show at least 10 degrees of sky or dirt regardless of the aircraft attitude. This happens as the aircraft passes approximately 20 degrees nose high or low and the horizon line disappears. The ladders on the VSD are not proportional (i.e., 40 degrees nose low looks the same as 70 degrees nose low). For pitch angles above 45, the Dash 1 recommends applying max power, unloading to reduce AOA below 10, rolling the aircraft as required to inverted, and pulling the nose below the horizon. In either case, complete the recovery when the nose is below the horizon and the airspeed is increasing above 200 KCAS. One of the prime dangers of a nose high unusual attitude is the corresponding airspeed loss and its effect on F-117 flight. The following are some Dash 1 warnings and cautions (for further reference see Dash 1, section VI).

WARNING: Do not use HUD as the primary reference for recovery from an unusual attitude unless it is the only attitude instrument available.

4.4.7.2.1 **Power.** Even at max power, airspeed bleed off can be as fast as 30 KCAS per second in nose high situations. It can be faster with high load factors and low power settings.

4.4.7.2.2 **Airspeed.** AOA and sideslip information to the FLCC is inaccurate below 125 KCAS, so if AOA limits are exceeded or very large sideslip angles are attained below 125 KCAS, control can be lost and ensuing recovery will be very unlikely. A minimum of 140 KCAS provides a safety margin.

4.4.7.2.3 **AOA.** Negative AOA. Monitor AOA during any negative G maneuver at low speeds (less than approximately 200 KCAS) where a large negative AOA could be attained. Attempt to maintain AOA more positive than negative 8. Otherwise an uncontrolled pitch down can occur with recovery very unlikely. Positive AOA limits are 14 gear down and 12 gear up. The FLCC AOA limiter works as long as airspeed is greater than 125 KCAS. As mentioned, 140 KCAS is a good safety margin speed.

4.4.7.3 **PAARS Recovery.** If unable to positively determine (i.e., when experiencing serious disorientation, confusion, and vertigo), use PAARS. Know the PAARS button location cold—sounds funny, but life may depend upon how quickly and accurately the button is depressed. Hitting PAARS does not release the need to regain control of the situation. Pilot recognition and recovery from a situation will probably provide the most expeditious recovery of both the aircraft and internal gyros, but if mentally incapacitated or just not sure, use the PAARS button. PAARS will recover the airplane from most unusual attitudes, but depending on severity, can command some aggressive maneuvering and will probably aggravate the disorientation problem. Concentrate on what PAARS is doing, note the predicted recovery altitude and consider ejection if it is close. Let PAARS fly until sure of bearings, then concentrate on a good cross-check and consider bringing the aircraft home. The PAARS can only command +3.4G to -0.8G. The PAARS is deactivated with the air refueling door open and less than 45 degrees of bank, pitch less than 25 degrees nose up or pitch less than 20 degrees nose low. This prevents the possibility of inadvertently activating the PAARS during air refueling. Also, if the aircraft gear down, the PAARS is deactivated with less than 20 degrees of bank, 15 degrees nose up or 10 degrees nose low. These prevent PAARS activation during landing.

4.4.8 Illusions. Illusions are possible in the F-117 flying environment.

4.4.8.1 **Oculogravic Illusion.** This is the apparent movement and false localization of visual targets (e.g., ground lights or stars) caused by aircraft acceleration or deceleration. On acceleration, pilots may notice an apparent change in nose attitude (upward movement) and displacement of objects in the visual field of view. The opposite may occur on deceleration. Normally, this is easily suppressed by good external visual cues. Dark nights and the black hole effect eliminate those cues and the danger occurs when false corrections are made without checking the instruments.

4.4.8.2 **Somatogyral Illusion.** During a prolonged maneuver at a constant angular speed (i.e., a sustained roll or turn), the semicircular canals give correct information only during the first few seconds of the maneuver. Again, visual cues normally compensate for this. At night, as soon as recovery is started from the maneuver, the resulting angular acceleration gives the sensation of a turn in the opposite direction. Although recovery is correct, the feeling is rolling in the opposite direction and wanting to make an inappropriate control movement to counteract the illusion, leading to even more confusion. Nystagmus (uncontrollable eye movements relating to the stimulation of the semicircular canals) can aggravate the situation by making the instruments harder to read.

4.4.8.3 **Differential Illusion.** This is an erroneous perception of aircraft attitude in a sustained turn due to seat of the pants G sensations. A 30-degree bank level turn can feel the same as a 60-degree bank descending turn because the G exerted on the body in both turns is the same. Correct aircraft attitude can only be determined by reference to the instruments.

4.5 Abnormal Procedures. As with other aircraft, the basic priority order of aviate, navigate, communicate still applies. Maintain aircraft control first and accomplish any boldface procedures. If any anomaly or system problem develops, request off frequency and discuss the problem with the flight lead or wingman. If the SOF is not F-117 qualified, briefly describe the problem and request that squadron ops come up on the SOF frequency or channel 14 for assistance.

4.5.1 Aborts. If aborting a takeoff, especially at high speeds, retard the throttles to idle, deploy the chute, and be prepared to lower the hook. Check your airspeed approaching the 5,000 feet remaining marker. On a dry runway, if greater than 155 knots or if there is any doubt about stopping before the end of the runway, begin maximum braking and lower the hook. Square up with the cable as near the center as possible and release the brakes for the engagement. Use power to control rollback, not the brakes, as the aircraft might sit on its tail. In any case, if the ability to stop in the available runway is in question, do not hesitate to use the hook. The decision to abort must consider many factors: aircraft malfunction, pressure altitude, temperature, runway length, cables, aircraft speed, max abort with chute, and so forth. An inoperative fuel gage (in test) or NWS light at 150 knots would not be cause to abort. Think about the malfunction before deciding to abort. One technique is to abort for engines, flight controls, or fire. Check for hot brakes any time aborting above 100 knots. Design engineers provided the data in the table below. (See **Table 4.3**, Aborts.) The numbers in this table are based on a standard day at 4,500 feet MSL, no wind, 3-second reaction time, throttles in idle, and max braking.

Table 4.3 Aborts.

Airspeed at 5,500 Feet Remaining	Action
< 125 KCAS	Action without chute—max braking should stop the aircraft with approximately 1,000 feet remaining with no brake fires—dry runway.
< 165 KCAS	Action with chute—max braking should stop the aircraft with approximately 1,000 feet remaining with no brake fires—dry runway
< 115 KCAS	Action with chute—max braking should stop the aircraft with approximately 1,000 feet remaining with no brake fires—wet runway
OVERALL NOTE: *The above numbers and criteria were developed for a 45,000-pound aircraft (F-117 typical takeoff gross weight).	

4.5.2 Possible Loss of Aircraft Zone. If an engine fails on takeoff, it is imperative to accomplish the boldface immediately; this aircraft is very underpowered compared to other fighters. Accelerate through the possible loss of aircraft zone (PLAZ) before accomplishing any other steps; use the flat area over the remaining runway to fly level and build up speed as much as possible before starting the climb. If the airplane touches down, use the remaining runway to accelerate. Keep the AOA below 10 and retract the gear as soon as possible after takeoff, once safely airborne. If the aircraft is settling back to earth, do not raise the gear. A slight bank (5 degrees) into the good engine with rudder to zero the beta, will provide the best acceleration.

4.5.2.1 **Weapons Jettison.** Weapons jettison of a 2,000-pound weapon will reduce the single-engine climb speed by approximately 9 knots, and the results are immediate. Opening a weapons bay door in the first few seconds following an engine failure will momentarily increase sideslip and may complicate aircraft control. Be prepared for momentary yaw and roll deviations as a weapons bay door opens.

4.5.2.2 **Fuel Dumping.** Fuel dumping will also reduce the gross weight and lower the single-engine climb speed. However, it will take longer to dump 2,000 pounds of fuel than it would to jettison a weapon.

4.5.2.3 **Additional Procedures.** After any close-in obstacles are cleared, using no more than 10 degrees AOA, level off and accelerate to the single-engine climb speed. While maintaining the single-engine climb speed, climb to a safe altitude (1,000 feet AGL minimum) and then level off and accelerate (220 KCAS minimum). Climb and maneuver as required at no more than 7 degrees AOA. Fly the pattern at 250 KCAS, if possible, and never go below 220 KCAS until configured and intercepting the glide path. One technique is to hold 250 KCAS until gear are lowered. Another technique is to hold 250 KCAS on downwind, 240 KCAS on base, and 230 KCAS on final until gear are lowered.

4.5.2.4 **Intercepting the Normal Glide Path.** Just prior to intercepting normal glide path (at approx 6 DME), lower the gear and fly a 7-degree AOA (maximum) approach as you start down. Be aware that the aircraft is close to 7-degrees AOA when the top of the bank steering bar in the HUD touches the bottom of the Big E reference. Also, the low intensity aural tones start at 7 degrees AOA. The 5,600 foot pattern is for training purposes and ATC restrictions. Consider a wider pattern and longer final. Flying with a slight bank (at approx 5 degrees) into the good engine is a technique to hold heading or to which good engine side rudder can be added. Ball is another technique to hold heading. Bank angle while flying the pattern is important. There is no maximum bank angle, but a rule of thumb is as airspeed increases above 220 KCAS, bank angle can increase above 30 degrees. Do not try using 45 to 60 degrees of bank near 220 KCAS or the aircraft's speed will drop below 220 KCAS.

4.5.2.5 **Approach Considerations.** A few notes about the approach are in order. Be careful about attempting level flight, single-engine, and gear down. This can be difficult, perhaps even dangerous, on summer days at Holloman AFB. Also, if attempting a single-engine ILS in night/actual instrument conditions, glideslope information does not appear until the gear is lowered. A technique for the single-engine approach to runway 16 only is to be at 7,000 feet MSL (3,000 feet AGL) at 11 DME (the 7/11 technique). This puts the aircraft close to the ILS glide path before lowering the gear. Yaw auto-trim will be effective with the gear up but must be zeroed out after lowering the gear. Use rudder to correct excessive yaw, and release the pressure while reducing power. Once landing is assured (approximately over the approach lights), start slowing to 9.5 degrees AOA. Be careful about holding too much airspeed until landing. Remember, if the drag chute fails to deploy, it is going to be extremely difficult to stop the aircraft if flying a faster than 7-degree AOA approach.

4.5.3 No Radio. If in day formation, the aircraft with the good radio should be given the lead. The pilot with the good radio should request clearance to the initial approach fix (IAF) and inform the controlling agency of the situation. The flight will hold until the F-117A has less than 7,000 pounds of fuel remaining. The aircraft with no radio (NORDO) will then fly a 9.5-degree visual straight-in and land with the chute. If the chase is NORDO, the chase will then do a closed pattern to a full stop. If single-ship, comply with the IFG.

4.5.4 Fuel Malfunctions. Fuel indicator malfunctions, fuel transfer problems, and fuel leaks can occur with limited warnings to the pilot. A good technique is to fly with fuselage total (FUS TOT) selected on the fuel indicator so side-to-side imbalances will be easily recognizable. Look for proper feed and balance on each fuel check. At times (e.g., steep turns), the FUEL IND light on the annunciator panel will illuminate, and the indicator will show a BIT light. The system is either doing a BIT or showing a strange reading (e.g., all zeroes). Usually the abnormality will go away by itself, but you can clear it by simply doing a fuel indicator BIT test. If that does not clear it, monitor balance, follow the checklist, and abort the mission if necessary. Fuel transfer problems most often appear to be trapped fuel at first, and then are recognized as slow feeding tanks. Check the fuel dump circuit breakers. If the L FUEL DUMP or R FUEL DUMP circuit breaker is popped, fuel sequencing may be abnormal. Whether the fuel is trapped, or just slow to feed, the best course is to determine usable fuel remaining, monitor the feed and balance, and determine whether to abort the mission. Fuel imbalance may result from asymmetrical fuel loading, one engine having a higher fuel usage, unequal engine demand flow from tank to engine, or a fuel leak on one side. One technique to correct the imbalance is to increase the high side fuel flow by twice the imbalance. For example, the left side has 4,000 pounds of fuel and the right side has 3,600 pounds of fuel. Set the left side fuel flow to 800 pounds/hour more than the right side. Using this technique, if the imbalance gets worse, immediately suspect a fuel leak. Remember, if the autothrottles are engaged, as they move the fuel flow imbalance may not remain constant.

4.5.5 Inertial Navigation System Malfunctions. The INS Alert indicates a hard INS system failure. Accomplish the INS failure checklist in the Dash 1 checklist. CK INS alert usually appears if the INS estimated drift rate exceeds 0.7 NM/HR. Do not do an air alignment as long as the INS is accepting GPS updates. The Kalman filter assumes the INS will only drift at a specified rate. If the INS is actually drifting faster than anticipated, the GPS updates eventually fall outside the acceptable window. Kalman assumes the GPS is in error and rejects the update. An air alignment may be necessary. The use of INS/GPS mode after an air alignment masks the accuracy of the alignment. If GPS aiding is subsequently lost, the drift rate will probably be high. Consequently, the use of air alignments should be kept to a minimum; do not do it unless it is absolutely needed. An air alignment can only be accomplished with a State 5 GPS. Follow the steps in the cold start air alignment checklist with the following considerations:

- Turn the INS OFF for approximately 30 seconds (to permit a complete INS shutdown) before cycling it back ON. It is very important to remain straight and level for the first 30 seconds (1 minute recommended) of the alignment.
- Maneuvering the aircraft greatly reduces required alignment time. The optimum maneuvering seems to be about 30 degrees of bank for 30 degrees either side of the initial heading. However, normal maneuvering can be accomplished after the initial straight and level period.
- Air alignments conducted with no maneuvering will take significantly longer to perform.

CHAPTER 5

AIR-TO-SURFACE

5.1 General. Precision surface attack is the primary mission of the F-117. With its long-range low observable (LO) design, and precision bombing capability, the F-117 offers the component commander the ability to strike high-value, high-priority targets in almost any threat environment. This chapter presents the fundamentals of surface attack planning and execution as they relate to two employment arenas: the controlled range (i.e., dropping practice ordnance from "canned" delivery patterns) and uncontrolled range or airspace (i.e., conducting tactical employment with live or simulated weapons).

5.2 Mission Planning. Although this volume offers extensive information on the basics to properly employ the F-117, refer to AFTTP 3-1, Volume 18, *Tactical Employment—F-117* (for tactics); AFI 11-2F-117, Volume 3, *F-117—Operational Procedures*; and AFI 11-214, *Air Operations Rules and Procedures* (for regulations); and the appropriate Dash 34 TO (for hardware and software specifics). Items common to surface attack sorties may include:

- Mission objectives.
- Threats.
- Weather.
- Terrain.
- Ordnance load.
- Weapons employment data.
- Tactical deception.
- Formations.
- Fuel.
- Communications.
- Support forces.
- Takeoff and landing data.
- Aircraft weapons delivery history.
- Ordnance preflight.

5.2.1 Mission Planning. Whether planning a continuation training (CT) sortie or an actual combat mission, the objective is to inflict damage on the assigned target. Total or 100 percent destruction is usually desired but may be difficult to achieve depending on resources or weapons availability. When planning the mission, the task is to achieve the highest level of damage with the weapons provided. Factors to consider include the following:

- Target—location, size, composition, coordinates, and imagery.
- Threats—location, type, numbers, status, and capability.

- Air tasking order (ATO) restrictions, special instructions (SPINS), and rules of engagement (ROE).
- Weather—day, night, IMC, haze, dust, humidity, snow, and illumination.
- Force composition—flight size and support assets.
- Weapons—precision guided, cluster, or general purpose (GP); numbers; fuzes and options; and JMEM air-to-surface weaponeering system (JAWS) considerations.
- Delivery—target acquisition versus exposure, weapons accuracy, and effectiveness.

5.2.2 Planning Delivery Parameters. Determine mission ordnance and select the best attack profile; next, determine the minimum release altitude (MRA). Dud bombs, fragging an aircraft, or ground impact can result from poor planning. The selection of minimum acceptable release altitude for the F-117 is based on four considerations: fuze arm, safe escape, safe separation, and weapons effects.

5.2.2.1 **Fuze Arm.** The release must be high enough to ensure the TOF is sufficient to allow for fuze arming prior to weapon impact.

5.2.2.2 **Safe Escape.** Safe escape is the lowest release altitude where the probability of self-inflicted damage is less than 0.1 percent or 1:1,000.

5.2.2.3 **Safe Separation.** Fuze arm times must allow sufficient weapon separation from the aircraft such that if the fuze functions at arm time, the aircraft has less than 0.1 percent probability of frag damage.

5.2.2.4 **Weapons Effects.** Release altitude may be dictated by required specific weapons affects.

5.2.3 Minimum Release Altitude. There are several options available to help compute weapons delivery parameters. Each fighter squadron has a mission planning system (MPS) and a computer with conventional weapons delivery system (CWDS) software capable of computing weapons delivery parameters. Operation of these computers is relatively easy to learn. Although the computer provides minimum release altitudes (MRA), it is still necessary to learn to calculate the minimum safe release altitude for the applicable fuze, munitions, and delivery. By using the Dash 34 charts and tables, all necessary values can be manually calculated. There will always be times when the computer or pilot aid is not available. All pilots need to know how to manually calculate delivery parameters.

5.2.4 Mission Briefing. After all planning is complete, ensure enough copies of mission materials are available for each flight member (e.g., line-up card, Form 70, photo pack, coordination card, and weapons card) and start the mission briefing. Brief as much as possible as "standard" and concentrate on the "meat" of the mission—the target attack. Do not slight items such as tanker procedures or en route navigation, but realize that minor errors or confusion in these phases probably will have less of an impact on the overall success of the mission than a dry pass on the target. Ensure all flight members are clear on their responsibilities before they step to their aircraft. At a minimum, be prepared with the following:

- Note minimum altimeter settings, and absolute humidity.

- Check notices to airmen (NOTAMS) for all potential divert airfields.
- Review the emergency procedures and weapon of the day and be ready to discuss both in detail.

5.2.5 Prior to Step. Refer to OG OI 10-1, for weapons delivery responsibilities, procedures release parameter requirements, and scoring criteria. Extensive mission preparation is required for a successful SA ride. Seemingly minor details can determine success or failure. One digit mistyped on a target coordinate can make something that appeared relatively simple, impossible.

5.2.5.1 **AF Form 70 Study.** This was extensively discussed in **Chapter 4**, "Aircraft Basics and Instruments." However, a few items rate detailed attention.

5.2.5.1.1 **Record Targets.** Check to see which deliveries are record/non-record/non-counter. This is not really a factor in initial qualification training (IQT)/mission qualification training (MQT), but will be important later.

5.2.5.1.2 **Ordnance.** Check type of ordnance and whether ordnance is to be dropped. Remember to ensure proper ordnance codes are set in the weapons loading panel (WLP) and stores management display (SMD). The WLP should always match the ordnance. The exception is the travel pod which will show blank.

5.2.5.1.3 **Leg Time/Speed.** Check leg time/speed to get an idea how busy each target run will be. Speed can also be important because some weapons require a minimum speed for release.

5.2.5.1.4 **Type of Delivery.** For syllabus and AFI 11-2F-117, Volume 1, *Instrument Flight Procedures* purposes, determine if instructor pilot (IP)/mission lead expects DLIR-only, Offset, Dual Door, or CMDI deliveries.

5.2.5.1.5 **Heading and Altitude Changes.** These can reduce leg time and/or increase workload on the target run.

5.2.5.2 **Photo Pack Study.** "Study the target photos as if your reputation depends on it, because it does." An overstatement perhaps, but formal training unit (FTU) weapons qualification, MQT Checkride, Ops Squadron hit rate, and success against Little Kim, or whomever else wants to take on the US, depends upon a pilot's ability to hit the target. Finding the target involves knowing it and its surroundings. Though target study is important, there are probably as many techniques to photo study as there are pilots in the wing. The following paragraphs will attempt to provide an overview of the more important points as well as a brief look at different methods.

5.2.5.2.1 **IRADS Factors.** When looking at the photos, remember that the infrared acquisition/designation system (IRADS) sees the target as a function of IR emissivity, not as a function of the eye. Volumes can be, and have been, written about IR target signatures. The following is a general discussion.

5.2.5.2.1.1 **Day versus Night.** Sunshine may heat asphalt and tile/tar shingle rooftops to where they stand out like beacons, or flood the picture, on the sensor display (SD). Any structure facing the sun, particularly in the afternoon, should be highly visible in the IRADS. After sunset, sun-heated items will start to cool.

5.2.5.2.1.2 **Time of Day or Night.** In the mornings, roads and rooftops will not stand out as well as in the afternoon. Rooftops may still appear hot at night when surrounding features have cooled because the structures on which they rest have interior heating. At night, roads may cool to a point where they show colder than their surroundings.

5.2.5.2.1.3 **Thermal Crossover.** At some point in the above cycle, usually twice a day, the target will be the same temperature as its surroundings. IR sensors cannot distinguish between two objects of the same temperature. The good thing is that the entire target usually does not experience thermal crossover at the same time. Having a good idea of what to expect before you step may mean the difference between a hit and a miss.

5.2.5.2.1.4 **Types of Structures.** Factories and refineries will normally show hot. A structure's appearance will depend on whether it is heated. The age of the photo may be another factor. Man-made structures and the surrounding terrain may have changed significantly since the photo was taken.

5.2.5.2.1.5 **Season.** Summer days feature a maximum IR return. Winters are opposite; so much so, that features expected to show do not unless heated somehow (by sun or interior). Also remember that deciduous trees that show on a summer photo may disappear along with their leaves in the winter. And snow on the ground definitely changes the way the ground looks as compared to the photo.

5.2.5.2.1.6 **Dirt Targets.** Unlike cultural targets (structures), dirt targets such as the bombing circle and tactical bombing layout at Red Rio are highly dependent on how the ground is plowed and on environmental factors.

5.2.5.2.1.7 **Vegetation.** Vegetation generally shows cool. It can also mask a not-so-warm target if it sits among trees.

5.2.5.2.2 **Weather.**

5.2.5.2.2.1 **Absolute Humidity.** Hazy, high humidity days can reduce IR vision to the point where an entire target area may not show until late. The weather shop can forecast the absolute humidity for the target area and also run a tactical decision aid (TDA) to help in determining when to expect acquisition of the target. Absolute humidity can range from less than one gram per cubic meter (g/m^3) in extremely dry climates to over 20 g/m^3 in coastal regions. Clouds are often a by-product of high humidity and are a definite target-area consideration.

5.2.5.2.2.2 **Wind.** Wind may reduce a target's contrast by dissipating the heat and bringing everything to a more uniform temperature.

5.2.5.2.2.3 **Temperature.** The IRADS is optimized for nighttime use when IR returns are expected to be lower. If a daytime attack is necessary, IR returns are much higher with the increased temperatures. The result is targets that tend to "balloon out" and lose distinctive edges because excessive energy is overwhelming the sensors. Lower gains will be required.

5.2.5.2.3 **Relationships.** Even more important is establishing spatial relationships between various features in the photos. Look for big features to lead to other features, which will lead to the target. Some ideas and techniques follow.

5.2.5.2.3.1 **Structures.** One technique favored by many pilots is to pick a set number of items for each size range. For example, pick three big structures/landmarks that can be relied upon to appear—freeway overpasses, runways, shopping centers, football fields, mountains, or lakes. From these work into three smaller features that are closer to the target. These are usually taxiways, roads, big buildings, block patterns, or fields. Finally, choose small items that are usually close to the target. These are adjacent structures with distinctive shapes: revetments, block shape, and so forth. Admittedly, not all targets lend themselves to this procedure. The target may be the big building or the runway or there may not be enough features to reference.

5.2.5.2.3.2 **Cross Referencing.** The above technique (or variations, based upon how many and what size features are used) allows a cross-reference with other features to find the target. This can be especially important when anticipating a late target area appearance due to weather or bad coordinates. It also helps when the target's IR appearance is indistinct and needs something to cross reference in order to establish its exact position. To cross reference, count things like blocks, houses, revetments, and so forth or establish the target's (or another point's) position by correlating the relative position of other distinct points.

5.2.5.2.3.3 **Think 3-D.** When looking at the photos, look for anything that stands out from its surroundings: a distinct street pattern or a uniquely shaped/positioned landmark such as a building in a field or a field among buildings. From these distinct, asymmetrical points, work the spatial relationship techniques mentioned above. One caution on choosing items—certain items that appear distinct on the photo may not show well. Streets and runways perpendicular to the run-in will not show until late. Bends in roads are highly exaggerated in the IRADS at oblique look angles. Buildings that appear flat in the picture may actually be multi-story. Remember, the photos are normally taken from directly above the target. During run in, perpendicular streets will be obscured by the initial flat sight angle. For multi-storied buildings or other vertically developed landmarks, one clue to their true nature is to look for shadows in the photos. Look for positional relationships such as what part of town the target is in and terrain features for dirt targets. Working big to small, having at least three ways to find the target, and using units of measure are all good techniques.

5.2.5.2.4 **Highlighting/Memory.** Many pilots use markers to embellish features and relationships. Some use different colors to signify streets versus buildings or to accent terrain features, and so forth. The choice is technique—whatever is needed to find the target. Consider just two reminders using markers. Make sure they are erasable and, as mentioned before with AF Forms 70, that the colors do not blend with night lighting. Simple memory may be the best tool. There may be too many targets and too little preparation time to memorize every feature/relationship on a flight. However, try to remember a few key items; picture them in your mind, especially on the blow-up photo. This will help when task saturated or the target shows late and there is insufficient time to consult the photo pack.

5.2.5.2.5 **Overall.** The factors above and numerous others, can interact to create surprises. The bottom line is the pilot must look at the photos and think through how the features on the photo might show during the mission.

5.3 Ground Operations.

5.3.1 Weapons Preflight. Conduct weapons preflight IAW Dash 34, Dash 34 checklist, and applicable phase and IP briefings.

5.3.1.1 **Cockpit Operations.**

5.3.1.1.1 **Edit Page.** This is covered in **Chapter 4**, "Aircraft Basics and Instruments."

5.3.1.1.2 **SMD.** Make sure the correct weapons configuration is showing. If dropping a laser-guided bomb (LGB), check the laser code. If there is a mismatch in either of the above, call the weapons troops.

5.3.1.1.3 **IRADS Checks.** This is covered in **Chapter 4**, "Aircraft Basics and Instruments."

5.3.2 End of Runway Check. This is the last chance for maintenance to catch any major issues with the aircraft. It is also a good time to organize the cockpit and prepare for target attacks.

5.4 Surface Attack Administrative.

5.4.1 Stealth Check. Accomplish the stealth check IAW 49 FW IFG, F-117 Annex.

5.4.1.1 **Range Operations.**

5.4.1.1.1 **Conventional Range.**

5.4.1.1.1.1 **Purpose.** The advantages of weapons deliveries on a conventional range include scoring capability, easier target acquisition, and canned delivery patterns which facilitate orderly, repetitive weapons delivery practice with up to four aircraft on the range simultaneously. Conventional ranges are useful for initial qualification and practice of basic delivery patterns. Some conventional ranges allow live weapons and have tactical target arrays.

5.4.1.1.1.2 **Mission Preparation.** During mission preparation for a flight to a conventional range, review the following items at a minimum:

- Range layout of targets, towers, run-in lines, restricted areas, and surrounding terrain.
- Airspace and run-in heading restrictions.
- Holding, entry, and departure procedures.
- Direction and altitude of radar and visual patterns.
- Radio frequencies.
- Target locations and elevations.
- Ordnance and arming restrictions.

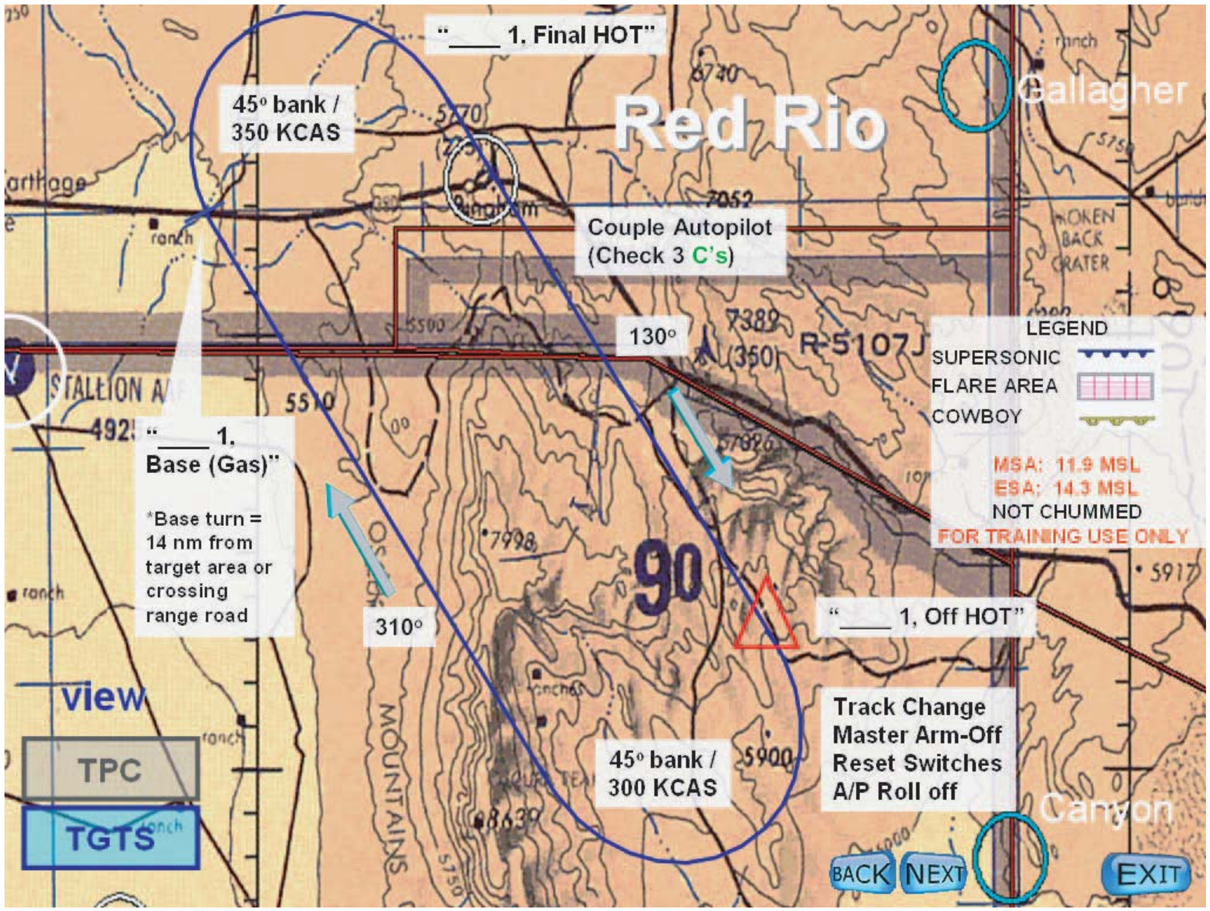
- Laser firing procedures.
- Weapons delivery parameters/ballistics.
- Range winds, sun angle, and tactical decision aids (TDA) at range time.
- Weather/minimums for planned deliveries.
- Weapons training requirements.
- Review AFI 11-214, *Aircrew and Weapons Director Procedures for Air Operations*.

5.4.1.1.1.3 **Range Entry.** If early and other traffic is still working the range, plan to enter the published range holding pattern. Do not interfere with the working flight's radio calls. Check in with the controlling agency and receive all applicable range restrictions and altimeter setting. A spacer pass may be used to enter a conventional range and establish spacing for the basic range attack pattern. See **Figure 5.1**, Sample Basic Range Attack Pattern, for an example of a basic range attack pattern and radio comm. The minimum release altitude (MRA) should be consistent with safe escape and fuze arming, and the weapon delivery minimum altitudes established in AFI 11-2F-117, Volume 1, F-117—*Aircrew Training*, and AFI 11-214, *Aircrew and Weapons Director Procedures for Air Operations*.

5.4.1.1.1.4 **Range Exit.** Lead normally calls “LAST PASS” on downwind and also adds this to the call on final. Following the last pass, lead climbs to departure altitude while slowing to rejoin airspeed. Departure procedures vary according to range. For the last pass, fly a normal pattern and delivery. After completing the pass, initiate the departure turn and establish a visual on all preceding aircraft. Turn the master arm and laser switches to safe, and announce the number of aircraft in sight. If there is no visual contact on all preceding aircraft, state so immediately. Do not begin or continue a turn until visual contact or until assured it is safe to do so. To assist in acquiring the visual, lead calls with the flight's altitude, heading, and position relative to the range. With all preceding aircraft in sight, establish join-up airspeed and rejoin to the briefed formation. If ordnance expenditure is not confirmed while on the range by the pilot or RCO, a visual confirmation (bomb check/battle damage check) is required. A battle damage check is a visual confirmation of bomb expenditure. On the F-117, opening the weapons bay doors via the combat jettison switch may be required to visually check for hung ordnance. The checking pilot visually inspects for hung ordnance, missing panels, fluid leaks, and battle damage. Use caution when flying chase and avoid flying directly under and behind the aircraft suspected of hung ordnance. Battle damage checks are not performed on the F-117 at night. If hung ordnance is suspected and visual confirmation is not feasible, follow local hung ordnance procedures.

Figure 5.1 Sample Basic Range Attack Pattern.

Sample Basic Range Attack Pattern



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5.4.1.1.1.5 **Completion of Range Work.** Perform the armament safety check in the F-117 In-Flight Guide Annex immediately after finishing weapons delivery on the range. This is especially important if the route continues from the range and camera attacks occur later along the route. AFI 11-2F-117, *Instrument Flight Procedures*, Volume 3, Local Supplement, forbids a camera attack to be performed on a point immediately following weapons delivery on the range. The armament safety check is as follows:

- MASTER ARM switch SAFE.
- LASER—STBY or OFF.
- FLIR/DLIR—STBY or IR.
- SMD fuze arming option—SAFE.
- STR Mode—deselect LVL and select an appropriate steering mode.
- TM/SRCH—selected.
- HATF/SHAFTA check—complete.

5.4.1.1.2 **Stay Ahead of the Jet.** Often weapons delivery on the range is the last point on the route before return to base (RTB). Be careful about getting rushed in the transition from weapons delivery to the approach. This situation was discussed in **Chapter 4**, "Aircraft Basics and Instruments," but warrants further review. Control the pacing during this transition by slowing down and/or taking a turn in holding. This allows for completion of destealth, in-flight report, and armament safety checks while preparing for the approach.

5.4.1.1.3 **Range Chase.** Flying chase on range presents new challenges and responsibilities for the instructor/evaluator. Be close enough to monitor the students' performance and still maintain visual with the weapons bay doors and weapons release.

5.4.1.1.4 **Deconfliction.** Who's got the hammer? Lacking a range control officer (RCO), the first IP on an uncontrolled range becomes the RCO. The controlling IP descends to the lowest altitude for F-117 weapons delivery, 11,400 feet MSL for Red Rio and 12,000 feet MSL for McGregor. As other aircraft join the range, the controlling IP will assign higher altitudes. When the controlling IP departs the range, he hands off control responsibility to the next lowest aircraft in the stack. The new controlling IP then descends to the lowest altitude in the stack and directs others to descend as appropriate. All pilots need to be aware of other aircraft in the pattern and deconflict on the radio to avoid conflicts.

5.4.1.1.5 **Abnormal Procedures.** Whenever an imminent dangerous situation is observed, make a directive radio transmission to stop it. Any flight member can initiate a knock-it-off, at which time involved participants cease maneuvering, climb—if necessary—to an altitude where terrain avoidance is not a factor (1,000 feet AGL minimum), and acknowledge with individual call signs. After a knock-it-off call, tactical maneuvering resumes only after clearance from the flight lead. Circumstances surrounding airborne malfunctions vary considerably. All require adherence to proper procedures and good judgment. Weapons malfunctions fall into three basic categories: inadvertent release, unintentional release, and failure to release.

5.4.1.1.5.1 **Inadvertent Release.** An inadvertent release occurs when ordnance, suspension equipment, or an aircraft part is jettisoned, fired, or released without pilot input. If an inadvertent release occurs, the pilot should take a mark point of the impact area, note switch settings, and then ensure all armament switches are safe. Any remaining ordnance presents a carriage and landing hazard. The ordnance should be expended or jettisoned in a suitable area if practical. If conditions do not permit jettison of the remaining ordnance, pilots should consider themselves hung. Return to base following the appropriate local guidance for hung ordnance. Switch positions at the time of inadvertent release and the impact point should be provided to weapons and safety personnel after landing.

5.4.1.1.5.2 **Unintentional Release.** The release or jettison of a weapon or suspension equipment through pilot error is considered an unintentional release. An unintentional release does not require the mission to be aborted if the ordnance impacted on the range complex. If an object is dropped off the range complex, "Safe" all switches and RTB. Mark the impact point and report the incident through local procedures as soon as possible.

5.4.1.1.5.3 **Failure to Release.** Ordnance that does not release when all appropriate switches are selected and the pilot attempts a release is considered hung ordnance. When wings-level on downwind, recheck the SMD and armament switches; make corrections as necessary. Do not become so engrossed in manipulating switches that pattern parameters are exceeded. Continue to fly the appropriate pattern executing dry passes (if required). If another attempt is made and no release occurs, combat jettison mode should be considered.

5.4.1.1.6 **Lost Sight Procedures.** Although not necessarily an emergency procedure, a "Blind" situation can rapidly deteriorate to a serious problem if some pilots do not adhere to a specific set of procedures. If sight of or SA on the aircraft in front is lost, immediately call "BLIND." The proceeding aircraft should come back with a position call based off the target. Once visual again, call "VISUAL," or if SA reveals it is safe, call "CONTINUE." Until the "BLIND" call is resolved, all other aircraft will remain high and dry. If not able find the proceeding aircraft, transmit position and altitude, and the flight lead will be directive.

5.4.1.1.7 **No Radio (NORDO).** In case of radio failure on the range, continue in the pattern but remain high and dry. Signal the RCO or other aircraft by flying past the tower rocking the wings. Continue in the pattern, remaining high and dry and rocking wings on final until the flight lead either rejoins the flight in sequence and recovers or directs a flight member to escort the NORDO aircraft to a recovery base as briefed. If other difficulties occur in addition to radio failure, turn opposite the direction of traffic and proceed as the emergency dictates. This signals the RCO to advise other flight members of the pilot's difficulty so they can provide assistance. The flight lead designates an aircraft to accompany the aircraft in distress, or if the flight lead has the emergency, the deputy flight lead designates a chase aircraft (as briefed).

5.4.1.2 **Uncontrolled Range or Airspace.**

5.4.1.2.1 **Introduction.** Uncontrolled ranges and airspace offer target arrays and tactics options to simulate the actual battlefield, and may include live weapons deliveries. This section approaches the planning and execution of an air-to-ground (A/G) mission from a combat perspective. Every mission on an uncontrolled range, even when dropping BDU-33s, should be approached as though all the targets, threats, and weapons are live. With the exception of a short discussion of applicable training rules on uncontrolled ranges, these sections address weaponeering, tactics planning, ballistics computations, and live ordnance considerations as they apply to the combat A/G mission.

5.4.1.2.2 **Uncontrolled Range.** Most uncontrolled or tactical ranges have a simulated airfield with typically associated surface-to-air missile (SAM)/antiaircraft artillery (AAA) defenses. Some ranges have televised optical scoring system (TOSS) available. Refer to the appropriate range regulation supplement for detailed information about the range the pilots plan to attack, including radio frequencies, restrictions, target coordinates, and target depictions and descriptions.

5.4.1.2.3 **Airspace.** The F-117 is unique in that the bulk of peacetime CT training occurs outside of MOAs or special-use airspace. Simulated target attacks are routinely conducted in airspace controlled by the air route traffic control center (ARTCC) or radar approach control (RAPCON). This offers valuable training on target sets that vary from large cities to rural areas. The following are some considerations for conducting CT training outside special-use airspace:

5.4.1.2.3.1 **Rules.** Training outside special-use airspace is conducted IAW federal aviation regulations and the *Airman's Information Manual* rules and is usually under control of ARTCC or RAPCON. Even though conducting military training, aircraft are still subject to these rules. Unauthorized deviations may result in a violation or worse, lead to a mishap. Prioritization is important. Complying with controller instructions always takes precedence over simulated target attacks.

5.4.1.2.3.2 **Weapons.** Always know what is loaded in the weapons bay. Never arm the Master Arm or fire the laser outside of special-use airspace. Do not be the pilot who has an unintentional release off-range while attacking a shopping mall.

5.4.1.2.3.3 **Clearing.** Visually clear when operating in any airspace. However, when flying under visual flight rules (VFR) rules, the primary responsibility for aircraft deconfliction rests with the pilot. A simulated attack with the IRADS requires a lot of attention inside the cockpit. Use discretion and good judgment when conducting simulated attacks in this environment.

5.5 Weapons Delivery.

5.5.1 Inertial Navigation System/Global Positioning System. When memory point track (MPT) or automatic video tracking (AVT) is selected, the system will automatically inhibit GPS updating in the inertial navigation system (INS)/global positioning system (GPS) mode. If MPT or AVT is maintained for more than three minutes, the CMDIs will display a circle around the aircraft symbol on the MAP display and indicate INS/GPS in yellow. Bombing is not affected with these indications but once the attack is complete, select RETURN to enable GPS inputs to the INS.

5.5.2 Global Positioning System. If operating in the GPS only mode, do not attempt weapons delivery using MPT or AVT, especially when delivering weapons with tight roll angle restrictions. When the IRADS is feeding autopilot steering, the aircraft can establish and maintain a constant bank angle of 5 degrees or less as time to go (TTG) approaches zero. Precise target tracking is very difficult and results in a significantly increased workload. However, with good coordinates, tracking should require minimal slewing. Depending on the munitions, ROE, system health, and accuracy of target coordinates and elevation, consider dropping "blind" bombs in cued point without laser ranging.

5.5.3 Weapons Switchology. For normal range delivery, the following switches must be correctly positioned in order to accomplish weapons delivery.

5.5.3.1 **Select Attack Mode.** This will always be level attack (LVL). Remember, if subsequently selecting a navigation mode, LVL will be deselected. When LVL is selected, the right CMDI automatically shifts to SMD.

5.5.3.2 **VTR.** Confirm on with IRADS video source selected.

5.5.3.3 **SMD.** Check appropriate weapon and set fuzing (remember to switch back to HSD or MAP).

5.5.3.4 **Master Arm—ARM.** Make sure the "X" is removed from the weapon ID on the CMDIs.

5.5.3.5 **FLIR/DLIR—IR/LSR, IR/LSR.** Polarity and automatic ALG/gray scale set as desired.

5.5.3.6 **FLLASER—AUTO or MAN.** Make appropriate selection.

5.5.3.7 **MPT/AVT.** Since usually setting switches somewhat far from the target, an AVT lock may be neither desirable nor feasible early in the run. However, if the tracker is erratic, an early AVT lock in the general target area may stabilize the tracker. This gets more into technique, but MPT is usually set at the same time as the other switches. With the long range of the laser, the MPT can be used as a consent switch when looking for laser ranging. This will reduce erratic and sometimes invalid range information.

5.5.3.8 **Narrow Field of View (NFOV) for IRADS Field-of-View.** Make appropriate selection.

5.5.3.9 **Sensor Display.** The SD provides a check that everything is set properly. RDY in the upper left-hand corner indicates proper switches. This indicates the weapon has been armed, Master Arm is in ARM, and the FLIR/DLIR and LASER are set for laser operation. Below the RDY there should be an "N" for narrow FOV. Below the "N" should be "CUED M", which indicates FLIR/DLIR is in cued point tracking mode with MPT set or it could simply say "CUED" with coordinates on the bottom of the SD. In the upper center of the SD should be an "A" or "M," depending on the type of laser setting.

5.5.3.10 **Track Ranging versus Laser Ranging.** Prior to release, select either track ranging (TR) or laser ranging (LR). This is spelled out in OG OI 10-1 and AFI 11-2F-117, Volume 3, and Local Supplement. Check these for other release restrictions.

5.5.3.11 **Pickle.** Press and hold the pickle button at TTG=10 until a release indication appears. Pickle should be no later than TTG=3 seconds remaining. Although valid releases have occurred with less time than this, there are no guarantees. If the doors begin to open and the pickle button is not depressed, get on it immediately. It may allow a bomb release. A zero (0) will appear in the SD next to RDY when the pickle button is depressed. Hold the button through TTG = 0.

5.5.4 Basic Weapons Delivery Technique. As mentioned before with photo pack study, there are probably as many different techniques for executing an attack run as there are pilots in the wing. This section will discuss the basic technique, from which spring several variations. Nearly all of the techniques share two features: a switchology check conducted early on in the bomb run and some sort of pacing from that point until bomb impact. Remember that this is a technique and weapons delivery checklists exist in the 49 FW F-117 In-flight Guide Annex.

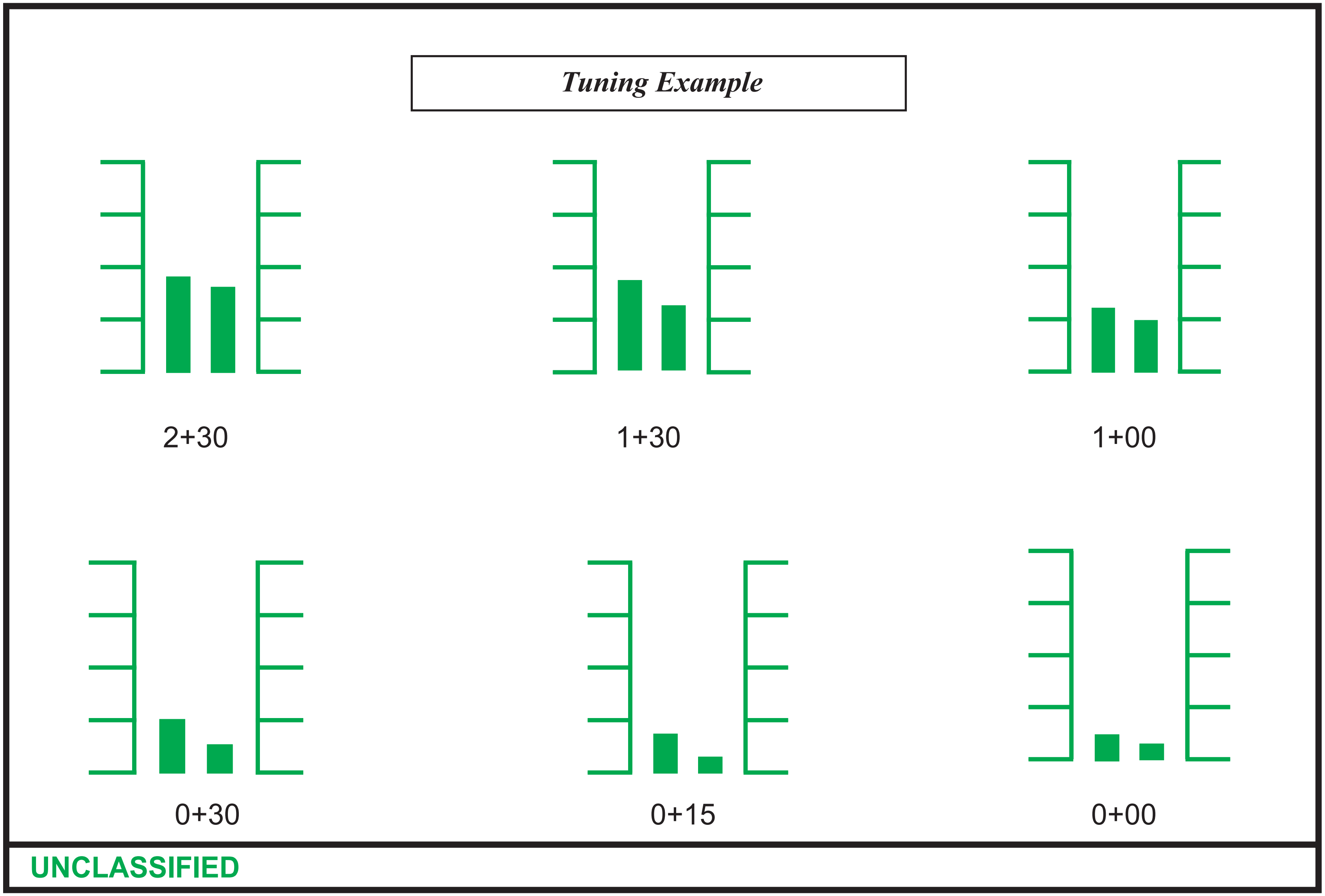
5.5.4.1 **Switches and Pacing.** Whatever the method of initially setting the switches for the attack, pilots normally accomplish it at around a TTG of two to three minutes and from that point conduct a time-related series of tasks paced through weapon impact. The switch settings shown in the time blocks below give a base line to develop pacing techniques. Level and gain settings adjacent to the time blocks are suggested starting points for tuning a cultural target. For dirt targets, more gain may be required. (See **Figure 5.2**, Tuning Example.)

5.5.4.1.1 **TTG = 2+30 (at the IP).** Set the switches as follows:

- LVL ATK–selected.
- VTR recorder–confirm RCRD (should already be running).
- SMD–weapon selected.
- Fuze option (Nose/Tail).
- Lase time.
- FLIR/DLIR–IR/LSR, IR/LSR.
- LASER–AUTO or MAN.
- MASTER ARM–ARM.
- IRADS–NFOV.
- Cued point.
- MPT selected.

5.5.4.1.2 **TTG = 2+00.** After setting the weapons switches, confirm that the autopilot is appropriately set and that it is properly coupled (i.e., three Cs). Check that the timing is good.

Figure 5.2 Tuning Example.



5.5.4.1.2.1 **Looking at the Overall Photo.** Work level/gain and polarities as necessary to set the picture up. Polarity is usually something that remains set throughout the run, but sometimes a change is required for IR conditions or can be useful in breaking out the target. Level and gain may not be such a player if using ALG. However, continually tweaking the picture through the run is a must, and normally requires experience to master.

5.5.4.1.2.2 **Work the Picture.** In the meantime, working the picture can be done on a mechanical time versus task basis (i.e., every 15 seconds), but should evolve into a continuous, almost habitual process. Otherwise, as the range decreases and aspect changes, the picture can flood or distort, destroying the chance for an AVT lock (if used) and maybe even the ability to discern the target.

5.5.4.1.3 **TTG = 1+30.** When the target area becomes more distinct, check the offsets and/or cross-reference the three big points from the overall photo to ensure the cursors are in the correct general area. Be careful about hunting for the target by slewing at long range. If slewing is fruitless or SA is lost on what the system is looking at, hit return to center cursors and reset MPT. This is also a good time to double check speed and altitude on the SD; particularly if using manual throttle control.

5.5.4.1.4 **TTG = 1+00.** Review switch set-up. Confirm LVL ATK, VTR RCDR ON, NFOV, Cued MPT, autopilot coupled with three Cs, and check the SD. Checking the speed can also be used as a reminder to disconnect autothrottles, especially when in the TOT mode. The autothrottle mode has a tendency to cycle the throttles during the time to impact (TTI) phase of the run, which can throw off target tracking. Using the medium photo, continue to refine the aimpoint by referencing the intermediate features that are closer to the target or offsets in case of a no-/late-show target.

5.5.4.1.5 **TTG = 0+30.** Study the blow-up photo. This a good time to final check speed, altitude, and autopilot status, as well as to deselect offsets and start concentrating on target identification. This may involve sneaking another peek at the photos. As mentioned before, the best time to study the photos is back at the squadron before stepping. But a quick cross-check of the photos is still a good idea, perhaps every 30 seconds or so down to about TTG = 30 or 15 seconds. If weather problems, bad coordinates, or lack of study opportunity dictate another look at them, then so be it; whatever it takes to hit the target. Use the detailed features identified in the blow-up photo to place the cursors on the exact DMPI.

5.5.4.1.6 **No Sight Offense.** A "No-Sight" offense should be considered if the target (or offset) is unrecognizable at this point. These steps will cue the IRADS to the point where the INS/GPS thinks the target is located. This is useful if there has been a lot of cursor slewing. Select RETURN, MPT, WFOV then NFOV. Look for the large, then intermediate, and then fine features to identify the target or offsets. Consider adjusting the polarity and using ALG if necessary to get a usable picture.

5.5.4.1.6.1 **WFOV.** Before discussing end-game pacing, consider wide FOV. Some pacing techniques include staying in NFOV after the TTG = 1 minute switch check. But in certain cases, such as a late target appearance, or high CD attacks, WFOV might gain/regain target area awareness and check for clear weather.

5.5.4.1.6.2 **Remembering NFOV Check.** In order to remember the NFOV check, one technique is to keep a finger resting on the FOV button until change back. Another technique is to use WFOV for large slews to prevent incremental banks and numerous IRADS gimbals.

5.5.4.1.7 **TTG = 0+15.** At approximately TTG = 15 seconds, no longer attempt an AVT lock. This is to keep the cursors from running off at the last second. Recheck that the autopilot is still coupled with three Cs. No later than TTG = 0+10 seconds, get on the pickle button and hold it until weapons release. Look for the "0" next to the ready indication on the SD. Check the SD for laser ranging. If not, squeeze the trigger to manually lase. Hold the pickle button through weapons release as indicated on the CMDIs and TTG changes to TTI, or when the weapon leaves the aircraft.

5.5.4.1.8 **TTI = 0+15.** After release, confirm that the weapon bay door light is out and return the Master Arm switch to SAFE. If the weapon is hung, the doors will stay open until Master Arm is safed. This is the last opportunity to work level/gain, recheck the photos, or attempt another AVT lock, as the situation dictates. The most important thing, however, is to get the cursor stabilized on the target. By TTI = 0+15, accept what tuning is set and concentrate strictly on tracking and killing the target.

5.5.4.1.9 **TTI = 0+00 ("Splash").** After weapons impact, reset the switches as follows:

- IRADS in SRCH or TM.
- Deselect LVL ATK.
- Turn VTR OFF.
- Confirm appropriate track change by running a HATF or SHAFTA check.
- Safe all weapons switches.

5.5.5 Working the IRADS. Different use of the IRADS features gives rise to various techniques and opinions, some of which are listed below.

5.5.5.1 **INS/GPS.** The full-up system, when used against mensurated target coordinates, is extremely accurate. In these conditions, it is typical to release within hit criteria without slewing. However, if the target coordinates are not accurate, it is very easy to mistake the lack of accuracy as a system problem—or at least get slightly confused because the target did not appear directly under the cursor. Do not let target identification skills atrophy.

5.5.5.1.1 **Polarity.** Generally, white hot gives a more realistic picture in day, while black hot works better at night. Obviously, this can vary with conditions and the target IR characteristics.

5.5.5.1.2 **Example.** With dirt targets, the opposite polarity may yield a better image. Keep in mind, if experiencing difficulty identifying any prominent features, try switching polarity. Something indistinct in one polarity may be a standout in the opposite polarity.

5.5.5.2 **ALG/MLG (Gray Scales).** As mentioned before, ALG may make the job easier on the target run, since in this mode only the level has to be adjusted. It may not be a player if there are IR returns in the target area, which can skew the gain and ruin the picture. Also, working in MLG can be a busy process, requiring experience to master. The advantage is that the gain is also controlled to best meet the IR situation. MLG helps prevent screen washout during simultaneous attacks, a common occurrence during combat. Think of the level function as picture brightness, while gain can be considered an IR return enhancer. Good initial MLG (gray scales) settings are roughly one-half level and one-third gain for cultural targets (developed areas), and one-half level and gain for dirt targets (Red Rio/Centennial). High-humidity may require much higher initial gain settings. In order to retain good picture quality, as the slant range decreases, gain is normally reduced, and possibly level as well. Humid situations normally require large reductions from the initial settings to those at weapons impact. Generally, if inside of TTG 0+45 and still not able to discern any distinct feature, consider increasing the gain to break out something. Once a prominent feature is identified, retune the screen or select ALG to optimize the image on the SD.

5.5.5.3 **Weather Considerations.** Be prepared to avoid lazing when clouds are under the IRADS cursor. Either delay MPT until a clear line of sight to the target, or consider using manual lazing. If dropping an actual LGB and choose to delay MPT, note that MPT will automatically select at TTG = 0+00. Also note that manual lazing for GBU-27 deliveries will cause reduced weapon performance and is not recommended. Know the rules of engagement and apply correct principles.

5.5.5.4 **AVT/MPT and Other Tracking Variants.** In **paragraph 4.1.7.2**, IRADS System Check, a technique was offered to set the AVT container to its smallest size. This will set the AVT to lock targets of most any size, whereas time would be wasted shrinking a larger AVT container to lock a small target. The IRADS ground check can also help get a feel for slewing the cursors and the AVT lock capability of the particular jet.

5.5.5.5 **AVT.** Be careful about attempting AVT locks within 15 seconds of release or impact. If the locking gates run away, the target could be missed. Once an AVT lock is achieved, a good technique is to work level and gain to make sure it maintains the lock. For locking a light target on dark background, run the level down and increase gain to magnify the intensity of the target return in relation to its surroundings. For locking a dark target, run the level and gain up to increase surrounding brightness while enhancing the dark return. Two other considerations about AVT merit discussion. Ensure that whatever is locked will remain visible throughout the entire target run and secondly, give consider tactical factors (i.e., explosions and smoke) that may break the AVT lock.

5.5.5.6 **MPT.** The biggest consideration in using MPT is tied to the technique used to track the target. Given the small allowable tracking errors for some targets, a smooth, steady hand/finger(s) on the slew and designate button is a must! Smooth and steady also applies to "AVT mash." Some pilots place one finger in the center of the button for tracking; others use their fingers to lightly grasp the outside rim of the button. Tracking with laser ranging is generally more stable.

5.5.5.7 **Tracking Variants.** Both techniques involve AVT locks. One is refined point track (RPT) which combines the considerations for AVT and MPT. In RPT, the target cannot be AVT locked, but something nearby has sufficient definition. Lock the highly defined return and slew the cursors to track the target. Make sure the other return will stay locked and remain in the IRADS NFOV while applying MPT-style tracking to the target. The advantage of this technique is that AVT track ranging provides more stable cursor tracking. Finally, there is a tracking technique used by many pilots who are unable or unwilling to use AVT, and perhaps do not trust MPT tracking. One "mashes" the slew and designate button to cause the AVT locking container to appear (assumes it is at smallest size) and tracks the target. This technique makes the tracker sensitive to any movement on the slew and designate button (the slew rates are the same as an AVT lock).

5.5.5.8 **Other Weapons Deliveries.** OG OI 10-1 contains the hit criteria for various weapons deliveries used by the F-117 in CT training.

5.5.5.8.1 **Offset Delivery.** This is a delivery designed for a target with a weak, indistinct target return or possibly obscured from the IRADS. The pilot tracks a more distinct offset until release and then switches to tracking the target through impact. Normal ROE for training attacks is to not select target direct until after TTG = 0 (i.e., be in offset at release). Study the target and its immediate surroundings well, in case the offset tracking does not put the cursors exactly on the target after going target direct.

5.5.5.8.2 **DLIR Only.** The DLIR delivery is designed to compensate for an inoperative FLIR. To simulate, bring FLIR to STBY. A generally accepted technique is to select WFOV until target area is acquired, then switch to NFOV. As the target run continues, remember to keep the DLIR slewed to its upper limit until reaching the target. The TTG readout will not be accurate until cursors are on the target. A technique to aid in knowing when the DLIR cursor is cued to the target is to use the HUD and watch the IRADS cursor as it moves towards the destination container. Another technique is to select MAP and watch the IRADS cursor marker move up the target track until it reaches the destination symbol. Another technique is to select an offset aimpoint (OAP) that is short of the target. The cursor symbology will be "fat" with thick lines. When the cursor symbology changes to normal "thin" lines, the OAP should be in the IRADS FOV. There will not be a RDY indication on the SD during an actual delivery with the FLIR in STBY.

5.5.5.8.3 **CMDI Only.** This is a delivery designed to compensate for an inoperative SD. Switch to electro-optical (EO) on the left CMDI mode switch and use the CMDI brightness (BRT) and contrast (CONT) switches to set the picture. Use ALG/gray scales in the same manner as with the SD. The EO display on the CMDI should be crisp and well defined, showing the same information as the SD (only smaller).

5.5.5.8.4 **Dual Door.** This delivery releases two bombs on the same attack. Remember to complete the "Big U" to set up for dual door (Station-Fuze-Fuze-Station). The first weapon selected will be the last to release and the first to impact! After setting both stations, select either first bomb (1ST BMB) or STICK CTR and minimum spacing IAW the Dash 34 and wing weapons directives. Keep an eye on max dual door delivery airspeeds; they may be less than single delivery speeds. Most pilots use 40 to 70 feet (see squadron standards) stick center for dual door BDU-33 deliveries. A common error is to not containerize stick center. There will be an RDY indication and the doors will open, but no weapon will be released. Switchology should be no different from other releases. There are several notes about minimum speeds, minimum indications, and other restrictions required for dual door delivery in AFI 11-2F-117, Volume 3, Local Supplement, and wing weapons directives. (See **Figure 5.3**, Dual Door SMD Example.)

5.5.5.8.5 **Camera Attacks.** Camera attacks are intentional dry passes. Certain ROEs exist in AFI 11-2F-117, Volume 3, Local Supplement, AFI 11-214, *Air Operations Rules and Procedures,* and in wing weapons policy publications to ensure safety during either on- or off-range attacks. These rules also provide hit/miss feedback criteria for training, flight evaluations, or turkey shoot purposes. Consult these documents for latest requirements. Generally, a camera attack requires the VTR on in IRADS, LVL selected, and MPT/AVT set—all before TTG = 0+00. There are also distance criteria for the cursors in relation to the target. As a safety precaution, for off-range attacks, the Master Arm will always be safe and the laser off (among other restrictions).

5.5.5.9 **Night Weapons Operations.** During night weapons attacks, the procedures used IP to target are no different than daytime operations. However, because limited light may have an affect adverse affect on photo review and pacing. If possible, devote extra time to review the target photos prior to the IP, and on final when necessary.

5.5.5.9.1 **Switchology.** Normal weapons switchology should not change from day habit patterns. Make sure that switches can be operated and confirmed by feel or that lighting is set for quick visual confirmation. Cross-check the flight instruments often to ensure autopilot operation, airspeed, altitude, and correct steering.

5.5.5.9.2 **Channelized Attention and Task Saturation.** These problems tend to occur more easily at night, so be aware.

5.6 Malfunctions. If something goes wrong with the autopilot, IRADS, INS, or aircraft at night, fly the aircraft first and work the system or aircraft problem only after absolutely sure that aircraft control will not be compromised.

5.6.1 Infrared Acquisition/Designation System Malfunctions.

5.6.1.1 **IRADS Alert.** An IRADS alert, accompanied by a FLIR/DLIR alert on the SD may or may not imply a serious problem. Punch off the alert. If it returns, check the STAT page for any fault codes before punching it off again. The IRADS alert can be a result of many things: a failure to cool properly, a failure to stow properly, a servo malfunction, and so forth. The best indication of the IRADS functional ability is probably the IRADS picture itself.

5.6.1.2 **Serious Malfunctions.** If the IRADS is malfunctioning to the point where the FLIR and/or the DLIR cannot be used, try re-initializing it. This involves turning both FLIR and DLIR to OFF for approximately 30 seconds and then bringing FLIR/DLIR to IR. Re-initialization may take up to two and a half minutes, so consider the impact on updates and weapons deliveries. Consider accomplishing a self-test while airborne to help maintenance identify and fix the problem. Remember the self-test takes 4 to 5 minutes.

Figure 5.3 Dual Door SMD Example.

Dual Door SMD Example

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5.6.2 Laser Malfunctions.

5.6.2.1 **Low Power (LOPWR).** If a LOPWR alert appears, check the ranging indicator to ensure the system is still getting laser ranging (LR). Keep an eye on this during the attack run.

5.6.2.2 **Laser.** A LASER discrete means the laser is inoperative. This can have a serious impact on weapons delivery effectiveness. Consult AFI 11-2F-117, Volume 3, Local Supplement, and wing weapons directives for further details on weapons delivery in these situations.

5.6.3 Hung Bomb. Follow hung bomb guidance in the F-117 In-flight Guide Annex.

5.7 Update Procedures.

5.7.1 Inertial Navigation System. The navigational accuracy of the GPS system is outstanding. The INS takes advantage of this by using GPS position and velocities to update itself through the Kalman filter while in the INS/GPS mode. These updates occur automatically about four times a minute with a State 5 GPS and once a minute with State 3 or BARO. Note that in INS/GPS mode, the present position of the aircraft is based only upon the INS. Therefore, if the GPS aiding becomes unavailable, the INS will drift normally starting from the position of its last update. As soon as a sufficiently accurate GPS signal is regained, Kalman filter updates to the INS automatically restart. Although the only certain way to judge INS accuracy is with a ground checkpoint, INS accuracy can also be estimated by using the INS to GPS comparison on the STAT page. A military coded GPS is so accurate that the INS to GPS distance can be viewed as a very close approximation of the actual INS accuracy. This value is typically less than 20 feet with a State 5 GPS aiding a properly aligned INS.

5.7.2 Global Positioning System. With the system in INS/GPS, there should be no requirement for any updates. However, if operating in INS only mode, consider performing an update. The procedures are given in the Dash 1. Again, only use these procedures if the GPS fails.

NOTE: Common errors—make sure the update point coordinates and elevation are reliable! Performing updates on points with unreliable information will only complicate the problem.

5.7.3 Update Considerations and Techniques.

5.7.3.1 **LR versus TR.** Unless on a weapons range that allows laser use, do not use laser ranging for updates on local training routes. This problem is partially overcome by using an AVT lock on the update point. This gives TR, which, though not as good as LR, is much better than estimated ranging (ER). For this reason, and the fact that their coordinates and elevations are usually very accurate, TACAN stations are the local update points of choice. The TACAN station "disc" provides a nice AVT-lockable single point.

5.7.3.2 **Bearing, Range, Altitude (BRA).** After initiating an AVT lock on the update point, push SNSR on the HSD or Map Display. The following three values will appear in the upper left corner: bearing in degrees from INS prediction, range in tenths of a mile, altitude in plus or minus feet.

5.7.3.3 **Opinion.** Opinions vary on what BRA values are considered good for accepting an update. Note the following opinions:

- Some say anything greater than 0.1 NM range or 100 feet altitude.
- Others say greater than 0.3 NM range or 300 feet altitude.
- Another consideration for accepting the update may be that at a previous point with known good coordinates and elevation, the IRADS cursor was nowhere near the target and/or the IRADS tracker was jumpy due to an apparent altitude error.
- Finally, others say, accept any TACAN or nav facility with highly reliable and precise coordinates; it does not matter that the error is small because it is right.

NOTE: Avoid a common error. If "B," "R," and "A" data read all zeroes, check to be sure the offset switch is centered.

5.7.3.4 **Straight and Level.** To further ensure the update is valid, the aircraft needs to be straight and level with the correct local altimeter set. Updates can be taken from any INS nav mode (e.g., DEST, HNAV, or LVL ATK), but most pilots prefer LVL ATK because it flies over the target and auto sequences once past the target (approximately 8 to 10 seconds). This will prevent the IRADS from gimbaling during the update. If another mode is chosen, make sure overfly (OV) is set in Edit Page to avoid turning short of the update.

5.7.3.5 **Hold and Lock.** Take and maintain the AVT lock and ensure TR is showing on the SD range readout! Although AVT is the preferred update tracking mode, MPT can be used for updates if there are no lockable update points and an update is needed to correct serious INS drift. After accepting the update by pressing ENTER, delay breaking the AVT lock or MPT for 3 seconds so the system can have time to decipher all the data and update the position.

5.7.3.6 **Minimize Slant Range.** If the conditions mentioned above are met, wait until roughly 5 seconds TTI remaining and push ENTER to accept the update. Another good "accept time" is when DLIR Seeker Cross is roughly approaching the 90-degree point on the "condom." This ensures the closest, best ranging sample.

NOTE: Be sure to accomplish all of these steps before overflying the point, or the system will not auto sequence.

5.7.3.7 **Rejecting the Update.** If the update is not wanted, then push HSD or MAP CLR. Another technique is to push F-7 on the CDNU. The INS page will appear. Push BIAS (another page change). Push BIAS again (page change). Push ZERO. This returns the system to the condition it was in prior to the bad update.

CHAPTER 6

AIR REFUELING

6.1 Ground Operations. Verify with the crew chief the operation of the air refueling (AR) door and AR light intensity. Confirm the AR status lights located on the canopy. If the AR door check is accomplished during FCS BIT checks, the reduced gains will cause a test failure. Set air-to-air TACAN to pre-briefed channel to get ranging, if possible.

6.2 Tanker Rejoin.

6.2.1 Air Refueling Initial Point.

6.2.1.1 **VMC.** Depart the ARIP in station keeping at night and route or station keeping during the day.

6.2.1.2 **IMC.** In IMC have the wingman maintain 1,000 feet altitude separation and 1 NM air-to-air TACAN. Consider splitting the wingman at the ARIP to hold or maintain trail formation.

6.2.1.3 **Airspeed/Comm.** Standard F-117 airspeed from the ARIP to the tanker is 330 KCAS. Call departing the IP with altitude: "BOOMER 11, HOBO 01, ARIP INBOUND, FL220." Listen for the tanker's altitude and a "CLEARED DOWN TRACK" or something to that effect. Query if unsure of clearance.

6.2.2 Emissions Control 1. Normal AR upgrade is accomplished using emissions control (EMCON) 1 procedures, which are essentially all emitters on and every radio call ever heard in an air refueling track.

6.2.2.1 **Tasks.** The following is a list of tasks applicable to the F-117:

- 15-minute call.
- Air-to-air TACAN set 15 minutes prior to ARCT.
- Halfway through turn call from tanker.

6.2.2.2 **Mandatory Boom Transmissions.** The following are mandatory boom transmissions:

- Pre-contact.
- Clear receiver to contact.
- Contact/disconnect.
- Verbal corrections.
- Advise receiver to return to pre-contact for checklist or equipment considerations.

6.2.2.3 **Mandatory Receiver Transmissions (post 15 minutes out call).** The following are mandatory receiver transmissions:

- Visual contact established/lost to include overrun.
- 1-mile closure transmission.

- Pre-contact.
- Contact/disconnect.
- Notify boom operator prior to initiating manual/emergency boom latching procedure.

6.2.2.4 **Post Air Refueling Report.** Provide tail numbers of receiving aircraft and request for end of air refueling clearance. Notify the tanker of any abnormalities experienced during refueling.

6.2.3 Emissions Control 2. On normal continuation training sorties, EMCON 2 is the standard; however, it requires some pre-coordination. EMCON 2 requires only two radio transmissions. The first call comes from the receivers approaching the IP: "BOOMER 61, HOBO 01, FLIGHT IP INBOUND AT FL220, NOSE COLD." Tanker responds with altitude. The second call is made by the boomer as the receivers approach pre-contact: "HOBO 01, BOOMER 61, RADIO CHECK." Receivers respond with their numbers: "HOBO 01, LOUD AND CLEAR, HOBO 02, LOUD AND CLEAR." Prior coordination will dictate how the end AR request is confirmed. The only other extraneous call that may be required, if not previously coordinated, will be the tail number of each receiver as well as required off load.

6.2.4 Finding the Tanker. There are several tools available, such as the following, to assist with the tanker rendezvous:

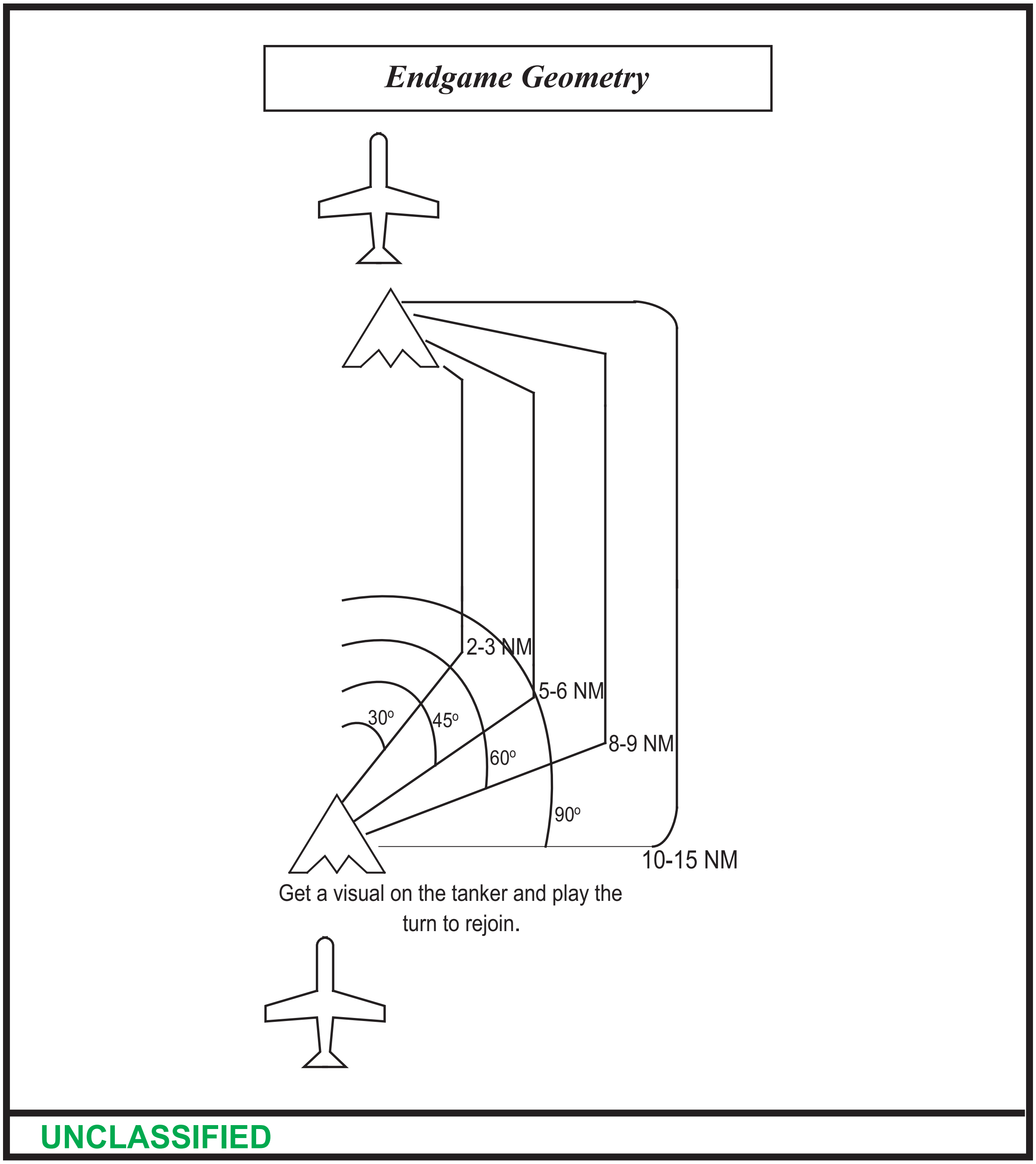
- Use autopilot altitude hold to maintain vertical separation until visual.
- Use autothrottle to maintain consistent airspeed. To make it easier on the wingman, consider pre-briefing airspeed change increments (e.g., 30 KCAS). In this example, the wingman would know the flight is accelerating to either 360 or 390.
- Depending on the track and entry angle, consider using CRS LINE or CRS SEL if flying the "black line" for the tanker track is desired.
- Use MAP to check ownship position relative to the black line between ARIP and ARCP.
- Select tanker A/A TACAN. Monitor distance and closure on the tanker. KC-10s have the capability to provide bearing in addition to range. Check the HSI for bearing to the tanker. This will verify INS steering and give a common reference to coordinate with the tanker.

6.2.5 Tanker Rendezvous. Level off and cruise to the ARIP at the pre-briefed airspeed. Lead should call passing the ARIP, accelerate to 330 KCAS and change the air-to-air TACAN to the Y channel. The wingman will turn the TACAN to STBY. A possible technique is for lead to call airspeed changes of greater than 20 KCAS and heading changes greater than 20 degrees to help the wingman maintain SA. The wingman should position on the outside of the tanker track to more easily monitor lead and visually acquire the tanker.

6.2.5.1 **Point Parallel.** The tanker should start the turn at 21 NM when at 26 degrees offset. A KC-10 will turn 2 to 6 NM earlier than this range because it uses 25 degrees of bank and offsets farther (11.5 NM). If this works as advertised, the flight should wind up 1 to 3 NM behind the tanker. The tanker will be at 275 KCAS (KC-135) or 280 KCAS (KC-10) until pushed up half way through the turn and it has accelerated to 300 KCAS.

Use the tanker's relative position on the canopy (lead or lag pursuit) to control closure with the tanker. See **Figure 6.1**, Endgame Geometry, for visual references.

Figure 6.1 Endgame Geometry.



6.2.5.2 **Fighter Turn On.** If the tanker has receivers on the boom the flight will be required to do a fighter turn on. Entry into the track and airspeeds remain the same as point parallel. For this rejoin KC-10s ability to provide bearing and range is very helpful for SA. Most pilots start the turn towards the tanker at 16 to 18 miles using 30 degrees of bank. This allows a great deal of freedom to adjust geometry throughout the turn.

6.2.5.3 **Undershoot.** Push it up immediately after recognizing the flight will roll out well behind the tanker. Thrust and available fuel are limited, so make the call early if required. Avoid premature push it up calls in order to preclude a tail chase with the tanker. Consider directing the tanker crew to continue their turn for a turning rejoin if they roll out too far in front. To help the wingman, consider briefing preplanned airspeed increments (e.g., 30 KCAS would mean changing airspeeds from 330 to 360 or 360 to 390). It is easier to maintain flight integrity if the wingman has an idea what airspeed lead is flying.

6.2.5.4 **Overshoot.** Slow down immediately after recognizing a possible overshoot, but maintain a safe airspeed. The F-117 at a high altitude (greater than FL 250) and slow airspeed (less than 250 K) does not handle well and does not regain airspeed easily. Slow to 290 KCAS minimum. Request the tanker to push it up if necessary or direct overrun procedures. The natural tendency is to get slow as the throttles come back to control V_c and bleed energy as the flight maneuvers. It is no fun to successfully BFM your way into a position behind the tanker's 3/9 line, only to realize you can't accelerate from 240 KCAS back to refueling airspeed.

6.2.5.5 **S-Turns.** One technique to avoid slowing excessively is to use S-turns. These can be disorienting because the canopy design will not allow maintaining visual while turning away. The degree of S-turn is dependent on the distance in front of the tanker. One technique is to turn 45 degrees away from the tanker then turn 90 degrees back to keep from doing multiple turns in the track. Consider limiting angle of bank to assist the wingman in maintaining visual. Another technique is to have both the receiver and the tanker do a 180-degree turn, pick up a visual on the tanker and then use the normal rejoin or undershoot technique as appropriate.

6.2.5.6 **Orientation.** Develop a good cross-check of the attitude instruments and autopilot. Most pilots will use control stick steering so the flight can maneuver, but still rely on the autopilot to maintain altitude and airspeed. This is fine as long as the autopilot stays engaged while rolling. Use the moving map to help in visualize ownship position in the tanker track, particularly when dodging weather (assuming the tanker track waypoints are entered in the INS).

6.2.5.7 **The Last Mile.** Approaching 2 NM in trail, begin to decrease towards 320 KCAS. The lack of speed brakes does not present any major problems. Overtake of 20 knots can be easily controlled with power reduction.

6.2.5.8 **Approaching Pre-Contact.** Lead will normally go directly to the pre-contact position and the wingman will rejoin to the observation position. Subsequent flights to the tanker will stay 1 NM trail and 1,000 feet below the tanker until the flight in front has departed. With the AR door open, the diminished authority in pitch and roll gains makes the aircraft more difficult to maneuver. For this reason, a good technique is to delay opening the AR door until approaching the pre-contact position.

6.2.6 Pre-Refueling Checks. Complete pre-contact AR checks. LETS will cover the major checks. It stands for lights—as required, emitters—IFF and radar altimeter, TACAN—receive only, slipway—IFR door open.

6.3 Observation Position. Line up the wing tips of the tanker. This will put the aircraft far enough forward and high enough to stay out of the receiver's way. See **Figure 6.2**, KC-135 Observation Position, and **Figure 6.3**, KC-10 Observation Position.

6.4 Pre-Contact Position. The pre-contact position is 50 feet or approximately one ship length behind the boom. The boom is about 30 feet long in the pre-contact configuration so visualize a little less than two boom lengths. Avoid the tendency to get too low and too far back in the pre-contact position. See **Figure 6.4**, Pre-Contact Position.

Figure 6.2 KC-135 Observation Position.

KC-135 Observation Position

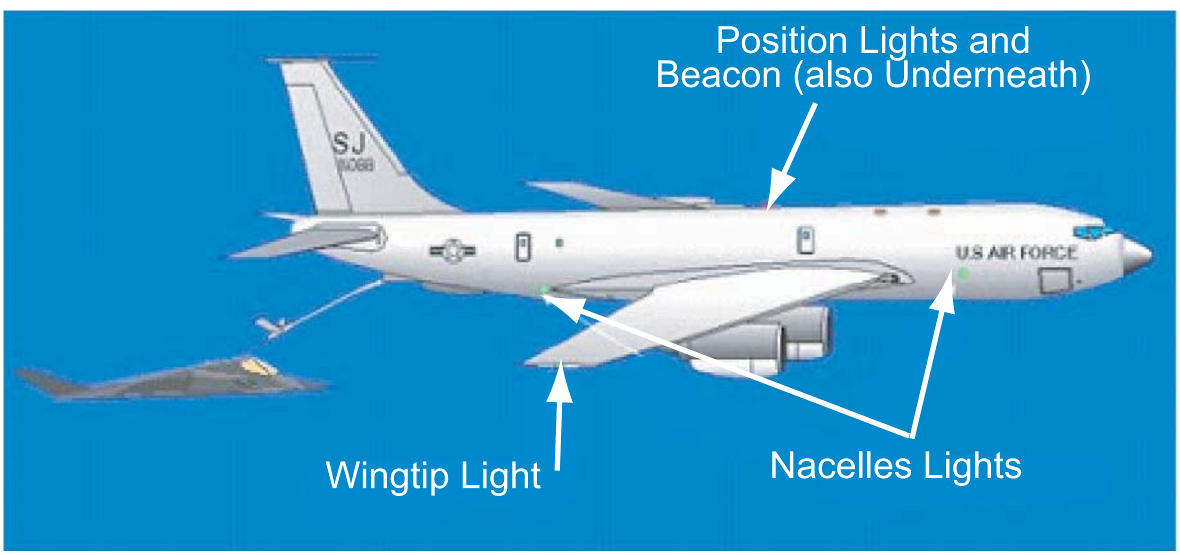


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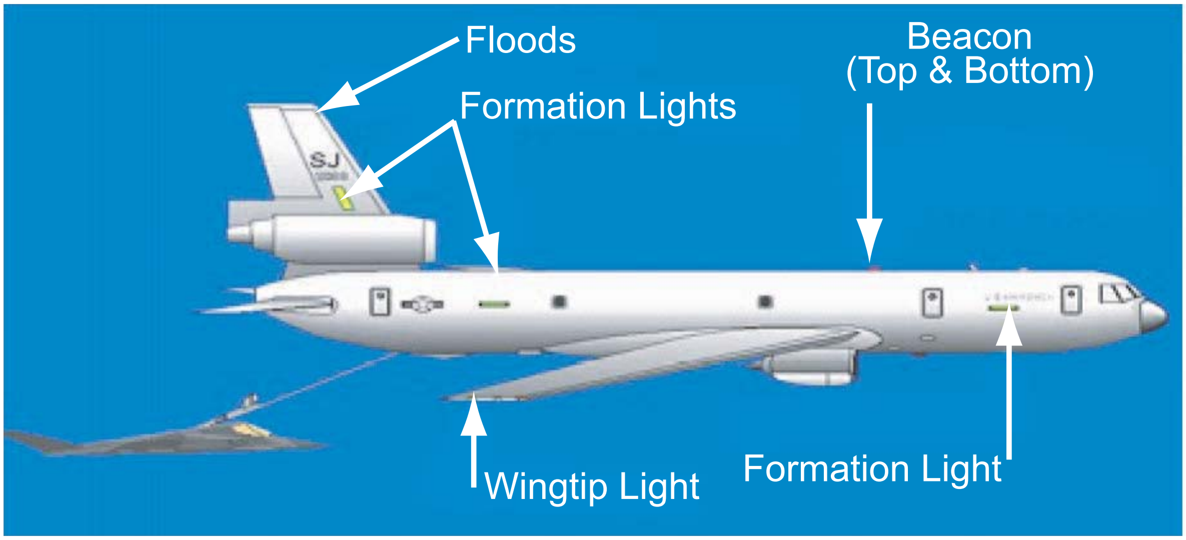
Figure 6.3 KC-10 Observation Position.

KC-10 Observation Position



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6.4.1 Aircraft Handling. Aircraft control and handling qualities with the AR FCS gains are good for maneuvering in the pre-contact position. Adequate power is available to maintain and adjust position.

6.4.2 Lighting and Switches. Double check switches while approaching the tanker or stabilized in the pre-contact position. Techniques vary and some lighting is optional, but as a reference, ensure the following is done:

- Recheck the APEX light rheostat position (it should have been set on the ground) and dim the navigation and fuselage lights. Most boom operators prefer dim fuselage lights and bright navigation lights; also turn off the anti-collision light.
- Select either FUS ONLY or ALL depending on required off-load.
- The green AR status lights are difficult to see in daylight.
- Ensure autopilot is not engaged.
- Push in the intercom button and adjust the volume full up.
- Know the aircraft's complete tail number.

Figure 6.4 Pre-Contact Position.

6.5 Contact Position.

6.5.1 Transition. As with most fighters, small, positive corrections will allow for the most efficient refueling. The aircraft may yaw slightly when moving from the pre-contact to the contact position, due to the downwash from the tanker. Because of the relative position of the seating height and the refueling receptacle, many pilots have a tendency to drop low when approaching the boom. To prevent this, set the end of the boom on the top of the HUD as the aircraft continues forward. As the aircraft closes to within 10 feet or so, the boomer should swing the boom out of the way. Continue to close and maintain elevation relative to the tanker.

6.5.2 Aluminum Overcast. Director lights are operated manually until contact and can be anywhere from nonexistent to continuous depending on the skill of the boomer. Be patient and maintain good formation relative to the entire tanker (not the boom) while watching for corrections from the director lights. There are no mirrors and no visibility out the top of the canopy like other fighters. Once under the boom, look at the entire belly of the tanker and maintain that reference. One technique for the KC-135 is to place the tanker's inboard engine pods in the center of the quarter panels as a position reference. Another technique is to place the top of the HUD combining glass on the forward portion of the tanker's director lights. On a KC-10 it may feel that the aircraft is too far forward. (See **Figure 6.5**, Contact Position.) It is difficult to feel contact with the boom, trust the lights and fight the tendency to drop low. Note that KC-10 director lights are trend lights while KC-135 director lights are directive. (See **Figure 6.6**, Director Lights.)

6.6 On the Boom.

6.6.1 Power. As the aircraft takes on fuel and enters turns, anticipate the need for more power. At high altitude and high gross weights, refueling can be especially challenging. Avoid large power corrections.

6.6.2 Fuel rates. A KC-10 pumps at 3,000 pounds per minute with both pumps operating. The KC-135 will pump at 2,300 pounds per minute. Note starting fuel prior to contact. Check it again after disconnect and ensure flight plan fuel matches current off-load. If less than a full load of fuel is needed, consider using the Bingo bug to alert when the aircraft has received the desired amount of fuel.

6.7 Post Refueling Procedures.

6.7.1 Post Refueling Checks. Do not forget the checklist. Running the LETS check will accomplish the major items before leaving the tanker: lights, emitters, TACAN, slipway. Regardless, do not forget the air refueling door! Check gas and total received.

6.7.2 Flight Rejoin. After refueling, rejoin as briefed. The flight will normally depart the tanker track at least 1,000 feet above the refueling altitude to the AR exit point. Be careful not to slow too much if heavily weighted and climbing out of a refueling track.

6.7.3 Steerpoint. It is a good idea to have the INS already set up for steering to the desired destination prior to the tanker rejoin.

Figure 6.5 Contact Position.

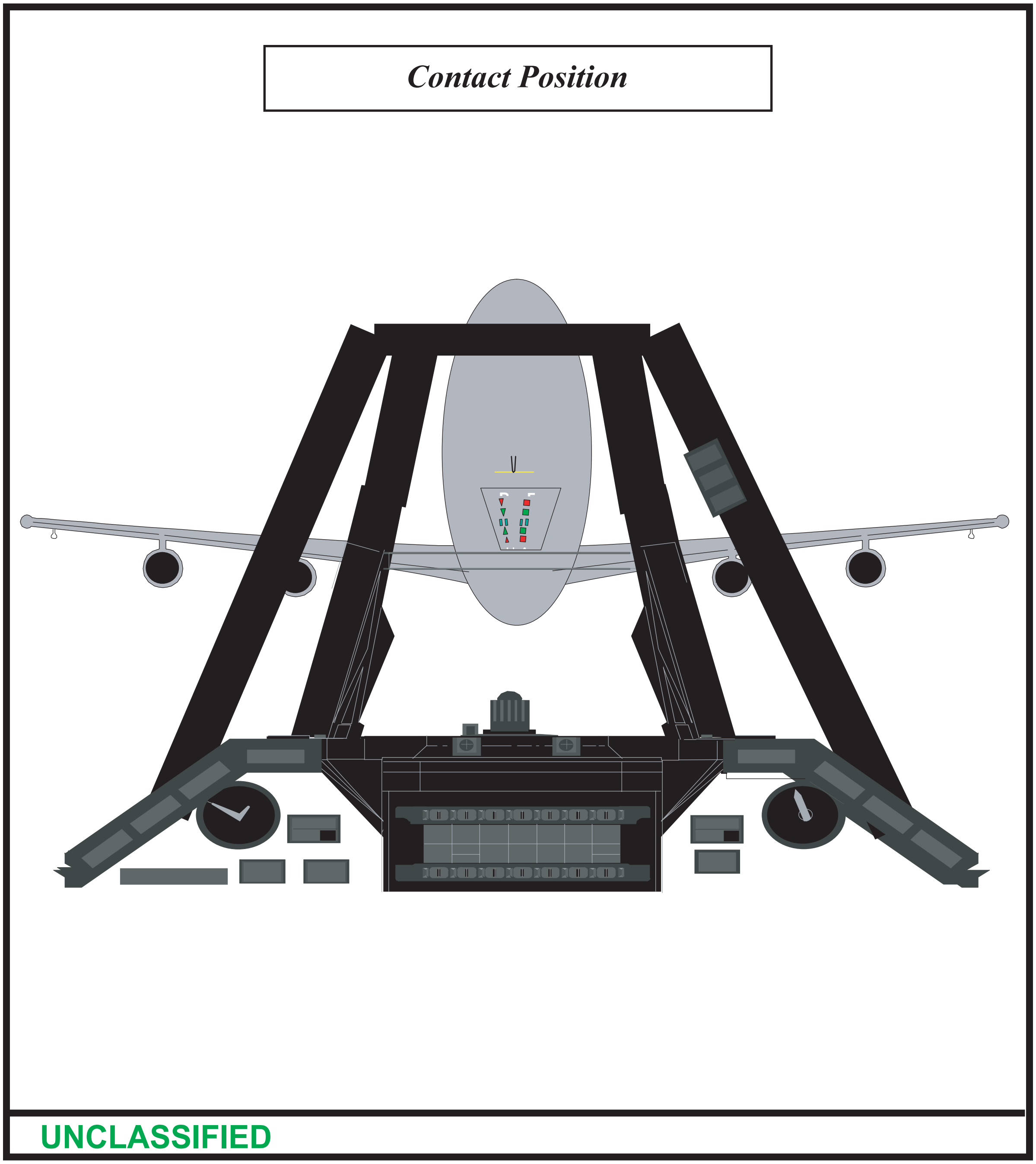
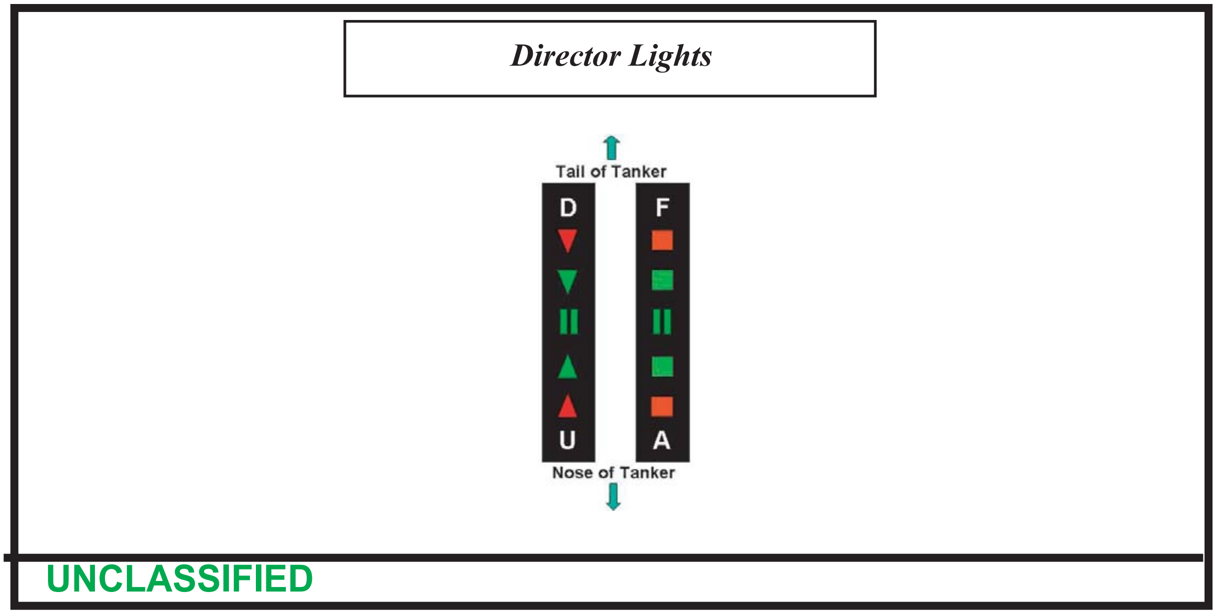


Figure 6.6 Director Lights.



6.7.4 Departing. Depart from the tanker track IAW the flight briefing and/or ATC's end-of-AR clearance. Remain cognizant of the position of other aircraft while departing the tanker and maneuver to provide at least three minutes separation on the navigation route. Delay descent to the preplanned initial route altitude until positive separation from other flight members is assured.

6.8 Abnormal Procedures.

6.8.1 Blind. If IMC conditions are encountered or the wingman loses visual with lead follow the procedures described below.

6.8.1.1 **Prior to the ARIP.** During the climb, lead will call all turns, rollout headings, and each 5,000 feet until level off. If still IMC at level off, the wingman will be cleared to hold at the ARIP and coordinate a new rendezvous time with the controlling agency.

6.8.1.2 **Beyond the ARIP.** The wingman will inform lead, slow 10 KCAS, and ensure 1,000 feet altitude separation. Lead will clear two to proceed to the ARIP to hold and coordinate a new rendezvous time with the controlling agency. Sometimes this is not practical for fuel, one-way track, and so forth. Use SA and have a good plan.

6.8.2 Fuel Imbalance. A small amount of fuel may flow into the wing tanks. Sometimes the fuel system will ignore this, resulting in trapped fuel. Other times, it will feed very slowly, resembling trapped fuel. In either case, analyze the distribution and monitor as required.

6.8.3 Spatial Disorientation. The departure from the tanker track can be disconcerting and spatial disorientation is a definite concern. As soon as possible after joining or approaching the tanker, set up the nav mode and exit point, timing, and anticipated altitude. This will give maximum SA when it comes time to exit. If experiencing spatial D, fly straight and level with the autopilot engaged, recheck instruments, and once oriented, continue toward the push point. PAARS is an option for spatial D, but will not work in all configurations (i.e., with the AR door open).

6.8.4 Fuel Spray. Continuous fuel spray from the receptacle is not normal, but probably the most common air refueling malfunction. Disconnect immediately after the boomer or wingman reports fuel spray. Attempt another contact, but if the spray continues, discontinue refueling. Write up the problem in the 781 after landing. Flying slightly high on the boom may stop the spray if refueling is necessary for safe recovery.

6.8.5 Breakaway. If a breakaway is initiated while in the pre-contact or contact position, it is possible to lose sight of the tanker in the top of the canopy. Execute the procedures found in 1F-117A-6CL-1.

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CHAPTER 7

LOW-ALTITUDE OPERATIONS

7.1 Introduction. The F-117 is able to conduct low-altitude ingress and egress, preferably at night, in visual meteorological conditions (VMC). Instrument meteorological conditions (IMC) remain feasible, but consider avoiding areas of thunderstorms, hail, snow, and other severe weather. Although the global positioning satellite/inertial navigation system (GPS/INS), fully coupled autopilot system and infrared acquisition and designation system (IRADS) and night vision goggles (NVG) give reliable low-level capability, crew proficiency is the most critical aspect of low-altitude operations. This chapter discusses the following low-altitude topics: awareness and considerations, low-altitude basics, route abort procedures, navigation techniques, mission planning, and employment considerations.

7.2 Additional References. In addition to local base and host nation instructions, the low-altitude references shown in **Table 7.1**, Low-Altitude References, will be helpful.

Table 7.1 Low-Altitude References.

Reference	Title	Notes
AFTTP 3-1.18	*Tactical Employment, F-117A*	Outlines capabilities of threat weapons systems and provides planning guidelines.
AFI 11-2F117V3	*F-117A Operations Procedures*	Directs low-altitude operations and procedures.
AFI-11-214	*Aircrew, Weapons Director, and Terminal Attack Controller Procedures for Air Operations*	Outlines training rules for low-altitude operations.

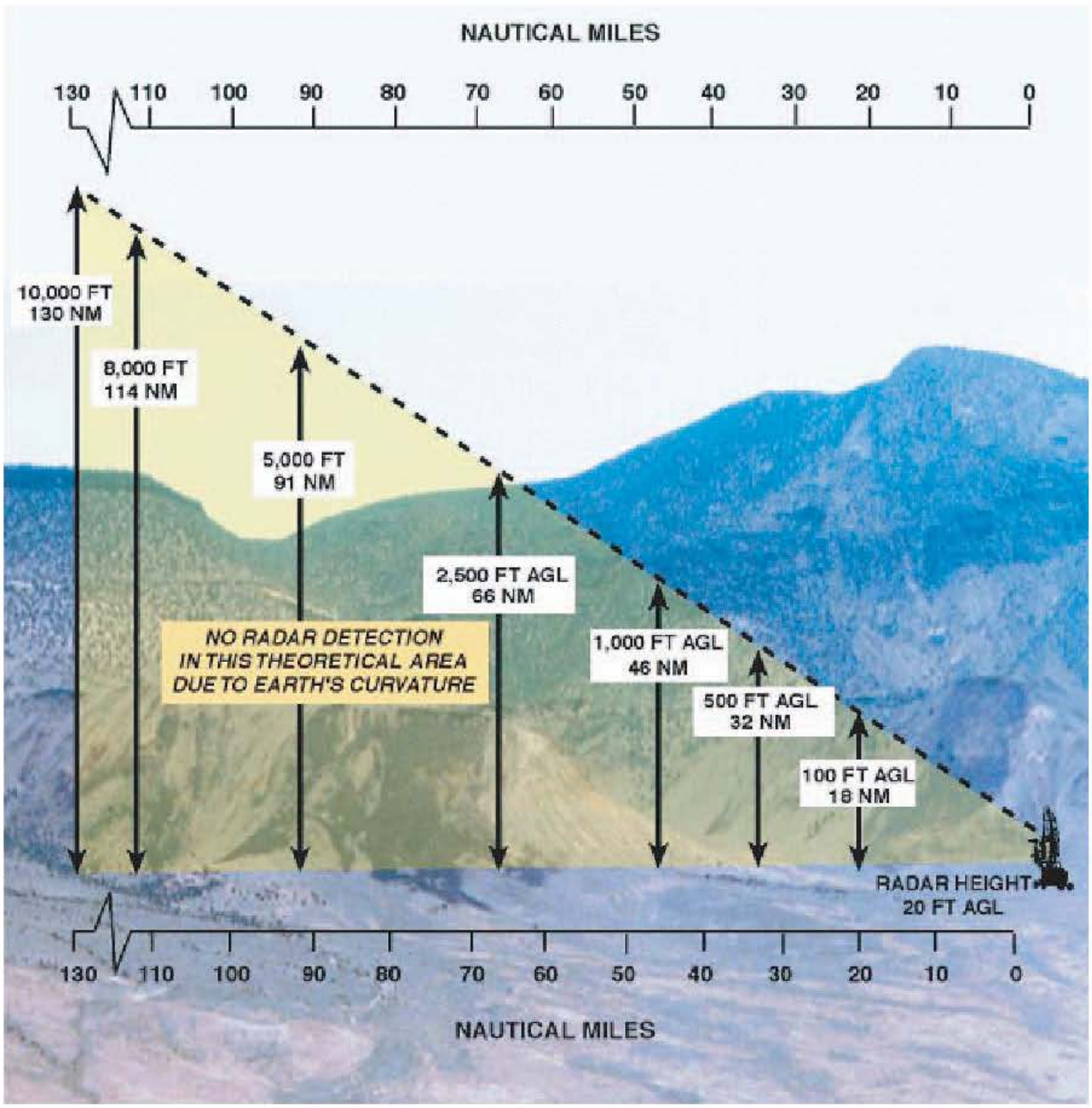
7.3 Awareness and Considerations.

7.3.1 Altitude. The proper altitude to fly will depend on many factors such as threat, weather, terrain, HHQ restrictions, fuel constraints, and weapons employment and/or effects considerations. As a general rule, flights should only be planned as low as necessary to perform the mission. At some altitude, even with a fully coupled autopilot, pilots cease performing any other mission tasks except terrain avoidance. Employment altitudes as low as 1,000-foot minimum en route altitude (MEA) within a 5-NM corridor allow adequate time to perform mission tasks and maintain situational awareness. **Figure 7.1**, Radar Line of Sight to Airborne Targets from Surface Emitters, illustrates some physical limitations of threat systems for use in planning ingress/egress altitudes.

7.3.2 Airspeed. Higher airspeeds decrease the time exposed to a specific threat, but increase fuel consumption and turn radius which can complicate target acquisition and tracking.

Figure 7.1 Radar Line of Sight to Airborne Targets from Surface Emitters.

Radar Line of Sight to Airborne Targets from Surface Emitters



7.3.3 Turns. Routes planned in the low-altitude environment may not follow typical F-117 ingress/egress tactics. Turns should be planned to avoid terrain, restricted areas, lines of communication, and threats.

7.3.4 Route/Form 70 Study. A thorough study of altitudes and terrain features along the planned route of flight and comparison to Form 70 calculations is critical to maintaining situational awareness. Study the route thoroughly; know how every major point appears, both visually and in the IR spectrum. For checkpoints, analyze the weather effects (e.g., smoke, haze, and dust). Consider selecting checkpoints that are more visible to the sides of the aircraft. Analyze the time of year for seasonal changes of both visual checkpoints and IR returns. Review the altitude, restrictions, headings, and timing. Geographic features of the route must receive special attention.

7.3.5 Autopilot. Understanding the idiosyncrasies of the F-117 autopilot system, with respect to airspeed/altitude change hierarchies and turn sequencing logic will prevent “surprises.”

7.3.6 Threats and Terrain. Low altitude operations can enhance tactical surprise and can significantly degrade threat A-A and A-G system capabilities, especially in mountainous terrain. Over relatively flat terrain, threats have better low-altitude capabilities.

7.4 Low-Altitude Basics. F-117 operations in the low-altitude environment are highly dependent on autopilot use along detailed mission planned routes. This does not alleviate the pilot from understanding basic principles.

7.4.1 Altitude Reference. The horizon and ground objects near the aircraft can serve as an altitude reference. Aircraft “altitude” alerts provide aural feedback of deviations below planned MEA along a route leg. In addition, the radar altimeter can assist in validating altitude.

7.4.2 Low-Altitude Hazards. Be keenly and constantly aware of low-altitude hazards.

7.4.2.1 **Visibility Restrictions.** The F-117 canopy is by design restrictive to good visibility. Visual illusions from canopy reflections can further hamper the situation. Terrain illusions due to shadows and low sun angles are normally not a factor during nighttime operations.

7.4.2.2 **Subtle Terrain Elevation Changes.** MEA information is only as good as the digitized terrain elevation data (DTED) loaded into the Air Force mission support system (AFMSS), which is not CHUMed. Constantly clear for “NEAR” rocks and then “FAR” rocks through any means available (e.g., IRADS or NVGs).

7.4.2.3 **Task Saturation/Fixation.** A solid cross-check cannot be over-emphasized. Appropriate task prioritization during different phases of flight (e.g., ingress, target area, and egress) is necessary to ensure aircraft systems (i.e., 3 Cs) are functioning correctly.

7.4.3 Insidious Descent. One of the most dangerous aspects of low-altitude flight is insidious, unplanned descent into terrain. An active autopilot cross-check to avoid “uncoupled” situations and the following data should help to understand the attention required for low-altitude operations.

7.4.3.1 **Wings-Level Shallow Dive.** In wings-level flight at 1,000 feet, if the aircraft is in a 2-degree dive at 500 knots true airspeed (KTAS), time to ground impact (TTI) is 35 seconds. A 5-degree dive, reduces TTI to 7 seconds. Recovery must be initiated within the first few seconds to avoid hitting the ground. **Table 7.2**, Time-to-Impact (seconds) in a Wings-Level Dive, shows additional examples.

Table 7.2 Time-to-Impact (seconds) in a Wings-Level Dive.

Altitude (feet)	Dive Angle (degrees)				
	1	2	3	4	5
100	7.0	3.5	2.3	1.4	0.7
300	21.0	10.5	6.9	4.2	2.1
500	35.0	17.5	11.5	7.0	3.5
1,000	70.0	35.0	23.0	14.0	7.0
2,000	140.0	70.0	46.0	28.0	14.0
OVERALL NOTE: * Impact times calculated at 500 KTAS; double AGL, then double TTI; double flight path angle (FPA), then halve TTI; double KTAS, then halve TTI.					

7.4.3.2 **Level Turn.** The TTI for overbank in a level turn is the same as the 0-G wings-level bunt with an added bank angle calculation which magnifies the vertical component. However, there is a distinct difference between the 90-degree bank and the 0-G wings-level bunt. It is extremely difficult to perceive that one is descending when experiencing 4, 5, or 6 Gs. Therefore, the pilot’s ability to catch an error by any means other than visual is hampered. The most significant difference is the bank angle sensitivity. Even very small bank angle deviations of 5 degrees or 10 degrees dramatically reduce time-to-impact for turns when compared to straight and level time-to-impact at the same AGL. Once 90 degrees is exceeded you are “pulling” toward the ground. A 10-degree overbank is considered the “typical” deviation. **Table 7.3**, Time-to-Impact, “Level” Turn, lists the time-to-impact for several turns ranging from 2 to 6 Gs. The first bank angle is required for a level turn and the second bank angle, in parentheses, includes the 10-degree overbank. The table illustrates the importance of controlling the bank angle and G combination. This table also shows the effects of the acceleration toward the ground as the bank angle and G increase. With a 10-degree overbank, the time-to-impact values are essentially the same for any turn of 3 Gs or more.

7.4.3.3 **Comparison.** Provided in **Table 7.4**, Wings-Level versus Level Turn, is a more useful side-by-side comparison for deviations from straight and level flight and level turns by comparing the actual time-to-impact along with the point of recovery. This comparison shows the relative safety of straight and level flight while showing the increased danger of turning maneuvers.

7.4.4 Ground Probability of Kill. “Terra Firma” is the number one threat at low altitude, and its probability of kill (P_k) is very close to 1.0.

Table 7.3 Time-to-Impact (seconds) in a Level Turn.

Altitude (feet)	Bank Angle/"G" Required (degrees)				
	60 Degrees/2 G(70 degrees)	71 Degrees/3 G(81degrees)	75 Degrees/4 G(85 degrees)	78 Degrees/5 G(88 degrees)	80 Degrees/6 G(90 degrees)
100	4.4	2.7	2.6	2.5	2.5
300	7.7	4.7	4.5	4.3	4.3
500	9.9	6.1	5.8	5.7	5.6
1,000	14.3	10.8	9.6	9.5	9.5
2,000	21.6	17.2	16.8	16.7	16.7

OVERALL NOTE:
* The numeric values in parentheses are for the 10-degree overbank.

Table 7.4 Wings-Level versus Level Turn.

Altitude (feet)	Time to Impact/Last Chance Recovery (seconds)	
	Straight and Level (-1 degree FPA)	Level Turn (+10 degrees overbank)
100	7.0/5.5	2.6/1.3
300	21.0/19.5	4.5/2.3
500	35.0/33.5	5.8/2.9

OVERALL NOTE:
* Chart is comparing TTI for deviations from wings level flight versus deviations from overbank in turns. Additionally, last chance recovery times are shown.

7.4.5 Ridgeline Crossings. Crossing ridgelines in high threat areas can highlight aircraft to threats, both ground and air. F-117 OFP constraints do not permit more than one preplanned altitude change per leg. The "climb early" capability of the autopilot must be carefully planned for to avoid simulation errors during route computing. Typical ridge crossings utilizing perpendicular, parallel, and saddle type procedures are not performed. NVG experience may allow for these types of profiles in future operations.

7.5 Route Abort Procedures.

7.5.1 General. There are several situations which require the crew to terminate the low level, such as an aircraft emergency or a systems malfunction. The ground is the biggest threat at low altitude and avoiding it is the number one priority. When distracted by an emergency or task saturation dictates, the only correct response is "CLIMBING TO COPE."

7.5.2 Aborting the Low-Altitude Arena.

7.5.2.1 **Misplaced Priorities.** Although the route abort concept sounds like basic common sense, it is easy to misplace priorities when operating at low level. With experience, you become quite comfortable in the low-altitude environment. When the situation forces you to divert attention from the task of ground avoidance for more than the normal cross-check time, abort!

7.5.2.2 **Execution.** Once the decision is made, roll to a wings-level attitude, pull the nose smoothly to +15 degrees, climb in Mil power and climb to the briefed minimum safe altitude (MSA)/route abort altitude (RAA).

7.5.2.3 **Pilot Activated Automatic Recovery System (PAARS).** Even though this mode does ensure terrain separation, it can be an effective tool if spatially disoriented and a climb away from the ground is desired.

7.5.2.4 **Controlled Abort Procedure.** Do not make a bad situation worse by executing an overly aggressive route abort, leading to spatial disorientation and possible loss of aircraft control. If you find yourself climbing above the safe altitude, smoothly unload to descend to the proper altitude. A large negative-G maneuver at night can be extremely disorienting. As in all aircraft emergencies, maintain aircraft control. Controlled airspace, clouds, and route restrictions are all consideration factors when aborting a route, but only after a controlled level off at the MSA/RAA. Additionally, if conditions permit the autopilot may be used to aid in execution of an abort. If the route abort is permanent for that sortie, coordinate with other flight members and air traffic control (ATC) to ensure deconfliction.

7.6 Low-Altitude Mission Planning.

7.6.1 Mission Objective. The mission objective (target, desired level of damage, etc.) has a significant impact on the attack plan. A requirement for a specific attack axis may dictate the desired routing to the target. Plan the attack first and then pick an initial point (IP) that allows you to achieve your desired run-in heading. Then plan the route to get to the IP and egress from the target, remember work from the target backwards.

7.6.2 Threats. Enemy threats are perhaps the greatest factor in low-level route selection. Avoid the threat when possible, and when necessary to fly through threat envelopes, plan the route to degrade the threat's capabilities. Current intelligence on the location and movements of enemy units is essential.

7.6.3 Terrain. Where possible, use terrain features to mask the aircraft from threats and provide tactical surprise in the target area.

7.6.4 Air Force Mission Support System Considerations.

7.6.4.1 **MEA Calculation.** AFMSS uses DTED information to calculate the MEA along a route. The MEA altitude and route width can be manipulated to the desired parameters; however, the corridor width cannot be reduced below an OFP constraint of 1 NM. In order to optimize operations in mountainous terrain, shorter leg lengths are required.

7.6.4.2 **Chart Update Manual (CHUM).** CHUM is not provided in AFMSS. Routes must be manually cross-checked on charts or loaded into the portable flight planning system (PFPS) for electronic-CHUM evaluation.

7.6.4.3 **Digital Maps (DMAP).** Ensure the elevation bands used for creation of the digital data cartridge (DDC) maps are scaled for the local area terrain. The DDC load should include scales and areas of coverage that mirror the DDC paper maps (PMAP).

7.6.5 Route and Turn Point Selection. All turn points should be visually or IR significant. Obviously, that is not always possible but search for such points. Avoid towns and lines of communication (LOC), since these are often sites of threats. When searching for turn points, make note of other significant points, potentially to the sides of the aircraft, which may be used for pilotage checkpoints or updates.

7.6.6 Multi-Ship Deconfliction. Multi-ship operations in the low-altitude environment will require increased attention to deconfliction issues. Tactical employment can be enhanced with NVGs.

7.6.7 Update/Offset Points. Plan for several update points along the low level. Reference the Form 70 for preplanned updates. Choose a point reasonably close to the target area to minimize subsequent drift errors. Additionally, OAP selection needs to consider IRADS field of regard limitations. Selecting OAPs along the route of flight, 3 to 4 NM short of the target is a technique which can provide confidence in system accuracy or allow adequate time to compensate for system drift prior to weapons release.

7.6.8 Chart Selection. If required, whenever possible, use a 1:50,000 scale chart of the target area for attack planning. For the low-level route, either joint operations graphic (JOG) (1:250,000) or tactical pilotage chart (TPC) (1:500,000) scale charts are appropriate. Be sure to update the CHUM. A new tower along the route of flight is not only a hazard; it may cause a pilotage error if the checkpoint for that leg also happens to be a tower.

7.7 Navigation. There are multiple means by which navigation may be conducted. F-117 tactics, survivability and weapons employment generally require 4-D coupling of navigation systems, with the capability to manipulate each as required for mission accomplishment and time-over-target management.

7.7.1 Computer Assisted Navigation. Due to the strict nature of F-117 mission planning and deconfliction, this is the primary means of maintaining course and timing requirements in the F-117. INS, GPS and INS/GPS modes may be relied upon to provide autopilot navigation once it is proven reliable. HNAV, VNAV and SNAV/TOT functions may be referenced, but must be cross-checked with expected performance to ensure proper steerpoints, altitudes, speeds and timing are maintained.

7.7.2 Visually Assisted Navigation. Map reading or "pilotage" is a less relied upon method of navigation. Maps used in close conjunction with Form 70 data or annotated with applicable data can be extremely useful. Caution must be taken to avoid too much detail so as to avoid fixation.

7.7.2.1 **Color Multi-Display Indicator (CMDI).** The moving map display can be used as a general reference. The smaller the scale the more detailed information available. Terrain elevation awareness is optimized by selecting DMAP, FN1 and BGD3 on the MAP page of the CMDI. This colors map terrain "red," that is higher than a selected DTED.

7.7.2.2 **Overall Mission Portrayal (OMP).** Navigating using a typical map becomes unmanageable at night with lower cockpit lighting. This "stick map" depiction of the route plan provides another basic reference to maintain general SA on mission status.

7.7.2.3 **"Stick Maps."** Other than the OMP a "stick map" can be a hand drawn route depiction on a line-up card showing prominent terrain features, LOCs, time lines, and the route of flight. Stick figure maps can vary widely, but the minimum items normally included are significant points, obstacles, minimum altitudes, and required cockpit tasks. Label heading and elapsed time beside each route segment; in addition, add time at each turn point, fuel, and MSA/RAA for that route segment. Additional annotations might include tactical information such as enemy defenses or forward line of own troops (FLOT), and so forth.

7.7.3 Dead Reckoning. Dead reckoning (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-117 avionics, DR is not required as a primary method of navigation, but on-board systems provide sufficient data to perform this method as an emergency backup.

7.8 Employment Considerations.

7.8.1 Attack Timeline. Pilots must be prepared for compressed target attack pacing. IR conditions and IRADS interpretation may delay target acquisition until late in the timeline.

7.8.2 Infrared Acquisition and Designation System. The low-altitude environment produces much higher LOS rates than medium altitude attacks. Memory Point Track provides adequate slew rates to permit tracking as low as 1,000 feet AGL. Automatic Video Track mode can provide a more stable track, but may not be feasible due to podium effects. IRADS lookback angles and laser occluded regions need to be referenced to ensure end-game guidance capability.

7.8.3 Low-Altitude Formations.

7.8.3.1 **Non-NVG Formations.** Typical F-117 Trail and Station Keeping formations can be flown, but are not optimal for low-altitude employment. Individual route deconfliction plans must be considered during most phases of mission execution.

7.8.3.2 **NVG Formations.** F-117 NVG Fluid is the preferred low-altitude formation. (See **Chapter 8**, "Night and Adverse Weather Operations.") As a ROT, wingman should stack 200 to 500 feet above lead when operating below a 5,000-foot MEA.

7.8.3.3 **Position Latitude.** Formation positions are usually not rigid, which allows the wingman latitude to close up spacing for weather or terrain clearance. However, the wingman should always know exactly what is expected and the limits of maneuvering. Flight leaders are responsible to specifically control the wingman's formation position. Consideration should be given to a route abort and/or flight split up if conditions do not facilitate formation operations.

7.8.4 Low-Altitude Weapons Employment. Low-altitude employment will shrink launch acceptability regions and decreases weapon times of fall. Careful consideration in the weaponeering process needs to be given to weapon effects, fuze arm time, safe separation, safe escape and weapon fragmentation deconfliction. For further information refer to AFTTP 3-1.18, *Tactical Employment—F-117*.

CHAPTER 8

NIGHT AND ADVERSE WEATHER OPERATIONS

8.1 Introduction. The information in this chapter, combined with a thorough knowledge of appropriate sections of AFI 11-2F-117, Volume 3, F-117 and local procedures, will prepare pilots for safe and effective night flying.

8.2 Night Ground Ops. It is important to have the cockpit set up to minimize fumbling in the dark. Photos can be clipped to the G-suit, placed on the left or right side, or in the pubs bag. Life support can provide a small flashlight to attach to the flight suit or harness. Have a large flashlight in the pubs bag. Do not hang equipment around the neck.

8.2.1 Lighting and Filters. Set the cockpit lights to 12 to 1 o'clock and install the CMDI/DEP night or night vision goggle (NVG) filters before engine start. The filters are left/right specific. The NVG CMDI filters are not left/right specific.

8.2.1.1 **DEP Filter.** The most important filter is the DEP filter. At night, without it, the DEP cannot be dimmed sufficiently enough to avoid distraction. If it is missing, get a replacement.

8.2.1.2 **Utility and Apex Light.** Place the utility light as desired. Some set it on the peanut ADI, others the engine instruments.

8.2.1.3 **Adjust to the Darkness.** After the post-start checks are completed, have the crew chief extinguish the hangar lights in order to begin adjusting to the darkness.

8.3 Night Taxi. The F-117 is extremely difficult to see at night. Keep the taxi light on in the arming area until absolutely sure of not hitting anything (not wanting to blind the arming crew is not justification for insufficient lighting). When the quick check crew is under the jet, turn the rotating beacon off. Turn the HUD, CMDIs, and flight instrument lights back up. They should be bright enough to be read at a glance. This is a good time to review the photo pack and check the IRADS picture, but ensure the SD is turned down until well after getting airborne. Put the warning and caution lights to BRIGHT (if desired) and turn the radar altimeter on. Seeing obstructions while taxiing is obviously more difficult at night. Bright cockpit lighting reflecting off the flat canopy glass will make the problem even worse. To minimize these effects, consider the following:

- Prior to taxi turn down the HUD and SD—a bright SD will be very distracting and will degrade night vision.
- Turn down the CMDIs to the point where they are readable but do not reflect off the windows.
- Put the warning/caution lights to DIM (if desired) and lower the other lights to reduce reflections.
- Flash the taxi (not landing) light once when ready to taxi.
- Flash the taxi light or turn on the beacon if the crew chief is needed back on the headset.
- Keep the speed low and watch for people and vehicles ahead.
- Keep the nose wheel on the centerline to ensure wing tip clearance.
- If wing walkers are needed, coordinate through squadron ops.

8.4 Night Takeoff.

8.4.1 Lights. When cleared for takeoff, turn on the taxi light and rotating beacon leaving the arming area. Dim the cockpit light to provide the desired balance between night vision and ability to quickly interpret the instruments. Do not dim the engine instruments so that they are unreadable. Do turn the brightness down on the IRADS SD (after quickly checking it to ensure the runway is clear of any large objects) and select TM/SRCH and WFOV.

8.4.2 Cockpit Review. Review the boldface items for takeoff and the positions of the drag chute handle (touch), the hook switchlight (do not touch), and the ejection handles. Review the position of the standby instruments, run-up the engines, check takeoff trim, and release brakes.

8.4.3 Lift off. Be prepared to transition rapidly to instruments after lift off due to the lack of lights off the end of the runway. The runway lights reflect off the canopy giving a "Star Wars effect," and then abruptly disappear in the darkness. This can be very disorienting. The "black hole" effect at night requires close monitoring of all instruments during the takeoff and departure.

8.4.4 Climb. Climb using the climb schedule and engage the autopilot when desired above 1,000 feet AGL. Remember, the autothrottle will hold whatever KCAS it saw when it was engaged. Enter the airspeed if something else is desired. If becoming severely disoriented, consider transitioning instrument reference to the AHRS gages (i.e., round dials and ADIs) or use the PAARS button.

8.4.5 Departure. Climb at 300 KCAS until level off. Above 10K perform a Tech Order Climb IAW the F117-1. If the aircraft slows while climbing, it is very difficult to regain airspeed. Accelerate to cruise speed after leveling off.

8.5 Night Formations. Available night formations are Station Keeping and Trail. (See **Chapter 6**, "Air Refueling" and **Chapter 9**, "Night Systems: Night Vision Goggles And IRADS.")

8.5.1 Night Vision Goggles Formations. NVG formations are modifications of Trail and Station Keeping, which allow the wingmen to swing the 180-degree arc behind the flight lead in azimuth while still maintaining the DME limits. (See **Figure 8.1**, Trail, and **Figure 8.2**, Station Keeping.) For more information on NVG specific tactical formations, see AFTTP 3-1.18, *Tactical Employment—F117*.

8.5.2 Night Vision Goggle Lead Considerations. NVG wingmen own the flight lead's external lighting. The halo effect of the non-compatible external lights can adversely affect wingmen's ability to quickly assess closure rates and aspect angles. Wingmen should be briefed to adjust leads nav lights, apex light, and fuselage lights as required for current environmental conditions. Leads should extinguish their rotating beacon as soon as wingmen as established in an ATC standard formation. More than one adjustment per flight might be necessary as illumination levels can change through out the course of a mission. At least one anti collision beacon must be on within standard formations.

8.6 Night Approaches. Once visual on final, begin to transition to a visual approach with the HUD. Uncage the flight path marker (if caged) to monitor drift, and set the intensity versus the runway lights.

Figure 8.1 Trail.

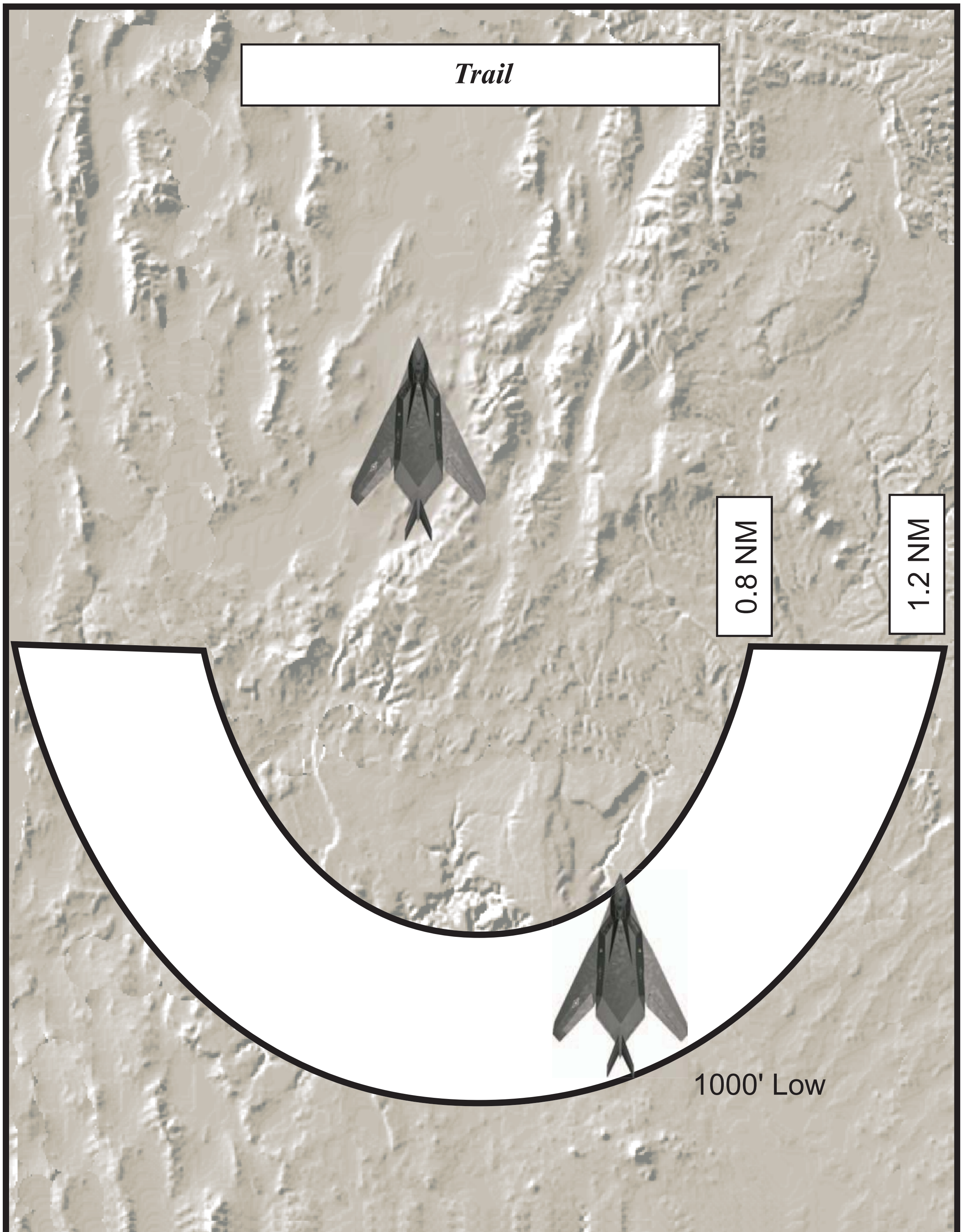


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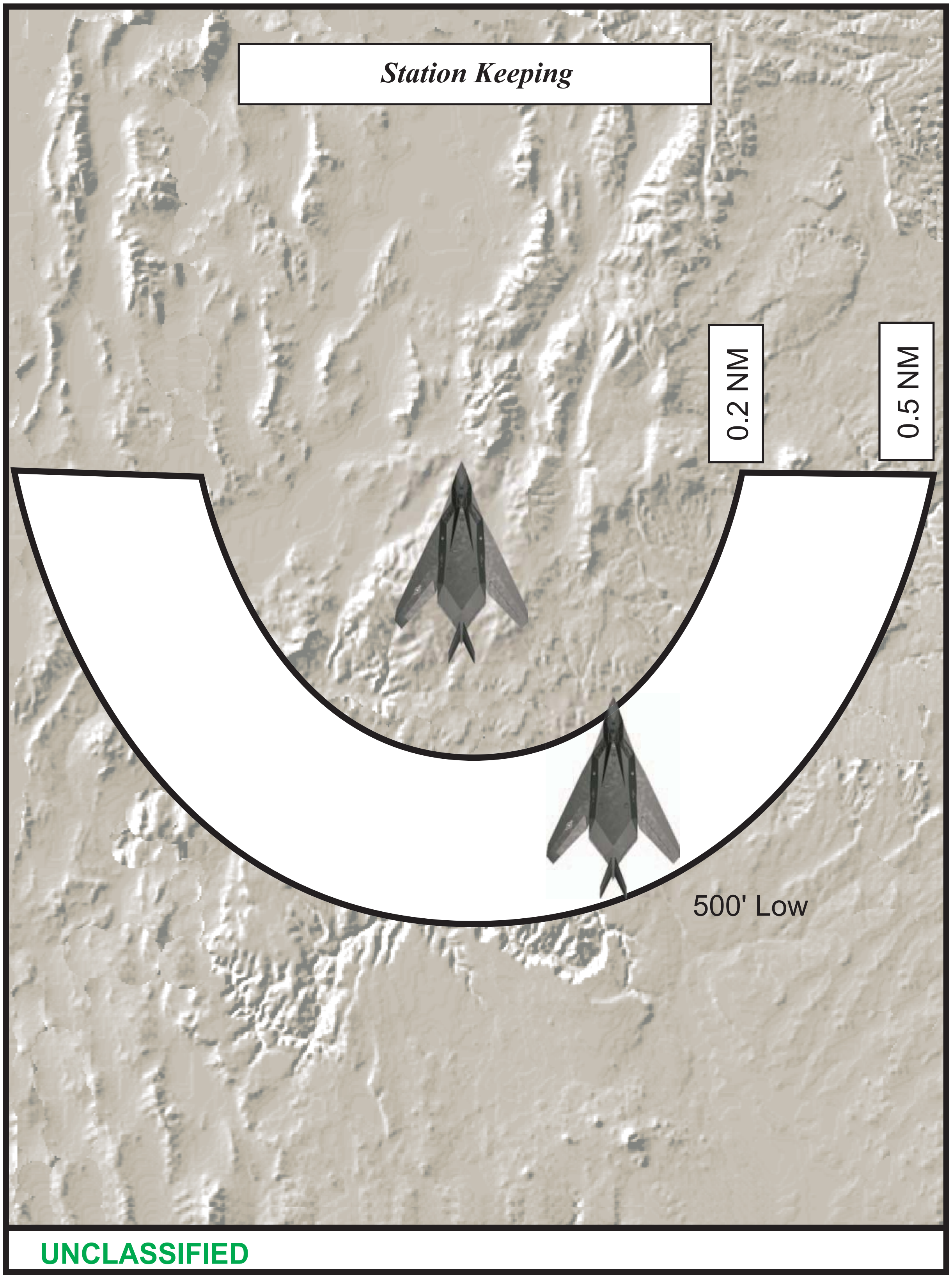
Figure 8.2 Station Keeping.



8.6.1 Double Checks. Reconfirm the location of the drag chute handle and the hook switchlight. If disoriented or not flying as precisely as desired, break off the approach early. The radar altimeter should be used on approaches to help maintain SA.

8.6.2 HUD Setup. Declutter the HUD, if desired. If the HUD is fairly dim, the symbology may fade away as the intensity of the runway environment increases. Turn it up early as the flare is not the time to be adjusting the HUD.

8.7 After Landing At Night. Use the same procedures as during the day. Watch for chutes. Be careful not to overcrowd the side of the runway. Be ready to find chutes anywhere. If there is a problem with chutes on the runway, tell the tower.

8.7.1 Taxi Back. After clearing the runway, keep taxi speed below 25 knots. Switch from landing lights to the taxi light. Turn the rotating beacon off upon entering the hangar. Also extinguish the taxi light when sure the path is clear and it comes to bear on the crew chief's retinas. For blackout recoveries, the crew chief should have a flashlight on the ground illuminating the taxi stripe.

8.7.2 Cockpit Clean Up. It is especially easy to forget things in the cockpit at night. It is also easier to miss after-landing checks because the switches may not stand out. An extra sweep around the cockpit with a flashlight prior to taxi back and after shut down may save some embarrassment.

8.8 Weather. Locally, the primary weather problem comes with summer thunderstorms. Thunderstorms are an obvious threat, but even heavy rain squalls can produce damage.

8.8.1 Avoidance. In the day, this can be easy if the storms are scattered and weather is otherwise clear. When dealing with embedded storms, ask Center for information and they may be able to help. At night, visually clear storms if the night is clear and/or moonlit and the storms are scattered. Using TM/wide on the IRADS can also show what is in the flight path. Wide FOV and scan may also help. If unsure, again try center. Day or night, dodging weather can create other complications.

8.8.1.1 **Timing/Fuel.** Obviously timing can be affected by significant deviations, but even moderate weather deviations can seriously affect the fuel plan.

8.8.1.2 **Climbs.** Make the climb decision early. Delaying until close to the storm will require a steep climb, which bleeds off speed and reduces climb capability. An early decision will also facilitate coordination/ approval with center. Do not hesitate to use emergency deviation authority to avoid severe weather penetration. Declare an emergency if necessary.

8.8.2 Avoidance Failed. If it is not possible to avoid the storm, or if not sure due to night/weather, remember these items.

8.8.2.1 **Weather Penetration.** The F117-1 recommends a maximum of 350 KCAS or optimum cruise airspeed, whichever is slower, for weather penetration. When unsure about flying through the storm cloud or its precipitation, resist the temptation to continue a target run at the higher speed. Err to the safe side and slow to below maximum weather penetration speed.

8.8.2.2 **Save the IRADS.** Bring FLIR to STBY to protect the seekers from precipitation that may build up on the FLIR screen.

8.8.2.3 **Anti-Ice and Wipers.** Make sure engine anti-ice is on (pitot heat should already be on). Follow the F117-1 recommended anti-ice procedures. Remember that turning on ENG INLET WIPER after ice has formed on the "trays," or when ICING annunciator and ICE alert have appeared, may cause engine ice ingestion. Turn on wiper before ice forms.

8.8.2.4 **Do Not Get Too Slow.** Watch for speed bleed off if the aircraft was climbing to avoid a storm after entering it. Slow airspeeds at high altitude (greater than 25,000 feet) can be unrecoverable without large altitude losses.

8.8.2.5 **Warning Lights.** Flying in clear air on days when storms are about, may cause PITOT/ICING annunciators as well as an ICE CMDI alert. The PITOT light indicates a probe heat malfunction. Check the electrical fault indicator panel in the right rear console to determine which probe for maintenance debrief procedures. The other lights illuminate because they automatically activated for icing conditions. Check to make sure the associated engine anti-ice and electrical fault panel lights are also illuminated. Finally, check outside air temperature on the STAT page and record when lights came on and off. All of this may help with maintenance debrief.

CHAPTER 9

NIGHT SYSTEMS: NIGHT VISION GOGGLES AND IRADS

9.1 Introduction. Night systems are night vision goggles (NVG) and the infrared acquisition and designation system (IRADS) system. NVGs are rapidly becoming the standard by which the F-117 community employs at night. Additionally, this chapter discusses combining NVGs with medium-altitude IRADS tactics and how to effectively integrate goggles with the IRADS system.

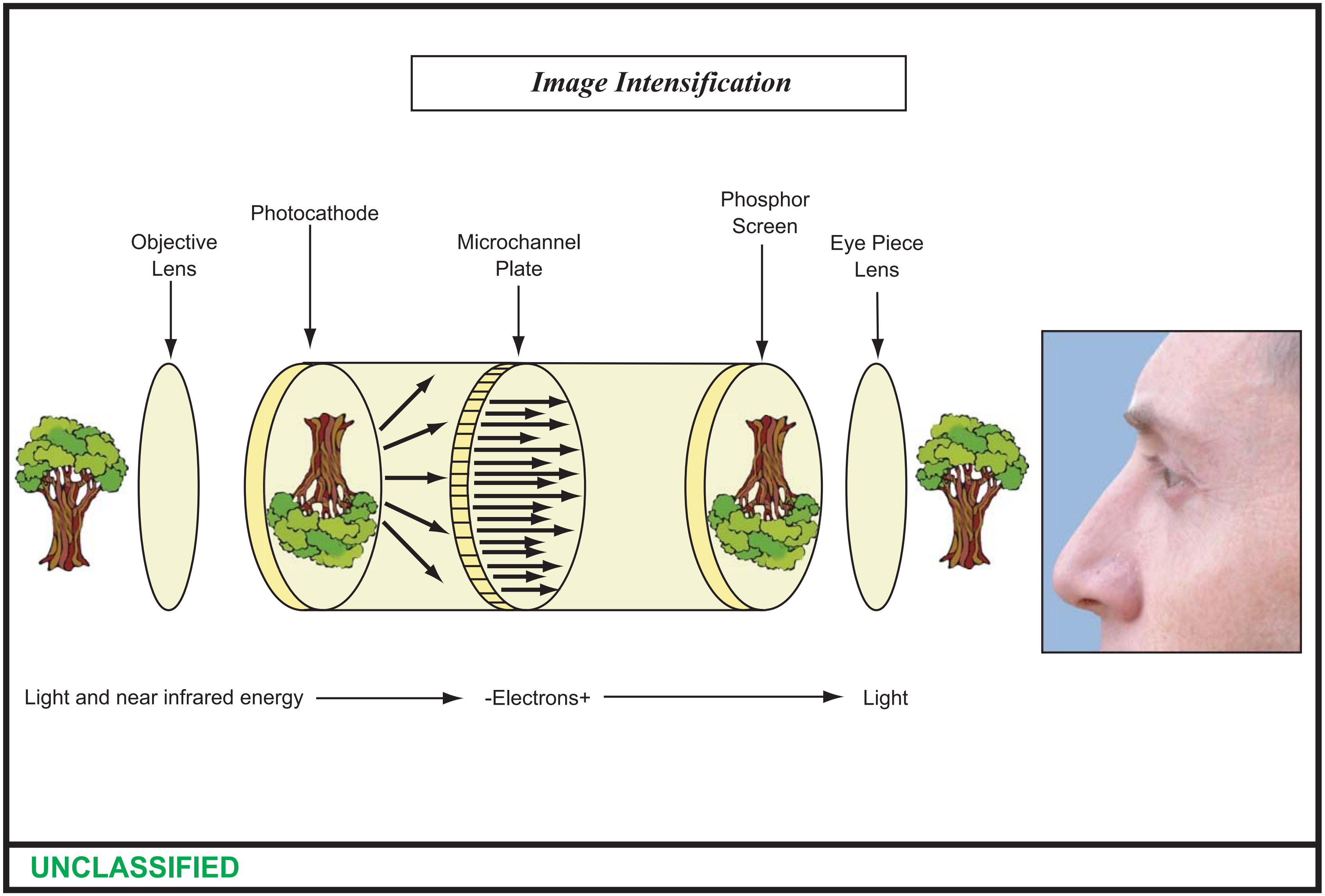
9.2 Night Vision Goggles.

9.2.1 Night Vision Goggle Operations.

9.2.1.1 **Night Vision Goggle Description.** NVGs used in F-117 operations 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. IRADS 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.

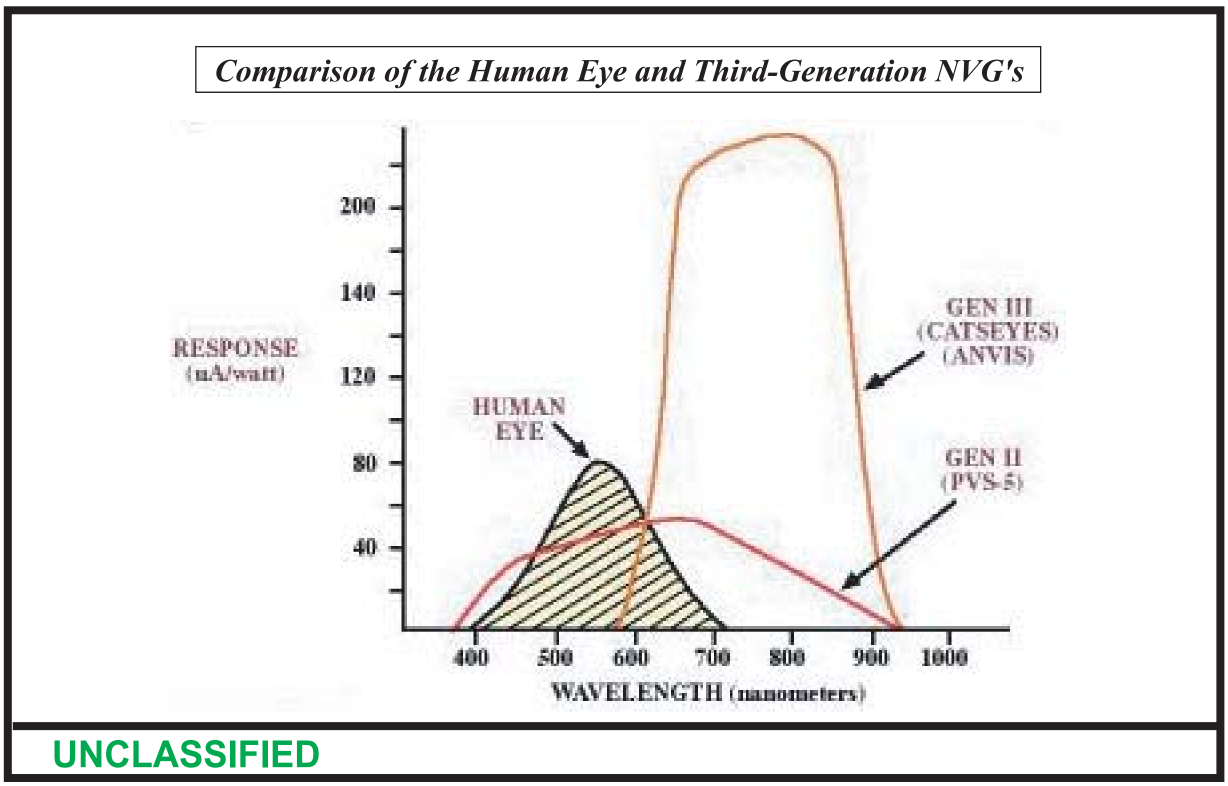
9.2.1.1.1 **Image Intensifier Tubes.** An image intensifier tube is an electronic device that amplifies available ambient light reflected from an object. (See **Figure 9.1**, Image Intensification.) The reflected light enters the goggles and is focused by the objective lens onto the image intensifier's 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. Currently the Air Force uses third-generation intensifiers.

Figure 9.1 Image Intensification.



9.2.1.1.2 **Third-Generation Intensifiers.** Third-generation intensifiers are preferred NVGs for the combat air forces (CAF). 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 9.2**, 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 lives 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-4949L 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.

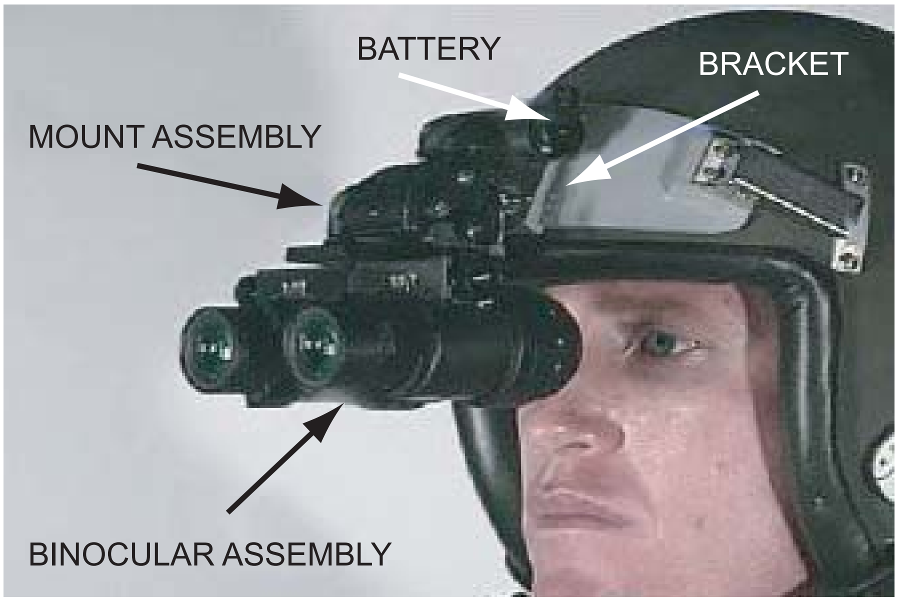
Figure 9.2 Comparison of the Human Eye and Third-Generation NVGs.



9.2.1.1.3 **ANVIS-9 NVG.** The Air Force uses the ANVIS-9/F-4949L NVG featuring a redesigned MCP that improves the resolution of the goggle from approximately 20/45 to 20/30. This version of the ANVIS-9 has visual acuities as good as 20/25, and comes with modified "leaky green" filters which makes them compatible with the F-117 head-up display (HUD). (See **Figure 9.3**, ANVIS-9 NVGs.)

Figure 9.3 ANVIS-9 NVGs.

ANVIS-9 NVG's



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9.2.1.2 **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 an eye test lane, or a Hoffman ANV-20/20 NVD infinity focus system.

9.2.1.2.1 **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.

9.2.1.2.2 **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 the 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.

9.2.1.2.3 **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.

9.2.1.3 **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. Non compatible interior lighting must be turned off (pinky switch) during in-flight ops.

9.2.1.4 **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. Compatible visible and covert/IR external lighting may be installed on the aircraft in the future, allowing aircrews to fly tactical formations while limiting the possibility of visual detection. (See **Figure 9.4**, Lighting Controls.)

9.2.2 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 IRADS, 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. Advantages can be broken down into four main categories: cooperation with other thermal imaging devices, visual formation/escort, visual navigation and terrain avoidance, and threat detection/survivability, all of which allow enhanced nighttime tactics.

9.2.2.1 **Cooperation with Thermal Imaging Devices.** NVGs and thermal imaging devices are complimentary sensors and can aid mission accomplishment through sensor integration. IRADS technology is based on the fact that all objects warmer than absolute zero emit heat. IRADS 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). IRADS sensors detect differences in the thermal properties of these materials and create an image on either the HUD or sensor display (SD). This process, called thermal imaging, results in a monochromatic image. IRADS allows detection, recognition, identification, and classification of targets, scenes, or activities that would otherwise be concealed by darkness. **Table 9.1**, NVG/IRADS Comparison, and **Figure 9.5**, Comparison of NVG and IRADS Technology, show a comparison of NVG and IRADS technology.

Figure 9.4 Lighting Controls.

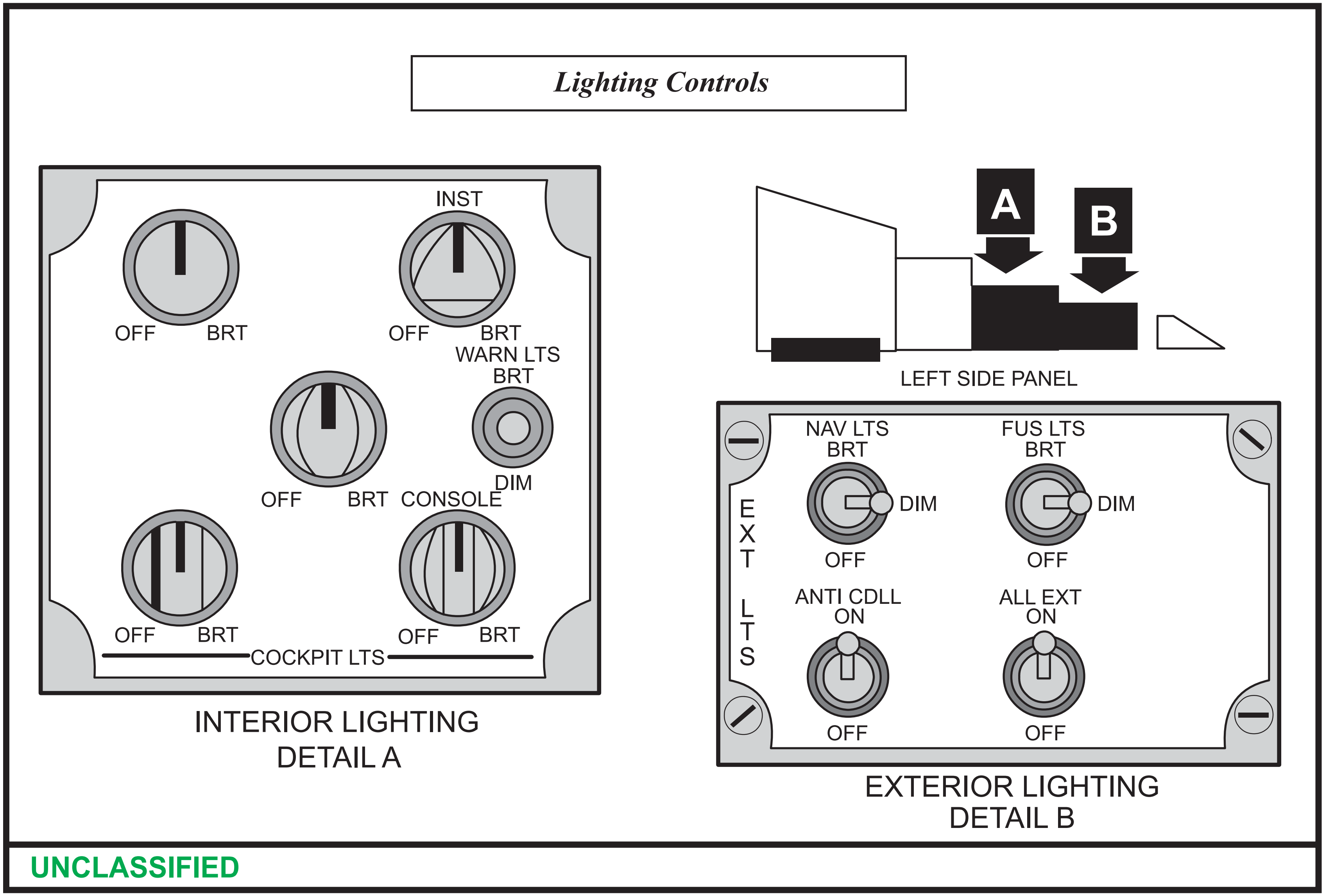
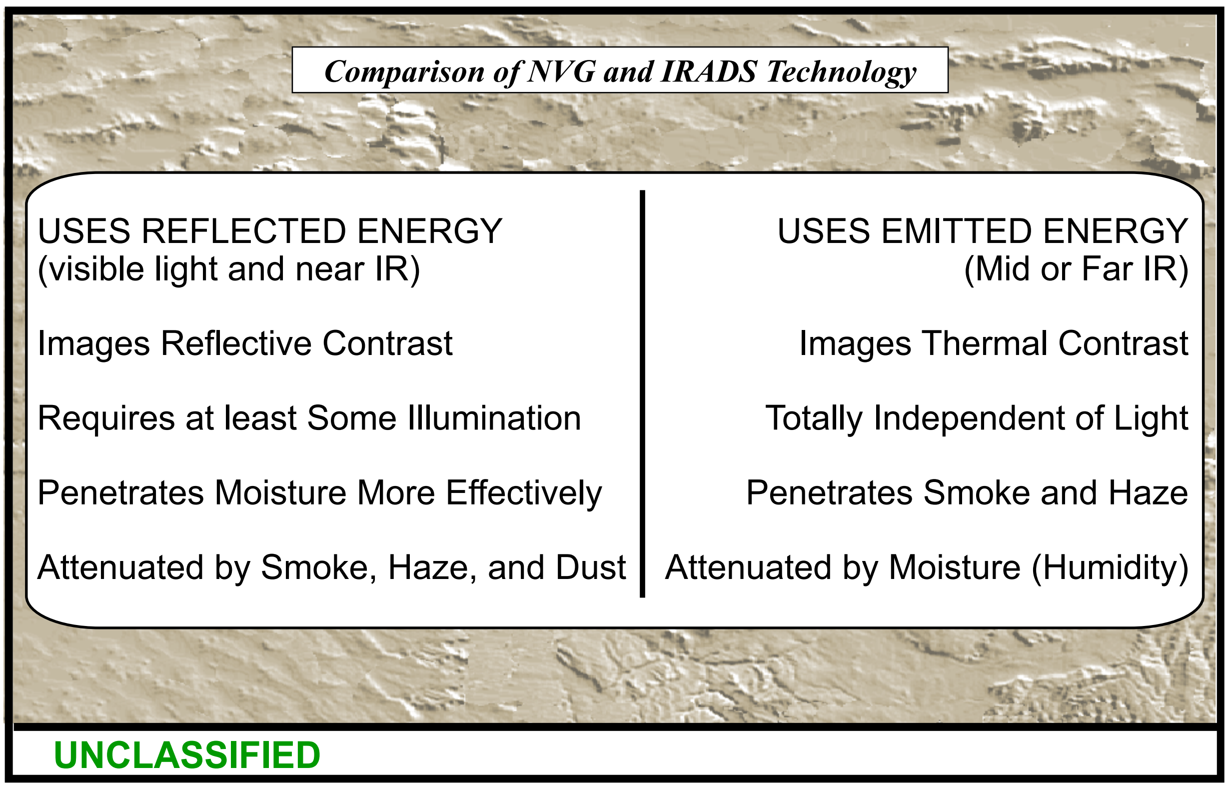


Table 9.1 NVG/IRADS Comparison.

NVG	IRADS
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)

Figure 9.5 Comparison of NVG and IRADS Technology.



9.2.2.2 **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 with other aircraft. 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 F-117s can do so visually, increasing mutual support and simplifying deconfliction.

9.2.2.3 **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 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 visually navigate at medium altitudes.

9.2.2.4 **Threat Detection/Survivability.** Operation SOUTHERN WATCH proved 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.

9.2.3 Night Vision Goggle Planning Considerations. Mission planning begins by determining expected illumination conditions. Light level planning software programs such as USAF NiteLite, 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 and can provide a copy of NiteLite for unit use. MAJCOMs define 2.2 millilux as high illumination. 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, 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.

9.2.4 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.

9.2.5 Night Vision Goggle Performance Considerations. The following environmental conditions affect NVG performance and must be understood to safely conduct NVG operations.

9.2.5.1 **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."

9.2.5.2 **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.

9.2.5.3 **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.

9.2.5.3.1 **Sunset and Sunrise.** NVG operations can be hampered by 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 IR 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.

9.2.5.3.2 **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.

9.2.5.3.3 **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.

9.2.5.4 **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.

9.2.5.4.1 **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, IRADS, may be required to conduct safe low-level operations.

9.2.5.4.2 **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.

9.2.5.5 **High-Illumination Conditions.**

9.2.5.5.1 **Employment.** High illumination allows pilots to identify turn points and targets, especially if they have vertical development and/or background contrast.

9.2.5.5.2 **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.

9.2.5.6 **Low-Illumination Conditions.**

9.2.5.6.1 **Preparation and Planning.** Low illumination planning must include the same considerations for flying at night with no NVGs. 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. Medium and high altitude missions require the use of on-board sensors (IRADS) and an accurate inertial navigation system (INS) or global positioning system (GPS).

9.2.6 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.

9.2.6.1 **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.

9.2.6.2 **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.

9.2.6.3 **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.

9.2.6.4 **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 out 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.

9.2.6.5 **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.

9.2.6.6 **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.

9.2.6.7 **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 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.

9.2.6.8 **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.

9.2.6.9 **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.

9.2.6.10 **Laser Eye Protection.** 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.

9.2.7 Night Vision Goggle Employment.

9.2.7.1 **Night Vision Goggle Preflight and Adjustment.** Extra time after the briefing must be allowed to accomplish the NVG preflight check. 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. Common malfunctions encountered during preflight of NVGs include battery problems, interpupillary distance (IPD) adjustment problems, one tube not focusing, 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.

9.2.7.2 **Ground Operations.**

9.2.7.2.1 **Pre-Engine Start.** Pilots must install all components of the NVG filter kit prior to engine start. 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.

9.2.7.2.2 **Post-Engine Start.** After engine start, pilots must ensure required external and internal aircraft lights are operational. For external lighting requirements, refer to the Federal Aviation Regulations (FAR) and any unit waivers for reduced lighting operations in MOAs.

9.2.7.2.3 **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.

9.2.7.2.4 **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.

9.2.7.3 **Takeoff/En Route.**

9.2.7.3.1 **Goggle Altitude.** Once established above 2,000 feet AGL minimum, wings-level or in a slight climb and with all three axis of the autopilot coupled (3Cs), 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.

9.2.7.3.2 **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 changing his 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.

9.2.7.4 **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. 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 one’s 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.

9.2.7.5 **Air Refueling.** NVGs will not be worn while on the boom. De-goggle NLT pre-contact. NVGs may be stowed or worn in the up position for air refueling operations. Goggle when refueling is complete.

9.2.7.6 **Night Vision Goggle Recovery.** Flights will remove and stow goggles at least 5 minutes prior to landing, or prior to the IAF, whichever is first. 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 “Christmas Tree” prior to exiting any reduced lighting airspace and when formations split to land.

9.2.7.7 **Night Vision Goggle Emergencies.**

9.2.7.7.1 **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/G onset effects on the NVGs. Normally, the NVGs will not remain fixed during the ejection.

9.2.7.7.2 **Wind Blast Effects/G Load During Ejection.** If the NVGs remain fixed, expect head/neck injuries caused by wind blast and G loading. Additional considerations should include parachute and/or riser entanglement increasing injury potential. Attempt to stow or remove the NVGs if ejection is anticipated.

9.2.7.8 **Night Vision Goggle Abnormal Procedures.**

9.2.7.8.1 **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: "STEALTH 1, CHRISTMAS TREE." 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 "STEALTH 2, BLIND, ALTITUDE (in hundreds)." 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 altitude game plan to ensure immediate deconfliction.

9.2.7.8.2 **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.

9.2.7.8.3 **NVG or Light Failure.** Deconfliction and maintaining spatial orientation is the primary consideration. Correcting the NVG failure is secondary. Accomplish the following:

- Transition to instruments and execute "Lost Wingman" procedures (if required).
- Terminate or knock-it-off as appropriate. Direct "Christmas Tree."
- Maintain correct altitude block.
- With deconfliction assured, attempt to identify and solve the problem.
- If NVG failure is unrecoverable, proceed with non-NVG plan.

9.2.7.8.4 **NORDO Plan.** Go "Christmas Tree." Following this, proceed with primary/briefed NORDO plan.

9.2.8 Night Vision Goggle Formations.

9.2.8.1 **Formation Considerations.** The 40-degree NVG FOV and the limited aft view behind 3/9 line requires several formation considerations.

9.2.8.2 **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.

9.2.8.3 **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. The optimum external light setup will be dictated by tactical and environmental considerations. Adjust the normal exterior lights to the lowest practical intensity that allows formation station keeping without going blind.

9.2.8.4 **Tactical Formation and Turns.** When maneuvering tactical formations at night, all flight members should generally strive for level turns with Max power and ensure at least the altitude axis of the autopilot remains coupled. 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 without the autopilot due to the limited FOV of the NVGs. Cultural lights or stars may become a problem when trying to maintain the visual. As NVG proficiency increases, all formation parameters are easier to maintain.

9.3 Infrared Acquisition and Designation System.

9.3.1 The Infrared Acquisition and Designation System. The infrared acquisition and designation system (IRADS) system is a self-contained dual system that provides the F-117 with a day/night/under-the-weather, low-level navigation, and precision air-to-surface weapons delivery capability. The primary focus of this chapter is night, medium-altitude, and laser-guided bomb (LGB) employment. The major areas covered are general IRADS mission planning considerations, night IRADS ground operations, cruise/en route sensor optimization, and IRADS attack planning considerations.

9.3.2 Infrared Acquisition and Designation System 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-117 missions.

9.3.2.1 **Mission Preparation.** Special planning considerations are driven primarily by the physics of the infrared (IR), vice the visual light spectrum, and the limited field of view (FOV) of the IRADS system compared to the human eye. IR imagery is fully discussed in AFTTP 3-1.1, *General Planning and Employment Considerations*.

9.3.2.2 **IRADS Turnpoint Selection.** In most cases, good visual turnpoints make good IRADS turnpoints. The two ingredients of valid IRADS 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. This will require a substantial amount of preplanning by units in their expected area of employment if they are to be responsive to short-notice tasking. The integration of RainDrop into current mission planning software allows planners to easily achieve the desired level of accuracy for steerpoint data.

9.3.2.2.1 **Choosing the Point.** Turnpoints will usually be chosen by the mission planning software in a high threat environment. In a low-threat environment, try to ensure that a readily identifiable IRADS turnpoint is along the ingress route 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, especially at lower altitude, is mission critical. Without it, pilot workload is greatly increased. Ensure that an IR 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.

9.3.2.2.2 **Loss of GPS.** Given system accuracy without GPS (0.3 NM per hour specification), the INS will require updates approximately every 15 minutes. Additionally, the accuracy of the system altitude will affect weapons delivery calculations and IRADS vertical pointing angles. Both the system altitude and the INS present position should be kept as accurate as possible.

9.3.2.2.3 **Weather Support.** To help interpret the IR scene, 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) and infrared target scene simulation (IRTSS) to provide this support. 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. To compute an IRTSS, the same data must be provided several hours in advance. 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.

9.3.2.3 **Environmental Considerations.**

9.3.2.3.1 **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 IRADS detection ranges and laser performance.

9.3.2.3.2 **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.

9.3.2.3.3 **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.

9.3.2.3.4 **Clouds.** Clouds directly affect IRADS operations since as previously discussed, they can block IR energy. Cloud free line of sight (LOS) is required to see the target. Overcast weather affects the IR visibility beneath it by reducing temperature contrasts. During delivery, if clouds become a factor (obscuring the target), a good technique is to leave the cursors open and attempt to get pre-release laser ranging by squeezing the trigger when the target is visible in the SD.

9.3.2.3.5 **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.

9.3.2.4 **Mission Materials.** Cockpit management is a critical part of flying night missions. Ensure all copies of mission products are legible and minimize the number of mission products to those required to accomplish the mission. The following mission materials are considered to be mission critical: TOLD card, route map, and target photographs.

9.3.2.5 **Targeting.** IRADS 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. For a detailed weaponeering discussion, reference AFTTP 3-1.18, *Tactical Employment–F-117*.

9.3.3 Infrared Acquisition and Designation System Ground Operations.

9.3.3.1 **After Start**. Ground operations and checklist procedures are essentially the same as daytime operations. Reduce lighting as much as practical as the eyes start to adjust to the night lighting. However, cockpit lighting during a night mission will still be considerable due to the bright video displays of the SD. The key is taking the time to set the desired brightness during ground operations to prevent distraction from a bright display once airborne.

9.3.3.2 **Function Checks and Setup.** Function checks verify initial sensor operation. Function checks include sensor built-in test (BIT) checks and sensor operation checks.

9.3.3.2.1 **BIT Checks.** When the cooling lights have extinguished, perform a BIT check prior to exiting the HAS so that a RED BALL can be called to address any indicated malfunction. As a technique, place the IRADS boresight/test switch to test while the IRADS are in STBY to display a printout of the last 9 BITs and check for a history of malfunctions. The IRADS should be BIT checked on every sortie.

9.3.3.2.2 **Sensor Operation Check/Setup.** After BIT checking the IRADS, ensure it is appropriately set up for the mission. Do not forget to set the desired laser code. Individual CMDI setup is an important habit pattern to develop.

9.3.4 Infrared Acquisition and Designation System 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.

9.3.4.1 **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 A/A TCN for station keeping. Altitude, heading, and airspeed contracts must be thoroughly briefed and understood in order to ensure mutual support and deconfliction. 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 steer points should be selected prior to the actual "Push" point to allow all flight members the opportunity to accomplish required navigation system updates, weapons checks (including laser check), and IRADS tuning.

9.3.4.1.1 **Sensor Tuning.** In order to ensure the ability to find and destroy the target, IRADS must be optimally tuned. For IRADS operations, select a steerpoint that adequately resembles the target. Starting at a point where target acquisition in NFOV is anticipated, track the steerpoint and de-select ALG. Now adjust the level and gain via the switches on the throttle for optimum picture quality. Subsequent steer points should be used to continue to fine-tune the gain/level requirements.

9.3.4.1.2 **SD Tuning.** It is critically important that the pilot not only tune the internal IRADS, but also tune the SD itself. De-select ALG and use the gray scale to adjust brightness and contrast knobs. Ensure the SD is displaying all shades of green in the scale and adjust the picture to enhance target area acquisition. It may be necessary to tune down the symbol brightness to identify smaller DMPIs.

9.3.4.1.3 **Formations.** Generally, en route admin formations should be relatively fluid, requiring minimum station keeping efforts, yet still provide acceptable mutual support.

9.3.4.2 **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 station keeping formation allows the opportunity to keep the flight together as long as possible and minimizes deconfliction issues. Turns are generally comm-out. Blind deconfliction contracts must be adhered to. A 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 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.

9.3.4.3 **Ingress and Egress.** Ingress and egress tactical considerations are weather, threat layout, package composition/routing, support assets, and weaponeering. The ingress and egress at night are complicated by the fact a pilot is literally blind except through the narrow field of view (FOV) capability of the IRADS unless NVGs are employed. Use of the A/A TACAN is critical to maintain SA on the events occurring around and within the

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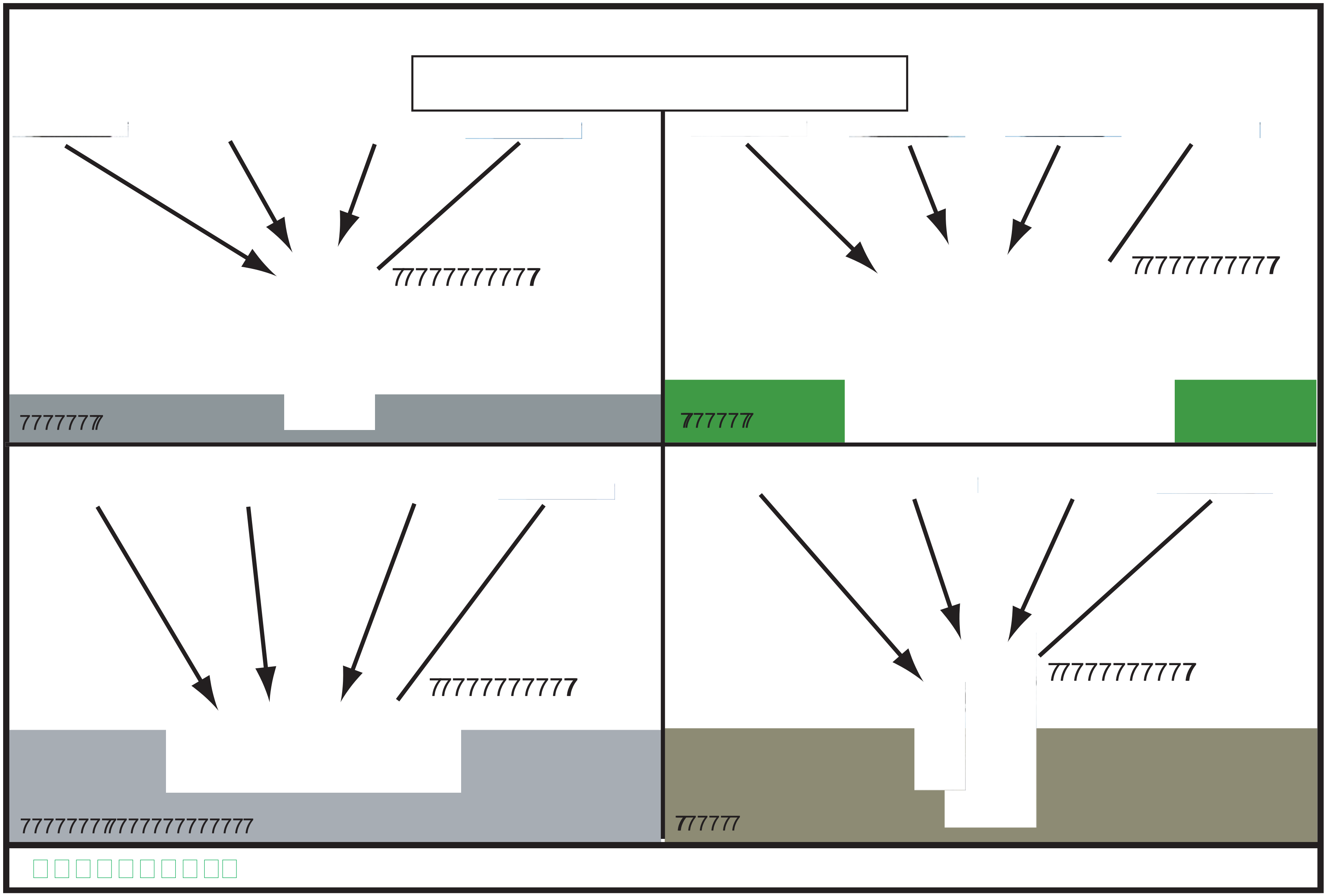

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9.3.6 Non-Visual Attack Formations. At night and without the aid of NVGs, LGBs are employed from Trail Formation. For specific attack options with Paveway II and III, refer to AFTTP 3-1.18, *Tactical Employment—F-117*.

9.3.7 Visual Formation Options—Day and Night Vision Goggle. Being able to fly a visual formation has many benefits over flying Trail. A Line Abreast Formation allows simultaneous impacts and the destruction of multiple DMPIs that would normally be obscured by flying a Trail Formation. Two-ship wingman deconfliction responsibilities depend on the turn direction after the lase leg. In a Line Abreast Formation, if the flight lead post-lase turns away from the wingman it is easier to deconflict as the wingman falls into a temporary trail formation. Another technique is to vary the post-lase turn of all flight members to help with the deconfliction problem. Turning 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 check turn is another technique. For further information, refer to AFTTP 3-1.18, *Tactical Employment—F-117*.

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A1.6.8.2.1 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.

A1.6.8.3 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 "high/low STACK," stating the higher altitude first then the lower altitude. For example, "DARKSTAR, NORTH GROUP HIGH/LOW STACK 30 THOUSAND, 10 THOUSAND."

A1.6.8.4 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 A1.30**, Inner Group Formations.)

A1.6.8.5 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. For example, "HYDRA, WEST GROUP, HEAVY, FOUR CONTACTS, CONTAINER."

A1.6.9 Maneuvering Groups.

A1.6.9.1 When ABM/WD or aircrews recognize a maneuver by a group, they will call the maneuver only and wait for the next sweep/cycle/hit to add amplifying information.

- (Using Group Name) "DARKSTAR LEAD GROUP MANEUVER."
- (Using Core Information) "DARKSTAR GROUP BULLSEYE 270/15 MANEUVER."

A1.6.9.2 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."

A1.6.9.3 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.

A1.6.9.4 Maneuvering Groups Inside "Meld/MTR."

A1.6.9.4.1 Arms. For groups that maneuver inside of meld/MTR, maneuvering groups (**paragraph A1.6.9**, Maneuvering Groups) still applies, with the following addition. Due to time constraints, the threat, the need to pass information quickly and clearly, and the need to facilitate the targeting of the closest threat, 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 A1.31**, Maneuvering Groups Inside "Meld/MTR.")

Figure A1.30 Inner Group Formations.

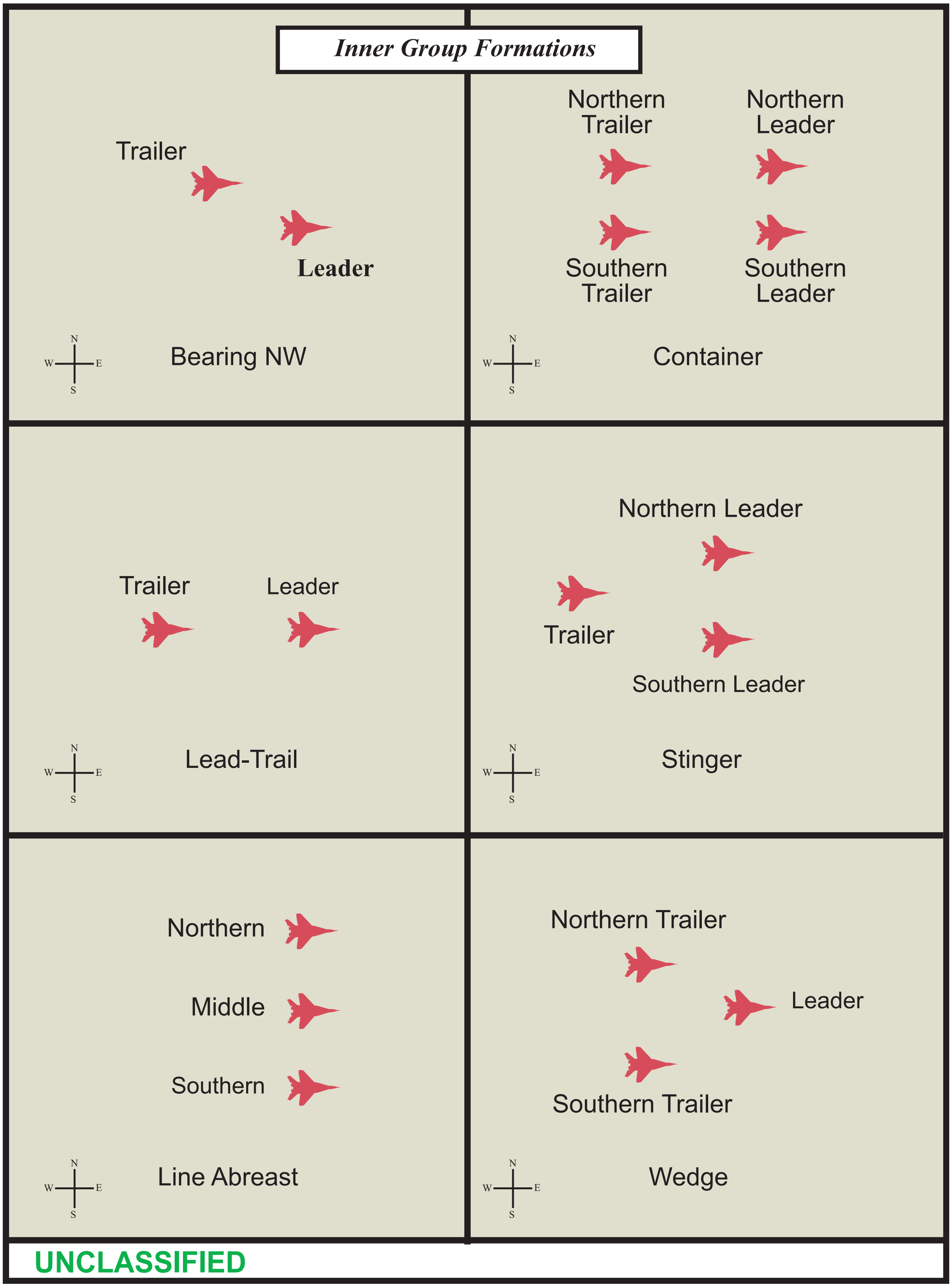
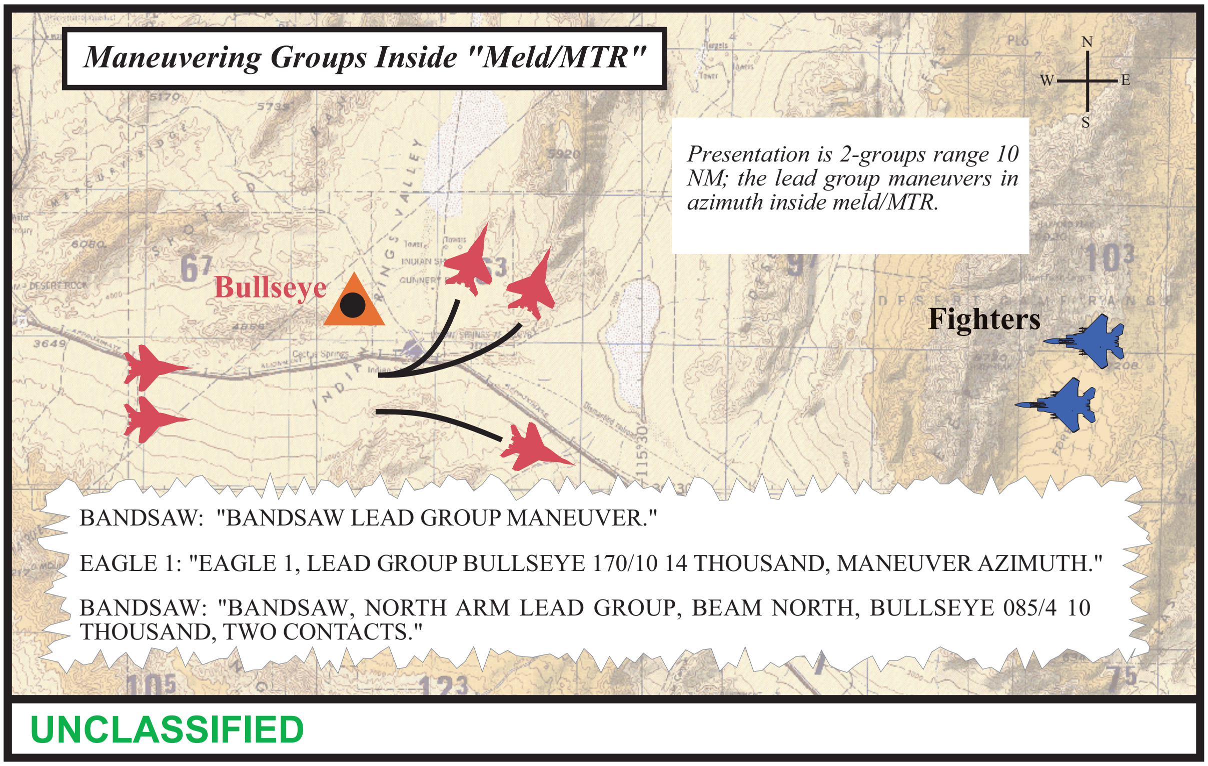


Figure A1.31 Maneuvering Groups Inside "Meld/MTR."



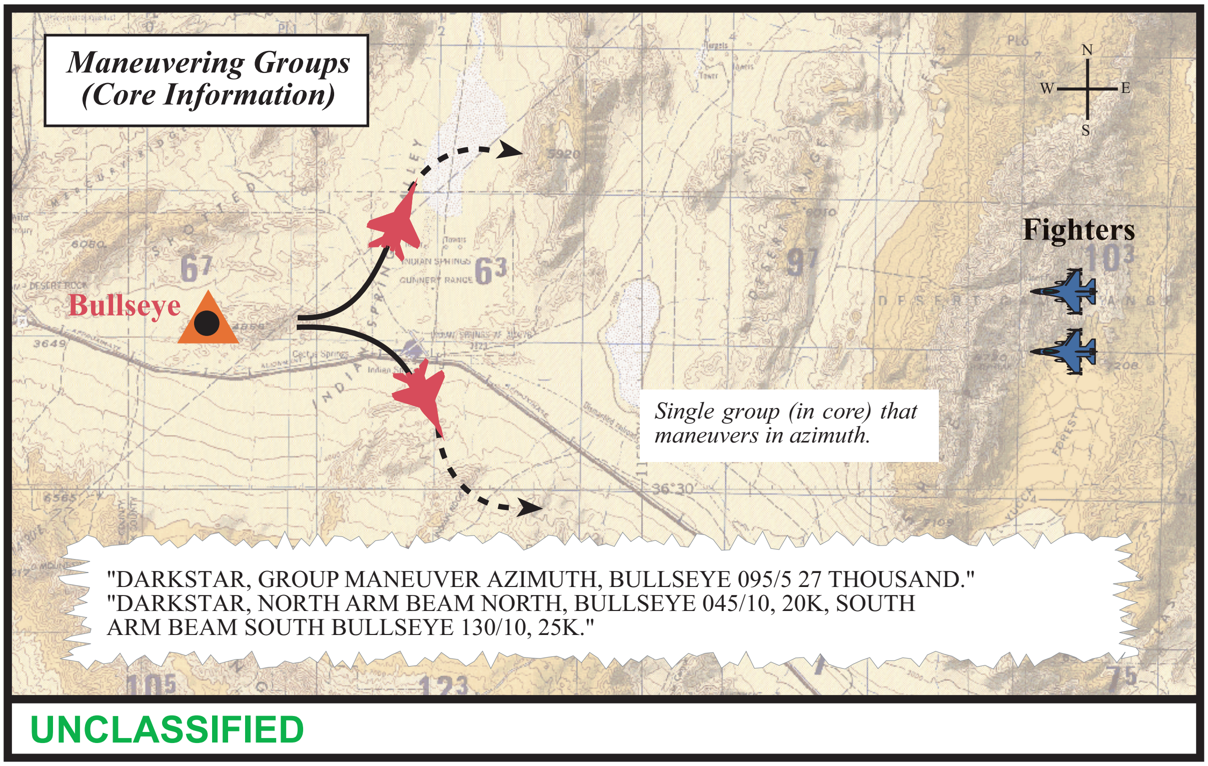
A1.6.9.4.2 Once the maneuver has been completed and comm time/priority exists, the relationship of the maneuvering group can be provided. For example, if the arms from the lead group maneuvered and then continued east, the call could be: "BARNYARD, LEAD GROUP LINE ABREAST 6." AZIMUTH and RANGE will not be used to describe the resulting formation when the maneuver occurs inside of meld/MTR. 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.

A1.6.9.4.3 If the picture was not a labeled picture (core information), this same concept would still apply. (See **Figure A1.32**, Maneuvering Groups [Core Information].)

A1.6.10 Faded Comm and Techniques.

A1.6.10.1 In general, if a previously reported group is not processed for two consecutive sweeps/cycles on an ABM/WD's scope, 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 (last radar hit) with a last known heading given (if known) and number of contacts. For example, "BANDSAW, NORTH GROUP FADED, BULLSEYE 270/27, TRACK NORTH TWO CONTACTS."

Figure A1.32 Maneuvering Groups (Core Information).



A1.6.10.2 By calling the group as FADED, the ABM/WD is informing the fighters C² 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 puts a radar on the FADED group and calls its location with a heading, the ABM/WD will update the DR process again. After the initial FADED call, if the group remains unaccounted for (either untargeted or unreported), then the group will be called "FADED, LAST KNOWN" with the "last known" radar hit location anchored off bullseye. For example, "BANDSAW, NORTH GROUP FADED, LAST KNOWN BULLSEYE 270/27."

A1.6.10.3 ABM/WDs will use "negative contact" to report a friendly aircraft that is not processed on a scope. For example, "EAGLE 1, DARKSTAR, NEGATIVE CONTACT."

A1.6.11 Electronic Attack. C² will respond to STROBE calls with range, altitude, and ID to the closest group along that azimuth and any follow-on groups along that azimuth. If C² is clean along that azimuth, then that should be reported for SA. This may indicate that the contact may be below C²'s coverage or may be a ground-based jammer. MUSIC calls should be responded to with number of contacts in that group (if able), aspect (if not hot), any maneuvers seen and ID.

A1.6.12 New Groups.

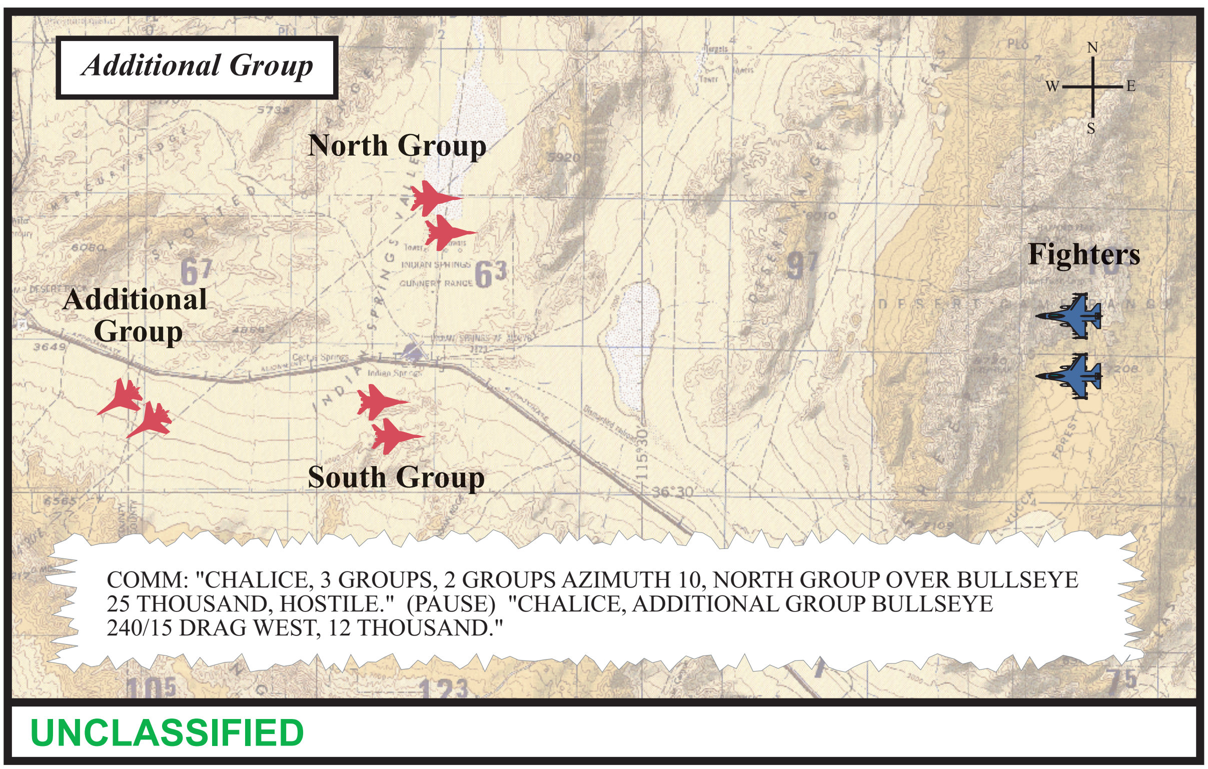
A1.6.12.1 Prior to a fighter reaching meld/MTR, any group previously undetected/unreported will be referred to as a "new group." If either a fighter or ABM/WD is describing a picture in core information and someone else detects a group that was omitted in the core picture call, that group will be called a "new group" and anchored off bullseye—usually with the next comm call. For example, "CHALICE, TWO GROUPS, GROUP BULLSEYE 360/10 32 THOUSAND, GROUP OVER BULLSEYE, 8 THOUSAND MANEUVERING" and then "EAGLE 1, NEW GROUP BULLSEYE 190/7, HITS 5 THOUSAND."

A1.6.12.2 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. For example, "VIPER 1 NEW GROUP BULLSEYE 275/15, 5 THOUSAND." Next, call a new picture if it fits. For example, "HOSS 1, NEW PICTURE, THREE-GROUP LADDER, RANGE 10, LEAD GROUP BULLSEYE . . ."

A1.6.12.3 If a "new group" appears within 5 NM of meld/MTR 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.

A1.6.13 Additional Groups. "Additional group" is used only when applying labels to a presentation when there is a group, within bounding criteria, 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 A1.33**, Additional Group.

Figure A1.33 Additional Group.



A1.6.14 Pop-Up Groups.

A1.6.14.1 Once a flight gets to meld/ MTR, any previously undetected/unreported group detected inside of meld/MTR will be called a "pop-up group."

A1.6.14.2 If the fighters are not within visual range of each other (nominally 3 miles), the pop-up group will be anchored off bullseye unless it meets threat criteria, where it will be called as a pop-up threat in BRAA format.

A1.6.14.3 If the fighters are within visual range of each other, the pop-up group should be anchored using a BRAA format. ABM/WDs will provide the BRAA call using the following priorities:

- A fighter threatened by the pop-up group.
- The flight lead (in order to target the pop-up group).
- A fighter not currently tasked with targeting a group. Because the "pop-up group" was detected inside meld/targeting range, the pop-up group will not normally be used to call a new picture.

A1.6.15 Fighter Cold Ops. This applies when all elements are cold to the threat; all communications will comply with the briefed priorities and occur on the primary frequency.

A1.6.15.1 Unless briefed otherwise, the comm priorities are as follows:

- Spikes/threats within a stern WEZ.
- Two-ship mutual support.
- Four-ship mutual support.
- Picture.

A1.6.15.2 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 inside a briefed 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.

A1.6.15.3 When a picture is requested, there is no requirement to meet the standard labeling criteria, the ABM/WD responsibility is to build a relationship for all the groups behind the elements within factor bandit range/factor range. In order to facilitate high fighter SA and targeting of the closest threats on the recommit, non-standard comm and labeling may be necessary and is acceptable as long as it makes sense, builds SA, and enables the targeting of the factor groups. For example, "BARNYARD FIVE GROUPS, LEADING EDGE TWO GROUPS AZIMUTH 15, NORTH GROUP BULLSEYE . . ." If fighters require BRAA to a group, BOGEY DOPE can be requested. For example, "BARNYARD, BOGEY DOPE NORTH GROUP FOR SNAKE 1 AND SOUTH GROUP FOR SNAKE 3."

A1.6.15.4 The audibled targeting and flow plan will be briefed on the primary frequency.

A1.6.16 New Picture Comm.

A1.6.16.1 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.
- Groups split.
- A group is destroyed.
- A previously undetected group appears (i.e., a new group).

A1.6.16.2 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 exception is when the trail element turns hot in a grinder, new pictures may be called even though the lead element is inside of meld range.)

A1.6.16.3 New picture during grinder ops. During grinder ops, fighters on the cold leg will make an "IN" call and then initiate the turn. The ABM/WD will wait until the IN element 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 IN element.
- Assist in gaining mutual support (as required).

A1.6.17 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. For example, "CHALICE, NORTH GROUP UNTARGETED BULLSEYE 270/15, 20 THOUSAND, HOSTILE."

A1.6.18 Final Lock Comm.

A1.6.18.1 Final Lock Comm Format: Bullseye.

A1.6.18.2 Final Locked Calls. There are four types of final locked calls:

A1.6.18.2.1 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."

A1.6.18.2.2 Second Type: Fighter is on the correct group but has no inner-group breakout. "EAGLE 2 LOCKED WEST GROUP BULLSEYE 270/5, 20 THOUSAND."

A1.6.18.2.3 Third Type: Fighter does not know which group he 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."

A1.6.18.2.4 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."

A1.6.18.3 "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.

A1.6.18.3.1 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 as follows:

- 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."

A1.6.18.3.2 In this case, the flight lead will normally be directive as to who holds or breaks lock unless it is briefed otherwise.

A1.6.18.4 Comparative Comm Techniques.

A1.6.18.4.1 If a fighter calls "locked" to a group but does not attach a name (after the picture has been labeled), ABM/WDs will respond by attempting to provide the name of the locked group and whatever fill-ins are available (such as inner-group formation) and practical to pass in a timely manner. "EAGLE 1, LOCKED GROUP BULLSEYE 250/35, 29 THOUSAND." ABM/WD's call would be: "EAGLE 1 LOCKED NORTH GROUP, HEAVY, THREE CONTACTS."

A1.6.18.4.2 If a fighter calls locked with a name, the ABM/WD will respond by providing fill-ins available (and practical to pass in a timely manner). "VIPER 1, LOCKED NORTH GROUP BULLSEYE 250/35, 29 THOUSAND." ABM/WD's call would be: "FOCUS, NORTH GROUP, HEAVY, THREE CONTACTS" or "FOCUS, NORTH GROUP MANEUVER."

A1.6.18.4.3 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.

A1.6.19 Clean Comm. Clean at meld/targeting range. If a fighter calls "clean" on their targeting responsibility, the element mate has first priority to provide SA to the fighter. The ABM/WD will allow time for the fighter response. 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).

A1.6.20 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."

A1.6.21 Threat Calls.

A1.6.21.1 When aircraft position is known, threat information will be provided to a specific aircraft call sign in BRAA (sub-cardinal direction will be used inside 5 NM), followed by range, group name, and ID, to untargeted groups meeting specified threat criteria. Threat information called in a BRAA format will include BRAA in the transmission. For example, "EAGLE 1, THREAT BRAA 340/14, 14 THOUSAND LAST, EAST GROUP, HOSTILE."

A1.6.21.2 If exact fighter location is not known, threat information may be provided using a bullseye reference, and 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. Examples include the following:

- ABM/WD: "EAGLE 1, THREAT BULLSEYE 295/26, 20 THOUSAND, HOSTILE."
- Fighter: "EAGLE 1 BULLSEYE 280/10, ANGELS 5."
- ABM/WD: "EAGLE 1 THREAT BRAA 260/15, 20 THOUSAND, HOSTILE."

A1.6.21.3 The following threat criteria will be used as the standard:

- Heat threat—10 NM hot, 5 NM any aspect.
- Short radar threat—15 NM hot, 10 NM any aspect.
- Long radar threat—20 NM hot, 15 NM any aspect.

A1.6.21.4 Hot is assumed for all threat calls. If threat is beam/drag aspect, the ABM/WD will provide an aspect with the threat call to prevent aircrews from making unnecessary changes to intercept options/engagement decisions. Threat calls should include altitude and ID, if available. For example, "VIPER 1, THREAT BRAA 260/12, 8 THOUSAND, BEAM NORTH, SPADES."

A1.6.21.5 When working with F-16s, due to MDS constraints and employment considerations, after providing the BRAA threat call with a hostile declaration, the ABM/WD will provide a bullseye-anchored call with the appropriate ID (e.g., "VIPER 1, THREAT BRAA 090/10, 20 THOUSAND, HOSTILE") followed by a different comm call (e.g., "VIPER 1, THREAT GROUP BULLSEYE 100/15, 20 THOUSAND, HOSTILE"). The follow-up bullseye call should only be made if the fighter is able to use the information to employ ordnance. For example, if an F-16 is anchored and a hostile meets threat criteria, only the BRAA format is needed. This will be based on good judgment, depending on phase of the intercept/engagement and comm priorities.

A1.6.22 BOGEY DOPE.

A1.6.22.1 In the postmerge environment or if C^2 has reported "negative contact" on the formation, fighters should preface BOGEY DOPE or SPIKE calls with their posit and altitude. For example, "THUMPER, EAGLE 1 BULLSEYE 110/22, WESTBOUND, BOGEY DOPE."

A1.6.22.2 Normal ABM/WD's response is a BRAA-formatted call from the requesting fighter to the requested group or nearest threat aircraft. Digital bullseye may be used if fighter location is unknown. 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). Acceptable "POSIT" responses by priority are in digital bullseye or in pre-coordinated GEOREFs.

A1.6.23 SPIKE Comm.

A1.6.23.1 When a fighter calls spiked, use digital magnetic bearing or one of the eight cardinal directions. When notching, use digital magnetic heading or cardinal direction. Also, add bullseye position if able. The ABM/WD will attempt to correlate the SPIKE to a group displayed on the scope and call the range, altitude, group name and ID. For example, "VIPER 1, SPIKED 270 NOTCH NORTH, BULLSEYE 240/15." The ABM/WD's response will be formatted as: "VIPER 1, SPIKE RANGE 17, 35 THOUSAND, SPADES."

A1.6.23.2 If ambiguity exists as to the location of a group (e.g., a group is not along that azimuth but another group is nearby), the ABM/WD should respond with a CLEAN call along that azimuth 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. For example, "VIPER 1, SPIKED 310, NOTCH NORTHEAST BULLSEYE 090/15." The ABM/WD response would be: "VIPER 1, DARKSTAR CLEAN 310, NEAREST GROUP BRAA 240/15, 15 THOUSAND, HOSTILE." If the ABM/WD does not see any groups near the azimuth the fighter called or the group faded for a prolonged period of time, the ABM/WD will be unable to call a reasonably accurate range and should respond with "UNABLE SPIKE RANGE."

A1.6.24 Mud/Singer Comm. An informative call on the primary frequency notifying all players of an active surface-to-air threat. When a fighter calls "Mud-X" or "Singer-X," use one of the 8 cardinal directions. When "DEFENDING," use digital magnetic heading and add your "bullseye" position, if able. "VIPER 1, MUD 6, NORTH, DEFENDING 270, BULLSEYE 240/15."

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ATTACHMENT 2

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

A2.1 References.

Air Force Publications

1. Department of the Air Force, Air Combat Command, *F-117 Phase Manual.*
2. AFI 11-2F-117 Vol 1, *Instrument Flight Procedures.*
3. AFI 11-2F-117 Vol 2, *Instrument Flight Procedures.*
4. AFI 11-205, *Aircraft Cockpit and Formation Light Signals.*
5. AFI 11-214, *Air Operations Rules and Procedures.*
6. TO 1F-117A-1, *F-117A Flight Manual.*
7. TO 1F-117A-1-6, *F-117A Air Refueling Operations.*
8. TO 1F-117A-34-1, *F-117A Non-Nuclear Weapons Delivery.*

A2.2 Acronyms and Abbreviations.

ADC .... air data computer

ADI .... attitude direction indicator

AFORMS .... Air Force Operations Resource Management System

AFI .... Air Force Instruction

AGL .... above ground level

AHRS .... attitude heading reference system

ALG .... automatic level and gain

AMAD .... airframe mounted accessory drive

AOA .... angle of attack

AP .... autopilot

APU .... auxiliary power unit

AR .... air refueling

ARCP .... air refueling control point

ARCT .... air refueling control time

ARIP .... air refueling initial point

ASR .... area surveillance radar

AT	autothrottle
ATO	air tasking order
ATIS	automatic terminal information service
AVT	automatic video tracking
AWACS	airborne warning and control system
BIT	built-in test
CAS	calibrated airspeed
CDI	course deviation indicator
CDNU	control display navigation unit
CMDI	color multipurpose display indicator
CT	continuation training
DEP	data entry panel
DH	decision height
DLIR	downward looking infrared
DME	distance measuring equipment
DMPI	desired mean point of impact
DNIF	duties not to include flying
DP	departure procedure
ECS	environmental control system
EDTM	expanded data transfer module
EGT	exhaust gas temperature
EIA	enhanced interrupted alignment
EP	emergency procedure
EPU	emergency power unit
ER	estimated ranging
FAAD	flight attitude awareness display
FAF	final approach fix
FAS	final approach speed
FCIF	flight crew information file

FCS	flight control system
FLCC	flight control computer
FLIP	flight information publications
FLIR................................	forward looking infrared
FMS	flight management system
FOV	field of view
FPM	flight path marker, or feet per minute, depending on context
FTU	formal training unit
GC	gyrocompass
GCI.................................	ground-controlled intercept
GLOC..............................	G induced loss of consciousness
GPS	global positioning system
GSL	glideslope
HSD	horizontal situation display
HSI	horizontal situation indicator
HUD................................	head-up display
HQ..................................	headquarters
IAF	initial approach fix
ICAO..............................	International Civil Aviation Organization
ICS	intercommunication system
IFF..................................	identification friend or foe
IFR	instrument flight rules
ILS	instrument landing system
IMC................................	instrument meteorological conditions
INS	inertial navigation system
INU	inertial navigation unit
IP	initial point, or instructor pilot, depending on context
IQT.................................	initial qualification training
IR	infrared

IRADS .... infrared acquisition and designation system
KCAS.............................. knots calibrated airspeed
KIAS .... knots indicated airspeed
LGB .... laser guided bomb
LO .... low observable
LR .... laser ranging
MDA .... minimum descent altitude
MEA................................ minimum en route altitude
MOA .... military operations area
MPT................................. memory point track
MQT................................ mission qualification training
MSL .... mean sea level
NAVAID.......................... navigation aid
NFOV.............................. narrow field of view
NIAC............................... navigation interface and autopilot computer
NM .... nautical mile
NORDO .... no radio
NWS................................ nosewheel steering
PA.................................... pressure altitude
PAARS .... pilot-activated aircraft recovery system
PAPI .... precision approach path indicator
PAR .... precision approach radar
PASS .... pressurized air start system
PIO .... pilot induced oscillations
PLAZ .... probable loss of aircraft zone
RAM .... radar absorbent material
RCS .... radar cross section
RNIP .... RLG navigation improvement program
ROE .... rules of engagement

RPM	rotations per minute
RTB	return to base
SA	surface attack, or situation awareness, depending on context
SD	sensor display
SEFE	standardization evaluation flight examiner
SMD	stores management display
SPINS	special instructions
SOF	supervisor of flying
SRCH	search
STEMS	structural tracking and engine monitoring system
TACAN	tactical air navigation
TM	terrain monitoring
T/O	takeoff
TOLD	takeoff and landing data
TOT	time on (or over) target
TR	track ranging, or transition phase, depending on context
TST	time sensitive targeting
TTG	time to go
TTI	time to impact
TX	transition qualification training
UHF	ultra high frequency
UP	upgrading pilot
VFR	visual flight rules
VMC	visual meteorological conditions
VSD	vertical situation display
VTR	videotape recorder
VVI	vertical velocity information (or indicator)
WFOV	wide field of view
WLP	weapons loading panel

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