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AIR FORCE TACTICS, TECHNIQUES, AND PROCEDURES 3-3.MQ-9

9 April 2021

COMBAT FUNDAMENTALS MQ-9

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9 April 2021

Tactical Doctrine

Combat Aircraft Fundamentals—MQ-9

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OPR: 561 WPS

Certified by: ACC/A3

Supersedes: AFTTP 3-3.MQ-9, *Combat Aircraft Fundamentals*—MQ-9, 7 January 2019

Pages: 450

PURPOSE: The AFTTP 3-3 series publications are the primary tactical doctrine references for the USAF. This series provides considerations to be used in planning and execution for effective mission accomplishment. These recognized best practices are presented as the foundation of employment and standardization for all USAF weapons systems.

APPLICABILITY: This publication applies to all regular, Air Force Reserve, and Air National Guard personnel. Per AFI 33-360, AFTTP publications are authoritative, but not directive. Deviations require sound judgment and careful consideration. In cases where this publication conflicts with an AFI, the applicable AFI takes precedence. The following definitions from JP 1-02 apply:

Tactics—The employment and ordered arrangement of forces in relation to each other.

Techniques—Nonprescriptive ways or methods used to perform missions, functions, or tasks.

Procedures—Standard, detailed steps that prescribe how to perform specific tasks.

SCOPE: This manual addresses basic weapon system tasks. AFTTP 3-3 provides information and guidelines on basic procedures and techniques used for standardization. It presents a solid foundation on which effective tactics can be executed.

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VOLUME MANAGEMENT: For any other questions regarding AFTTP volumes, contact 561 WPS volume management at: e-mail: 561jts.vm@us.af.mil or DSN: 682-3975.

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TABLE OF CONTENTS

CHAPTER 6—BASIC WEAPONS AND EMPLOYMENT TOOLS

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LIST OF FIGURES

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LIST OF TABLES

SUMMARY OF CHANGES

Chapter 1

- Minor edits.

Chapter 2

- Rewritten for clarity.
- Added SMART acronym to describe mission/tactical objectives.
- Removed matrices and added reference to 26 WPS Debrief Guide v 7.1.

Chapter 3

- Updated for current software.
- Removed duplicate TO information.
- Removed nadir avoid.

Chapter 4

- Edited throughout.
- Added walk around and AFTO Forms 781 TTP.
- Added/deleted and updated acronyms (i.e., LAGS, WARNSELF, WET, etc.)
- Rewrote aircraft handling and pitch and power settings for clarity.
- Removed BRU-15 suspension rack information.
- Added required ground speed for 180 degree taxi turn.
- Added target criteria to course/glide path.
- Updated overhead pattern figure to include distance/gear call.
- Added AN/DAS-4 boresight info.
- Added technique for go-around from a SFO.
- Updated gear down criteria.
- Added barrier verbiage/considerations for aimpoint on landing.
- Rewrote crosswind correction and flare mechanics for clarity.

Chapter 5

- Deleted. Moved up rest of chapters. Now titled “Basic Mission Execution.”
- Chapter rewritten for clarity; added several techniques and considerations.

Chapter 6

- Formerly Chapter 7, titled, “Single Ship Surface Attack Tactics.”
- Removed redundant academic information.
- Consolidated multiple TTP.

Chapter 7

- Formerly Chapter 8, titled, “MQ-9 Formations and Multiship.”
- Chapter rewritten for clarity and logical flow.

- Incorporated GBU-54.
- Updated tables and figures.
- Added target/weapon pairing considerations for Hellfire.
- Updated attack phases.
- Replaced CP and Mental Math TOT methods with TOI technique.
- Updated HUD manual delivery release cues.
- Added Planning Tool v10 to assess reattack timing/geometry.

Chapter 8

- Formerly Chapter 9, titled, "Moving Target Engagements."
- Rewritten for clarity.
- Deleted Zeus 2.0 references.
- Updated to reflect new software.
- Updated restricted laser-to-target line with TOT.
- Deleted extraneous communication examples.

Chapter 9

- Formerly Chapter 10, titled, "Tactical Tools."
- Added tables for post-rifle track employment parameters.
- Deleted 7/5 second rule for manual track.
- Rewrote execution section for clarity.

Chapter 10

- Formerly Chapter 11, titled, "Support to Special Operations Forces."
- Updated figures.
- Updated descriptions and transmit instructions for messages.
- Updated terrain analysis TTP.
- Updated Minotaur for latest software version.
- Updated Zeus FENCE flow.

Attachment 1

- Minor edits.

Attachment 2

- Deleted. Added new attachment titled, "MQ-9 Link 16 MPC Data Sheet."

CHAPTER 1

INTRODUCTION

1.1 Overview. War in the aerospace environment is currently in a period of fast-paced evolution. The rapid advancement in remotely piloted aircraft (RPA) capabilities has culminated in the MQ-9's role as a player in various mission sets; this increase has made it challenging for MQ-9 aircrews to stay abreast of current equipment and tactics. Nevertheless, the basic principles of aerial combat have remained virtually unchanged: situational awareness (SA), critical thinking, and airmanship are still foundational to effective weapon systems employment. These fundamentals provide the building blocks for effective tactical execution. This manual provides tactics, techniques, and procedures, which in conjunction with aerial combat fundamentals enable the correct employment of the MQ-9 weapons system.

1.2 Purpose. This manual supplements both formal and continuation training (CT) programs and when used in conjunction with other TTP including AFTTP 3-1.MQ-9, provides pilots, sensor operators (SO), and support personnel with the necessary information to employ effectively during any phase of a tactical mission. This manual provides no authority to depart from established AFIs, technical orders (TO), training procedures, regulations, or directives, nor is it directive in nature.

1.3 MQ-9 Variants. This volume addresses multiple MQ-9 hardware and software variants. Where applicable, the text addresses these variants. Due to the multiple acquisition channels and rapidity of system maturation, not all systems have been thoroughly included into this document. Address dramatic changes to execution due to system upgrades through the change procedures noted in **paragraph 1.4**, Change Procedures.

1.4 Change Procedures. Aircraft modification and operational/training experience will, and should, dictate changes to this text. Do not disregard old procedures and tactics simply because they have been around for an extended period. However, newer and better ways of accomplishing the mission will evolve and need inclusion into this document. Incorporate safety-of-flight changes as soon as possible. Several avenues exist to suggest changes within the MQ-9 hardware, software, and tactics.

1.4.1 Recommendation for Change of Publication. Submit recommended changes to publications to the wing standardization and evaluation office by using AF Form 847, Recommendation for Change of Publication. Use AF Form 847 for recommending checklist or publication changes, as well.

1.4.2 Tactics Improvement Proposal. Submit recommended changes to tactics to the squadron weapons and tactics shop via the AF IMT 4326, *Tactic Improvement Proposal (TIP)*. AFI 11-260, *Tactics Development*, contains detailed information regarding tactics development and the TIP process.

1.4.3 Hardware Deficiencies. Report noted hardware and software deficiencies to the squadron weapons and tactics shop. The chief of weapons and tactics will coordinate squadron and wing agencies to assist with or submit a deficiency report (DR). A DR is a report highlights a problem with the aircraft, associated hardware, or software after proper submission through maintenance channels.

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CHAPTER 2

AIRCREW FUNDAMENTALS

2.1 Introduction. The long endurance of the MQ-9 Reaper compared to other attack aircraft, and the ability to change crews during flight, creates the foundation for persistent airpower, and more specifically, persistent attack. This section outlines how disciplined crews will prepare, plan, brief, execute, and debrief combat sorties in the MQ-9.

2.2 Permission Considerations.

2.2.1 General Considerations. Aircrew should be well-rested, properly nourished, and mentally prepared. Know what is expected during the mission. Study and ask questions if any aspects of the mission are unclear.

2.2.2 Flying Directives. Prior to any mission, aircrew must have thorough knowledge of all governing Air Force instructions (AFI), flight crew information files (FCIF), standards, AFTTP, TOs and local procedures. Safe conduct of the flight depends on aircrew proficiency in basic airmanship skills and knowledge of all applicable rules.

2.2.3 Psychological Readiness. Every time they fly, pilots and sensor operators (SO) must be ready to make life or death decisions without hesitation. The detail of an MQ-9 TGP can psychologically bind aircrew to target engagements more viscerally than traditional aircraft. The remote split ops (RSO) beyond-line-of-sight (BLOS) operations challenges aircrew to compartmentalize operational combat stress and daily life. Relying on fellow Airmen, base chaplains, various mental health organizations, including embedded operational psychologists, and developing a strong family support network, can aid to reconcile the daily stresses of combat.

2.2.4 Physiological Readiness. The MQ-9 mission is ongoing, demands precision airpower 24 hours a day, 365 days a year. A consistent sleep schedule is critical, especially as most squadrons rotate shifts every month or two, to avoid chronic fatigue. Working with a flight doctor, fellow aircrew, and home cohabitants is required to find a sleep schedule that will work. The human body is only able to shift the natural circadian rhythm by approximately one hour per day. Trying to advance from a day schedule to a swing schedule may take over a week to feel normal. It is also far easier for the body to shift forward (i.e., sleep later). Common symptoms encountered during a shift change include rapid heart rates, tremors, diarrhea, constipation, and most commonly, decreased attention to details with increased aircraft mishap chance. Aircrew must recognize that there are solutions for many of these symtpoms and seek expert medical help if symptoms persist. Proper nutrition and exercise are also keys to success. Over reliance on caffeinated beverages, sugar, or workout supplements can be very unhealthy, especially in the long term. Poor diets may exacerbate shift work which already tax normal biological systems. Regular aerobic exercise helps to reduce stress significantly and is recommended at least three times a week. It is the responsibility of each crew member to find balance for themselves that is sustainable.

2.2.5 Systems Knowledge. The following are reasons to stay in the books that are unique to the remotely piloted aircraft: rapid and dynamic fielding of new weapons, sensors, and operation flight programs (OFP); mission execution software, auxiliary computers, and communications equipment makes up-to-date systems knowledge and consistent creation of habit patterns difficult; self-study of roadshow academics and manufacturer supplied supplements aid to understand and employ the system or software more safely.

2.2.6 Aircrew Discipline. Aircrew discipline is a standard tactical objective for all MQ-9 sorties. Even if aircrew discipline is not written as a tactical objective for the day it still must be executed and debriefed. Without aircrew discipline flight integrity breaks down and the MQ-9s ability to KILL and SURVIVE decreases. Examples of aircrew discipline include the following.

2.2.6.1 General Knowledge (GK)—aircrew are expected to study tactics, techniques, and procedures (TTP) relevant to the mission prior to the brief and be held accountable for all MQ-9 GK during brief/execution/debrief. As a baseline, all MQ-9 aircrew must have a full understanding of the following.

2.2.6.1.1 Standards: OG Standards, Squadron Standards, In-Flight Guide(s).

2.2.6.1.2 AFTTP: 3-1.MQ-9, 3-3.MQ-9, 3-1.IPE, 3-1.Shot Kill.

2.2.6.1.3 AFIs.

2.2.6.1.4 TOs (or applicable ASIs).

2.2.6.1.5 Applicable FCIFs.

2.2.6.1.6 Punctuality: Being late for a show time, brief, and step is unacceptable. Making a time on target (TOT) starts with showing up to the squadron on time.

2.2.6.1.7 Clear, Concise, and Correct Communication (C3 Comm): Excellent communication discipline minimizes both radio transmissions and cockpit communications that hinder mission accomplishment.

2.2.6.1.8 Perfect Admin: Strive for perfect position, fuel management, airspeed and altitude control, airspace management, safety of flight, and adherence to rules during all phases of flight.

2.2.6.1.9 Professional Debrief: All crew members must to be mentally prepared for debrief. Aircrew will gather required truth data from execution prior to debrief. Aircrew will adhere to AFTTP 3-1.Shot Kill debrief standards, will not quibble, and will ensure that valid learning occurs.

2.2.6.1.10 Ownership of Mistake: Aircrew should identify own errors, be an honest broker, and bring up the mistakes no later than debrief to ensure that the rest of the crew learns from those mistakes. If an error or correction is identified post debrief, the aircrew should ensure that the learning is still passed on to the rest of the crew and/or squadron as applicable.

2.2.7 Continuation Training. Procedurally correct practice reinforces mechanics, and solidifies a resilient cross-check that will survive the stresses of combat: chair flying, simulator events, and transit training.

2.2.7.1 Chair flying is practicing system setup or TTP without a simulator or live flying. Chair flying can occur anywhere. Robust chair flying is best in a cold cockpit; simple chair flying occurs in a briefing room with interactive software trainers, cockpit visual aids, flying software, or even drawings on a whiteboard. Chair flying excels as a means to practice cross-check, check perceptions and making decisions.

2.2.7.2 Simulation is the best means to check perceptions, practice making decisions, and practice execution in an environment where mistakes are free. The control of variables (weather, winds, and targets) also makes the simulator ideal to practice skills in less than optimal conditions and practice TTP under difficult circumstances.

2.2.7.3 Transit training occurs when an aircraft is not actively employed in a combat mission. This often occurs when the aircraft is transiting to, from, or between targets. This training will be done if there are no taskings that can be accomplished while on transit. Combat aircrew should always strive to find additional taskings (even menial ones) that contribute to the overall mission. This type of training is especially valuable to sensor operators getting hands-on-experience with the targeting pod, which is simulated notoriously poor in simulator. Pilots may be able to practice some maneuvers, but often transits are planned with minimal deviations to course.

2.3 Plan. The core of the planning comes down to four key tasks: understanding overall intent of the mission; identifying the tactical problem to be solved; solving the tactical problem using available aircraft, sensors, weapons, communication, integration, and battle tracking; and defining objectives, which the crew can brief, execute, and debrief.

2.3.1 Understanding the Problem and Intent. Understanding intent is one of the most challenging parts of the mission planning. While it may seem an obvious at first, depth of knowledge, planning biases, assumptions, and missing information often prevent crews from knowing or understanding the intent without asking a multitude of questions. If a crew understands who/what the target(s) is (are), where it is (or could be) located, when effects are needed, and why those effects are required, the crew most likely has a solid understanding of the intent for the mission. If there are ambiguities with any element of who/what, where, when, and why crews must query prior to continuing planning the mission. The following paragraphs expand upon the principles of who/what, where, when and why.

2.3.1.1 The crew needs to have a clear understanding of who/what the target is as well as a visualization of what the target looks like and the anticipated number of targets. The number of targets comes down to knowledge of enemy tactics, attrition, patterns of life, and behavior. Working with squadron intelligence to determine the amount and composition of enemy forces is crucial in the planning phase.

2.3.1.2 Coordinates or grids are often given to aircrew to fix the target. These coordinates are generated by a number of different sensors from something as simple as a joint terminal attack controller (JTAC), correlating what is seen with a gridded map to a national level sensor fixing the location of a detectable signature. In other cases, the MQ-9 crew is responsible for finding and fixing the target given a wider search area. In any case, understanding where the target is likely to be found inside of a search area will help narrow down unlikely areas and focus the crew on the task. Understanding wheeled vehicles and people will not stray far from roads or dirt paths in rough terrain will help narrow the search to lines of communication in the target area.

2.3.1.3 Understanding of the time line the crew has in order to complete the task is very important. Timing cannot be overlooked regardless of whether the crew is searching for something or trying to destroy a target with a specified TOT.

2.3.1.4 The most overlooked question but arguably the most important is “Why?” This question ensures the crew and tasking authority are on the same page. Understanding of the “why” underpins all of the decisions a crew will make in the seat and sets the conditions to support and lead in the fight. When the mission intent is understood, simply asking, “What does a win look like today?” outlines the tactical problem to be solved in the rest of mission planning. For example, if the intent of the mission is to prevent the overrun of a friendly force position by three unlocated enemy armor platoons, a win looks like finding three enemy armor platoons and forcing them to stop or retreat with zero friendly aircraft or ground force losses. Writing the problem in this way allows one to look at the problem holistically and not artificially limit solutions that otherwise might achieve the same effect. An example of a poor framing of the tactical problem would be wanting to find and destroy all of the tanks. While that would certainly achieve the intent of preventing an overrun of friendly forces, it will most likely require a lot more munitions, time, coordination, and would not be the most efficient solution.

2.3.2 Mission and Tactical Objectives. Preparation for every mission begins with determining the mission objectives. The mission objectives give the “big picture” of what is happening. An example of a mission objective is “timely/effective close air support (CAS) to meet the ground force commander’s (GFC) intent.” The specific tactical objectives or “desired learning objectives (DLO)” are performance statements used to measure success during the mission. Tactical objectives must be specific, measurable, attainable, realistic, and timely. An acronym to remember when building tactical objectives is SMART.

- Specific—specific objectives are detailed, concise summaries that, if achieved, will result in mission accomplishment.
- Measurable—measurable objectives provide detailed accomplishment criteria that provide a yes/no solution for execution/debrief.
- Attainable—attainable objectives lay within the aircraft and aircrew performance envelope.
- Realistic—realistic objectives require a reasonable chance of success.
- Timely—timely objectives are bound by time.

2.3.3 Solve the Tactical Problem. Tactical problem solving starts with the assessment of area of operations (AO) conditions (e.g., weather, terrain, restrictions, collateral concerns, friendly force integration etc.). With the conditions known (or assumptions made) identify different courses of action (COA) that achieve the desired intent and solve the tactical problem. Pick the COA that is most executable and balances simplicity, risk and effectiveness.

Break the chosen COA down into executable elements. The mantra of aircraft, sensors, weapons, communications, integration, and battle tracking provides a framework to think through all of the executable elements the crew has control over.

2.3.3.1 Where does an aircraft need to be in 3D space and time to deliver the needed effects within the constraints of the AO? The aircraft is the first factor to consider because almost all effects are at the mercy to aircraft positioning. Planners must determine the altitude, airspeed, angle of bank required, run-ins, standoff range, and emergency mission placement for each target based on the limitations of weapons range, sensor range, threat ranges, cloud decks, terrain, look angles, and line of sight to name a few.

2.3.3.2 What sensor is required and how must it be employed to find/fix the given target within the given time constraints. This requires planners to identify fields-of-view widths (FVW) for finding objects that are the size of the given target, FVWs for zooming in and positive identification (PID), scan rates, scan area, and mechanical scan plan. Those plans must be balanced against expected range to target, type of terrain (i.e., grassland, ocean, etc.), presence of obscurations (i.e., trees, buildings, mountains, etc.), and atmospherics (i.e., sun position, sun reflection, cloud cover, thermal crossover, haze, moonlight, etc.).

2.3.3.3 What communications are required in-cockpit and out-of-cockpit to achieve overall intent and solve the tactical problem? Message, means, and format are the three elements a planner must address for a communications plan to be successful. Message covers the content of the message. Means covers the physical transmission of the message to include: radio, mIRC, Zeus chat, VoIP systems, and ClearCom. Format is the standardized packaging of the message to ensure correct processing of the information (e.g., Savage will pass all ZSUs found in the Kawich range using mIRC on the COAC-N server, SAVAGE_MSN room, using the following format, "Kawich, ZSU A, 11SPA86717 15189, elevation: 4,512 feet."

2.3.3.4 What specific weapons effects are required from each weapon to satisfy overall intent and solve the tactical problem? Planners must identify desired points of impact (DPI), impact angles, weapon guidance, weapon velocities, penetration depth, and fuzing. This is balanced against target composition, weapon guidance, target movement and handover boundaries, desired probabilities (i.e., kill, function, movement, etc.), and desired point of impact (DPI) separation.

2.3.3.5 Leverage other airborne, ground, and maritime forces, with unique sensors, communication, weapons, and battle tracking capabilities to achieve the overall intent.

2.3.3.6 By what means will the crew maintain situational awareness of the battlespace? Zeus, whiteboard, notepads, mission execution software, Claw and rote memorization are all options each with own pros and cons. Finding the simplest way to maintain SA is most likely going the be the most successful.

2.4 Brief. The briefing sets the tone for the entire mission and outlines how the crew will use the aircraft, sensors, weapons, comms, battle tracking, and integration with other players. Briefs convey "what" the crew will do, and "when" the crew will do it. Instructional briefs include "how" students will accomplish each task. The "why" of the mission should be understood from premission planning, and any clarifications outlined in debrief.

2.4.1 Briefing Preparation. Preparation is essential to delivering clear, concise, and correct briefs.

2.4.1.1 A good way to ensure proper preparation prior to the briefing is to write out a personal briefing guide based on the AFTTP 3-1/3-3, TOs, and regulations. A briefing guide is an organic, customized tool that codifies mission materials into a succinct and easy to follow sequence. A briefing guide simplifies speech, visual aids, whiteboard drawings, and mnemonics that ensures all briefing content is discussed. This guide should be viewable by only the briefer to avoid distracting the crew. A briefing guide is not a script. Reading word-for-word will very quickly bore, and distract the crew.

2.4.1.2 Preparing whiteboards and/or slides is essential to enhancing the overall quality of the briefing. Limit information on boards to what is essential. As a general rule, the less cluttered the briefing boards, the less distracted the crew will be during the brief. It is a poor technique to fill the boards with laundry lists for the mission. Although some use this as a memory jogger for the briefing, it distracts the audience by taking attention away from the briefer. If using computer slides for a presentation, after presenting a slide, either turn off the computer or use a black slide to remove the slide from the screen. Ensure the whiteboards and room are clean and that any computer systems work appropriately prior to the briefing. Always ensure any computer-based content used is current and in accordance with (IAW) the latest TTP.

2.4.1.3 Correct integration of visual aids in a briefing can enhance a briefing and better communicate the message to the crew. As with briefing room boards, computer slides, and interactive multimedia, the key is to practice with the visual aids. The inappropriate or inaccurate use of visual aids can confuse the crew and distract from the overall quality of the brief. Common visual aids include whiteboard drawing or pictures, heads-up display (HUD) diagrams, stores management system (SMS) page printouts, and vital information tables (VIT) printouts.

2.4.1.4 Drawings must be accurate and scaled enough to support the desired point. A common error is briefing to the board while drawing and/or blocking the board from the crew's view. When using the board for visual aids, look at the board and make an accurate drawing or depiction without talking. When finished, move to a side allowing the crew to see the picture and then brief the visual aid while looking at the crew.

2.4.2 Briefing Techniques. Briefings must be dynamic and enthusiastic. Briefers motivate and challenge the crew to perform and ask questions to involve crew members, and determine briefing effectiveness. Limit speaking roles to avoid duplication, contradictions, and to control timing. Allocating times for each portion of the briefing is one technique to deliver a timely briefing.

2.4.2.1 Public speaking skills are critical to a successful briefing. High levels of general knowledge or tactical expertise do not safeguard an inability to communicate ideas in a clear and logical way. Practice briefing at every possible opportunity, preferably with a knowledgeable crew member who will provide candid feedback. Practice will help improve speaking skills and aid in timing control. Practice also aids in eliminating distracting verbal pauses (e.g., "all right," "basically," or "um").

2.4.2.2 Sitting in the briefing room studying notes prior to the brief conveys a lack of preparation. Leave the room before beginning the briefing, and return with enough time to close the door and prepare for the time hack.

2.4.2.3 Always stand during the brief. Standing is professional and commands the attention of those in the briefing room. Do not stand in one place however; move around to keep the crew engaged and focused. If another member of the crew is going to speak (i.e., “pen-swap”), the primary briefer should sit and the new briefer should stand.

2.4.2.4 Voice inflection is an outstanding tool to keep the attention of the crew. A monotone briefer is distracting and loses the audience.

2.4.2.5 Maintain eye contact with the crew while briefing. Facial expressions provide immediate feedback of the effectiveness of a brief. If an item is confusing, it will be immediately evident. This allows the briefer to correct a miss-speak, try another method, or reinforce the topic.

2.4.2.6 Ensure that the brief addresses each portion of the mission in a timely manner. Ensure that the brief ends with adequate time for aircrew to ask questions and facilitate an on time step.

2.4.2.7 Mission Support. If adversary, friendly, intelligence, or other mission support personnel are present, only brief them on pertinent information of the mission and clear them off.

2.4.3 Motherhood and Tactical Administration. Motherhood covers relevant safety topics and ensures the crew is legal to fly in accordance with squadron, wing, major command (MAJCOM), and command level guidance. Tactical administration (tac admin) is the portion of the brief that covers scenario specific aircraft, weapon, and system setup. See **Table 2.1**, Sample Briefing Outline, for specifics of motherhood and tac admin.

2.4.4 Tactical Content. The majority of any brief should be on tactical content that directly addresses how the crew is going to achieve the mission and tactical objectives.

2.4.4.1 Tactical content must take into account the experience level of each crew member. For example, a basic (B) course CAS sortie will provide very detailed instruction for setup, execution, and mechanics. A CAS continuation training (CT) sortie may only cover the “what” versus the “how.”

2.4.4.2 Briefing Flow. Begin the briefing with general concepts and work towards specifics, incorporating the mechanics of how to accomplish the mission. In general, a briefing that covers mission elements in a logical progression is the most successful. Phase, task and trigger is a common approach to briefing the tactical content. What is the current phase, what are the associated task, how to execute the task, and what is the trigger into the next phase?

2.4.4.3 Briefing Mistakes. Avoid philosophical discussions, blanket statements, and academics in mission briefings. Philosophy is an important element in tactics development and understanding the “why” behind the tactics; however, reserve these discussions for an academic environment where sufficient time is available to discuss the pros and cons of a certain philosophy. A tactical briefing must be clear, executable, and concise.

Table 2.1 Sample Briefing Outline (1 of 2).

Motherhood/Tactical Admin Briefing Guide Example	
Introduction Hack/call sign/roll call Classification Question ROE Mission Objectives Tactical Objectives Mission Flow Products (Inventory only) • Graphical Range Restriction (GRR) • Weather • NOTAMs • Line Up Card (LUC) • Additional questions **Motherhood** Go/No-go items FCIFs ORM SIIs Training Rules IAW 11-214 • KIO • Terminate • Weapons (2-switch, MA/Trigger) • Live Ordnance? Minimum safe distances? • LRD vs TRNG LRD - Range Restrictions Airspace/Weather/NOTAMs Comm Priorities • Safety of flight/external/Flt Lead/Internal Collision Avoidance: MACA/MARSA • Radios, TacSit, mIRC MSA NORDO Real world emergency procedures EPoD IP responsibilities	**TAC Admin** LUC Review Loadout • PRFs/fuzing Altitudes (climbs/descents) LHO/GHO Plan Holds • Wheel (CW, HF: as required, GBU: 1+30 - 2+00 TTR) Sector (HF: 10 km, GBU: 6 NM) **Fence** A/C Position (A/S, Alt) Tracker/HUD/HDD SMS RMIT SAR/CLAW Planning Tool GWTS/GBIT TacSit Setup mIRC Clearcomm Clearance Comms • Cleared hot/continue dry/CTE Fence NLT **Contracts** Plots Default weaponeering Sensor contracts Auto PRF swap Auto Lase ("In"/0+30 TTR) 5+00, 3+00, 1+00 call for TOTs
LEGEND: **A/C**—aircraft **A/S**—airspeed **EPoD**—emergency procedure of the day **GBIT**—GBU bomb impact tool **GHO**—gaining handover **GRR**—graphical range restriction **GWTS**—guided weapon trajectory software **HDD**—head-down display **LHO**—losing handover **LUC**—line up card	 **MA**—master arm **MACA**—military assumes collision avoidance **MARSA**—military assumes responsibility for separation of aircraft **MSA**—minimum safe altitude **ORM**—operational risk management **PRF**—pulse repetition frequency **SAR**—search and rescue **SII**—special interest item **TTR**—time to release

Table 2.1 Sample Briefing Outline (2 of 2).

Basic Attack Briefing Guide Example	
Phase: Intent **Task:** • Communicate and build SMM with tasking authority - Determine attack restrictions - Understand desired end state/effects • Direct aircraft to either 10 km (HF) or 6 NM (GBU) **Trigger:** Aircraft is directed to hold for attack ***Phase: Game Plan*** **Task:** • Determine weaponeering • DPI Breakout and track plan (SO) • Update holding game plan • Determine timing solution (as required) **Trigger:** Weaponeering and hold plan solidified ***Phase: Hold*** **Task:** • Enter hold IAW plan • Maintain hold • SLAPUM WTARSEC **Trigger:** Time, position or clearance	***Phase: Execute*** **Task:** • Turn in • STAT • SO cross-check • Release • Post release maneuvers • Post impact procedures **Trigger:** Post impact procedures complete ***Phase: Egress*** **Task:** • Maneuver for reattack • BHA/BDA • ASULT **Trigger:** Intent met ***Contingencies:*** • Weather • Weapons malfunction • Aircraft malfunction • Threats
LEGEND: **ASULT**—airspeed, SMS, update, laser/LAR, track **BDA**—battle damage assessment **BHA**—bomb hit assessment **SLAPUM**—SMS, laser/LAR, airspeed/autopilot, payload, update, master arm **SMM**—shared mental model **WTARSEC**—weapon, target/track, aimpoint, restriction/run-in, shift, egress, clearance	

2.5 Execute.

2.5.1 Ground and Flight Safety. The combat mission is often the highest priority. In peacetime however, there is no mission more important than safe recovery of the aircraft and ground personnel. Aircrew must have a thorough understanding of all ground and flight safety aspects of the mission. Never exceed safety limits in the desire for mission accomplishment.

2.5.2 Pilot in Command Leadership. The pilot in command (PIC) is responsible for planning and organizing the mission, leading the crew, delegating tasks, maximizing crew effectiveness, and ensuring mission accomplishment. The pilot and SO will work together as a crew to meet DLOs for each mission. PICs must know the capabilities and limitations of each member of the crew.

2.5.3 Task Prioritization and Situational Awareness.

2.5.3.1 Fundamental Tasks. Fundamental tasks include the following.

- Maintain aircraft control.
- Do not hit the ground or anything attached to it.
- Do not hit anything in the air.
- Do not let anything shot from the ground or air hit the aircraft.
- Do not run out of fuel.
- Maintain situational awareness.

2.5.3.2 Task prioritization during the mission is critical. There are occasions when all tasks cannot be done at once; prioritizing the tasks is necessary to ensure mission accomplishment. Priorities will shift, but fundamental tasks remain the same.

2.5.3.3 Task management is the organization of in-flight tasks to keep aircrew workload manageable. In the MQ-9, the crew concept allows for division of tasks which facilitates workloads that are more manageable. However, having two crew members does not prevent task saturation in either seat. The following techniques will assist in preventing or overcoming task saturation.

- Ensure checklist items and habit patterns are followed. If events interrupt habit patterns, slow down to accomplish tasks correctly.
- Anticipate and be prepared for the next briefed event; always push to stay ahead of the aircraft.
- Maintain a good cross-check among instruments, HUD, tactical situation display (TacSit) and ancillary computer systems.
- Be flexible and prepared for changes in task priorities.

2.5.3.4 Task Saturation. Task saturation is the failure of proper task management. If allowed to go unchecked, this will lead to a breakdown of in-flight execution. Task saturation can lead to the loss of mission effectiveness, and more importantly, increase safety of flight risks (e.g., ground/in-flight collision and training rule violation). Task saturation is caused by an overload of duties such as: aircraft control, navigation, formation, tactics, and weapons employment. This will often take place during highly dynamic situations in complex training or combat scenarios. Additionally, changes due to weather or other unexpected events can quickly task saturate even the most experienced aviator. Recognizing that another crew member is task saturated is essential to effective employment and safety. The following are some symptoms of task saturation.

- Missed or unacknowledged radio calls.
- Failure to respond or react to intercockpit comm.
- Difficulty controlling the aircraft.
- Difficulty controlling a sensor.
- Inability to anticipate or prepare for briefed events (i.e., “getting behind the jet”).

- Loss of situational awareness.
- Channelized attention.

2.5.3.5 Poor prioritization during any mission may result in channelized attention or target fixation and can have disastrous results. Task saturation factors can be mitigated by preparing for each mission and defining objectives so that the least experienced flight member can effectively employ the MQ-9. Each member of the crew must mentally prepare for the mission. It is every crew member's responsibility to ensure the crew is ready to fly. During preflight preparation, crew members should mentally prepare for the situations most critical to effective execution while addressing what could happen during these phases. Examples of critical areas to address may include the following.

- Terrain avoidance.
- Sensor manipulation.
- In-flight and intracockpit communication.
- Weapons employment.
- Crew coordination.

2.5.3.6 Task Saturation Mitigation Techniques. Watch for symptoms of task saturation and act to minimize them in the following ways:

- Reprioritize current tasks, placing aircraft control first (i.e., aviate, navigate, and communicate).
- Inform crew about situation.
- Call "KNOCK IT OFF" if tactically maneuvering.

2.6 Debrief. The objective of debrief is to determine if the desired mission objectives were achieved and what aspects of training need improvement. The majority of the learning occurs in the debrief. The purpose of debrief is not to just identify if there was a mission failure or what went wrong. It is important to assess how the aircrew used aircraft, sensors, weapons, communication, integration, and battle tracking and how to do it better on the next sortie. Even the best missions, attacks, and scans have something that could be better or flown more efficiently. See **Table 2.2**, Sample Debrief Guide, for an example of how to run the debrief and *26 WPS Debrief Guide v 8.0*, for mission specific debrief flow and data matrix examples. See **Figure 2.1**, Debrief Board Setup Example, for an example of the debrief board.

2.6.1 Data Compilation. Data compilation is the organization of notes and important time stamps for data analysis. When a crew is complete with their sortie and arrive in the debrief room, data compilation is the first step. This step occurs before the official start of debrief and can take anywhere from 10 minutes to an hour, depending on the availability of data from the sortie. Use of a matrix that allows for quick event-by-event comparison is optimal. For instructional sorties, put the matrix on a whiteboard for all in debrief to see. For a crew debrief, organizing information on a sheet of paper may be sufficient for reference by both crew members. Data compilation should be limited to just that, data. Interpretation of the data (e.g., tape review) for root causes is out of place in this phase of debrief. Data is limited to information that is quick to find, quantitative, typically transcribed from notes on hand from crew members.

Table 2.2 Sample Debrief Guide

Prebrief—Data Compilation

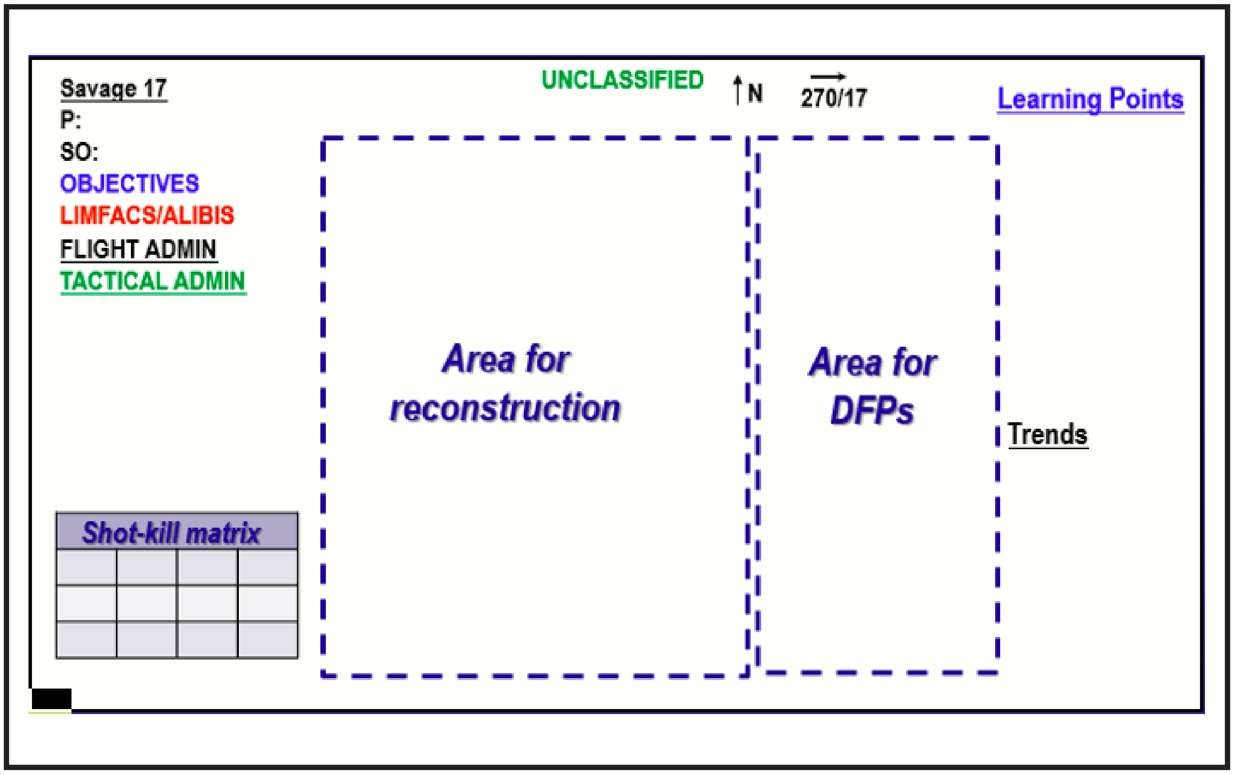
1. Fill out data matrix
2. Validate weapons employments
3. Conduct error analysis to highlight possible DFPs
4. Conduct any DFP reconstruction as time allows prior to debrief

Start Debrief

1. Review objectives
2. Alibis/LIMFACS from sortie
3. Flight admin
    a. Safety of flight/ground
    b. Special interest item adherence
    c. Training rule violations
    d. SPINS compliance
4. Identify plan, products, brief errors
5. Tactical admin
    a. Communications
    b. Deconfliction
    c. Ingress/egress
6. Review flow of the mission (2 to 3 minutes max)
7. Complete data compilation
8. Complete error analysis
9. Identify applicable DFP question for DFP of highest importance
10. DFP Process
    a. Reconstruction
    b. Identify contributing factors
    c. Create instructional fixes
    d. Identify root cause
11. Repeats steps 9 to 10 for next DFP
12. LP Process
    a. Identify any remaining learning points
    b. Provide instructional fixes
13. Trends
14. Grade objectives

LEGEND:
DFP—debrief focus point
LIMFAC—limiting factor
LP—learning point
SPINS—special instructions

Figure 2.1 Debriefing Board Setup Example.



2.6.2 Motherhood/Tactical Administration. The formal debrief starts with a review of motherhood and tactical administration. Crew debriefs motherhood and tactical administration review happens upon completion of data compilation. The purpose of motherhood review is to recage the crew on the purpose of the mission with an objective review. Motherhood is reviewed to ensure there were no airspace violations, list alibis affecting mission effectiveness, as well as any debrief limiting factors. A quick two-to-three minute overview of the sortie's main events and then highlight any training rule (TR), special interest item (SII), SPINS, or safety-of-flight violations. Review the sortie's plan, mission products/briefing, and determine the effectiveness of each (i.e., confusion, missed items, and poorly prioritized efforts). Finally, debrief tactical administration items to include systems setup, communications, deconfliction and ingress/egress. Do not recount every event in chronological order; rather, only highlight items that require discussion.

2.6.3 Error Analysis. Debrief time should be used as efficiently as possible. Begin by analyzing the compiled data matrix for errors committed by or omitted by the members assembled in the debrief room. For example, if data compilation shows three invalid releases for Hellfires, and one untimely attack due to a slow scan and lots of confusion on the crew, the crew debrief should omit the Hellfire releases. Save any crew position-specific mistakes for a personal debrief or self-study. When trying to determine where to start in the debrief use the following hierarchy for debrief order: safety of flight/ground; lost effects that result in mission failure; failed mission or tactical objective; "lucky" outcomes (rather than clearly correct and repeatable behaviors); and lastly, minor/stylistic concerns. Finally, if there appear to be multiple reasons for a mistake, then use the debrief focus point (DFP) method. If a mistake appears caused by one single reason, then use the learning point (LP) method.

2.6.4 The DFP Method. If an error appears to have many smaller mistakes that contribute to it, use this method. This method has a five step, repeatable process that is geared to asking the most powerful question in debrief, which is "why" something happened. This method can be intimidating and confusing to write at first, but it is nothing more than error analysis and determining the root causes for mistakes. Because this method dives deep into every mistake that contributes to a larger error it can be time consuming. Understand, however, that time spent on a DFP is often saved later in debrief when the same root causes for mistakes are identified in other parts of the sortie. In other words, fix it in the DFP and one does not need to talk about it again in debrief, regardless of how many other times the same error occurred. The outline of the five-step process for DFPs are below.

2.6.4.1 DFPs are built around specific questions that identify the lost effect (think missed opportunity) or unfavorable outcome (why the mission failed, etc.). The question cages everyone in debrief as to what the crew is going to determine while working on the DFP. For example, if the crew of SAVAGE 11 took 26 minutes to work a coordinated attack against eight tanks as tactical lead with a two-ship of F-16s, a DFP question of, "Why did SE11 require 26 minutes to destroy 8x Tanks with Wolf Flight?" would cage the room to what the debrief lead wants to focus on. Now when the crew watches tape, each crew member will be listening and watching for mistakes that cost the crew time in that engagement. It is also a filter for all in the room. If a crew member or debrief lead finds learning that does not address that question it is set aside to be addressed later in the debrief.

2.6.4.2 Reconstruction is targeted collection of data that comes from reviewing segments of HUD tape, Zeus recordings, mission execution software playback, questioning crew members about decisions, etc. It is the unfiltered truth of "what" and "why" something happened and is critical to the success of debrief. Without an accurate reconstruction of the sortie, valid and quality instruction is impossible to achieve. As stated in **paragraph 2.6**, Debrief, the brief should be set up to debrief the mission and tactical objectives. Data collection should provide the ability to analyze aircrew performance against the objectives. For example, if a strike coordination and reconnaissance (SCAR) mission has the tactical objective of zero untasked assets for more than five minutes, then data needs to be collected during reconstruction of each asset's time line from task completion to the assignment of the next task. Data collected that does not highlight any mission impact supporting objectives, leads to an inefficient debrief. However, if data collected does have an overall mission impact but does not have a related objective, then an objective should be made to support the content of the debrief. For example, on the same SCAR sortie reconstruction discovered that the aircrew simultaneously assigned the same airspace to two assets without positive deconfliction, but asset deconfliction is not a tactical objective. An objective should be added addressing this situation as this collected data highlights an item that has mission impact. Different mission sets have different objectives and therefore have different data collection requirements during reconstruction. All valid objectives must be assessed in a way to collect data supporting and allowing for analysis of the objectives and should be determined well prior to debrief. The ability to focus on the correct mission reconstruction tool to accurately collect data over a lengthy and/or event-filled sortie is critical to debrief flow. Refer to Major Brian Gyovai's USAFWS paper, *Reconstruction: Finding the Truth in the RPA Debrief*, (26 WPS, 13A), and Major

Ronnie Hawkins' paper, *Tools and Techniques for Conducting an MQ-1/9 Combat Debrief* (26 WPS, 10A), for specific details on an MQ-9 centric debrief. Timely, accurate and applicable reconstruction highlights the deficient and proficient areas of execution and leads to correct error analysis and valid instruction.

2.6.4.3 When reconstruction is complete, contributing factors that led to the mistake or failure will be identified and highlighted. A contributing factor is a faulty perception, a decision error, or an execution error committed by a member in flight. Additional reconstruction might be required in order to determine all contributing factors for a DFP. Once a contributing factor is identified, the debrief lead should ask "why" that particular error occurred. If another factor is highlighted in the questioning it should be written down and nested underneath the parent contributing factor. Contributing factors tend to branch quickly so leave space on the board or in notes for branching. The only time the debrief lead should stop asking "why" when the crew being questioned hits a knowledge gap, or when contributing factors reach a logical conclusion.

2.6.4.4 After identifying contributing factors, the debrief lead will provide instructional fixes to each contributing factor. Adequate instructional fixes include what the crew will do differently next time, when the crew will accomplish the fix, and specifically how the crew will accomplish the fix. Expert instructional fixes not only correct the contributing factor encountered in the sortie, but the perception, decision and execution processes the crew uses in all cases. Thorough fixes include all applicable aircraft, sensor, communications, weapons, integration, and battle tracking elements.

2.6.4.5 Once instructional fixes are completed, the root cause is highlighted by the debrief lead. The root cause is the single critical contributing factor with the most significant impact that led to the DFP. This helps emphasize the gravity of the mistake and drive home the learning for the crew.

2.6.5 Learning Point Method. A learning point is a factor that does not contribute to a larger failure. Learning points are generally mistakes mitigated by the crew to some extent. Learning points still contain learning and still need fixes. Write learning points on the board like a contributing factor in a DFP. Organize learning points in a column on the board with other learning points. Nested under each learning point is the instructional fix that corrects the error.

2.6.6 Identifying Trends. Trend identification is a technique that helps highlight repeated mistakes or omissions (sometimes positive trends are applicable as well) by the crew. A trend is a reoccurring contributing factor or learning point occurring in the majority of events in the sortie. For example, on a surface attack (SAT) ride the crew shot employed without the laser on for four of seven attacks. The instruction for correcting the error was covered in a DFP and a couple of learning points. The trend on the board is "Laser."

2.6.7 Objective Assessment. The combination of data collection and mission reconstruction should clearly present the criteria for grading objectives. A strong debrief has the mission reconstruction, data collection, DFPs, learning points, and trends displayed on the board and/or other debrief tools to provide the framework for developing lessons learned and assessing the objectives.

2.6.7.1 Debrief concludes with the debrief lead assessing the tactical objectives and then the mission objectives for overall success or failure. When grading the objectives, the answer to whether or not each one was achieved or failed should be objective and uphold the briefed standard. Leave personal feelings out of the equation. If a tactical objective is not assessable, (no data was presented to prove or disprove achievement) it will not be graded. The debrief lead should make adjustments to debrief process to include required data in future debriefs.

2.7 Student Papers. For an in-depth discussion of mission debrief, refer to the following USAFWS student papers:

- *26 WPS Debrief Guide v 8.0.*
- R*econstruction: Finding the Truth in the RPA Debrief*, by Major Brian Gyovai.
- *Tools and Techniques for Conducting an MQ-1/9 Combat Debrief*, by Major Ronnie D. Hawkins III.
- *Methodology of the Debrief*, by Captain Robert Brown.
- *A Debriefing Guide for Operational Viper Squadrons*, by Captain Michael F. Hernandez.
- *MQ-1/9 Instructional Briefing Methodology*, by Captain Scott VanOort.
- *MQ-1/9 Remote Split Operations Mission Planning and Execution Cell (MPEC)*, by Major Albert F. Scaperotto.

CHAPTER 3

AIRCRAFT FUNDAMENTALS

3.1 General. The MQ-9 weapon system consists of the MQ-9 aircraft, the cockpit, the data link system that connects them, and the aircrew elements that operate the system. The standard mode of employment is via a remote split operation (RSO) configuration using a launch and recovery element (LRE), mission control element (MCE), and a remotely located SATCOM terminal. This publication reflects the capabilities and functionality of the following operational flight program (OFP) branches:

- OFP 2409 and AN/DAS-1 software 14.0000 (Block 1 or Block 5 Aircraft with Block 15 or Block 30 Cockpit).
- OFP 2409 and AN/DAS-4 software 14.0000 (Block 1 or Block 5 Aircraft with Block 15 or Block 30 Cockpit).

3.1.1 Auxiliary Information Displays. In addition to the Block 15 and Block 30 primary cockpit aircraft controls, MQ-9 aircrew have access/control to six or more auxiliary information displays (AID) in the cockpit, which are often connected to computers outside the cockpit. Connection to multifunction workstations (MFW) is also possible via keyboard video mouse (KVM) switches. AID displays provide access to critical mission information and mission execution software at the certified classification level of the cockpit (e.g., NIPR, SIPR, and JWICS networks). Availability and accessibility could be limited due to supported units or unit-specific approvals. For further details of the following, see **Chapter 10**, "Tactical Tools."

- TacSit (Zeus or equivalent).
- Google Earth.
- SKYNET.
- Internet browser.
- R-Missile Impact Tool (RMIT).
- GBU Bomb Impact Tool (GBIT).
- Guided weapon trajectory software (GWTS).
- CLAW.
- Internet Relay Chat (mIRC).
- MINOTAUR.
- Analog Frame Grabber.

3.2 Administrative Checks. Administrative checks provide additional guidance outside of the TO 1Q-9(M)A-1 (or applicable Aeronautical Systems, Inc. [ASI]) to verify weapons loadout, expenditure, current weather conditions, and system operations, and ensure the aircraft and cockpit are set up appropriately for the mission. The most common checks include: airborne ordnance; battle damage; weather sweep; in-flight operations; and fuel, emitters, navigation, communication, and engage (FENCE) checks.

3.2.1 Airborne Ordnance Check/Battle Damage Check. An ordnance check is normally done shortly after takeoff, gaining the aircraft, and when leaving the target area/training range, and is a visual confirmation with the targeting pod (TGP) of weapon condition and expenditure. The ordnance check is also used to verify the variant of Hellfire on each station and if ordnance is live or inert.

3.2.1.1 To accomplish the ordnance check, the pilot will coordinate with the SO to rotate the TGP and visually check number, type, and location of munitions. After a visual check is accomplished, the crew must ensure the M-310 rails arm. Prior to selecting the “Master Arm” button on PPO1, the SO will focus on the “Arm/Safe” switch in the center of the M-310 and watch the switch transition from Safe to Arm.

3.2.2 Battle Damage Check. A battle damage check includes both an airborne ordnance check and a visual inspection of the aircraft for damage that could have occurred throughout the course of the sortie. Before accomplishing a battle damage check, the SO will coordinate with the pilot. At a minimum, a battle damage check should be accomplished on every sortie prior to RTB once clear of the target area/range and outside of any threats.

3.2.3 Weather Sweep. The weather sweep is a scan across the horizon to build the weather picture and adjust the aircraft flightpath if required. Weather sweeps can be accomplished in conjunction with ops checks, or whenever the target area becomes obscured by clouds for a significant timespan. Perform a 360-degree sweep of the horizon. It is recommended to do this in wings-level flight. The frequency of weather sweeps should increase with deteriorating weather conditions to minimize the possibility of inadvertent interference with the aircraft, weapon employments, or lasing responsibilities. To maintain constant SA on the weather while maintaining the TGP on a target, ensure the nose camera is operational, configured, and displayed. See **paragraph 3.2.5**, FENCE checks, for configuration and set up.

3.2.4 In-Flight Operations Checks. Operations (ops) checks should be accomplished IAW AFI 11-202v3. In order to expedite ops checks, pilots may use the center MFW to display additional VITs (23, 48, 50, 68, 98, 99, as required) without cycling VITs on the HDD. Note trend data to maintain irregular system performance, usually accomplished via a whiteboard application.

3.2.5 Fuel, Emitters, Navigation, Communication, and Engage Check. A FENCE check should be accomplished upon gaining the aircraft, performing a crew swap, or entering a tactical airspace. Below is a set of recommended FENCE check items. Use the prioritized FENCE check for time critical scenarios, such as troops in contact (TIC) immediately after gaining the aircraft from LRE.

3.2.5.1 FENCE Check Items. FENCE check items can be added or removed based on relevancy. An example of the minimum items to be checked is shown in **Table 3.1**, FENCE Check. These items can be accomplished in any order. Some items can be accomplished prior to crew change out or gaining aircraft control through the use of VIT repeaters and mission execution software on MFWs.

3.2.5.1.1 Fuel. Fuel FENCE items consists of checking the fuel system by referencing the appropriate VITs, assessing Joker, and calculating Bingo.

Table 3.1 FENCE Check.

FENCE	Check
Fuel	Fuel Level—checked Joker/Bingo—calculated
Emitters	Air Handler—set IFF—set RVT—set Lights—Nav/Strobes and IR Beacons Set, A/R AV transmitters—freqs/modes set SAR—on/enabled SAR Ctrl—on Ku Configuration—set VORTEX—on, not transmitting
Navigation	TacSit Display—set ACO—loaded Tracker Display—set Lost Link Profile—updated MSA/Altimeter—checked/set
Communication	Radios—set/checked TDL—checked mIRC—set A/R Telephone—verify
Engage	SMS—inventoried/set, A/R HUD—set TGP—set Laser—LRD coded, LTM rate set, systems tested Mission Planning/Execution Tools—set
LEGEND: AV—air vehicle IFF—identification, friend or foe RVT—remote video terminal TDL—tactical data links	

3.2.5.1.1.1 Joker/Bingo. These coordinated fuel levels can be found in respective theater MCE/LRE standards. Create a flightpath in the TacSit (Zeus or equivalent) and input fuel flow and flight level winds to calculate an accurate Bingo. The pilot will need to update these calculations throughout the mission as changes occur, such as weather, flight parameters, RTB routing, and new mission tasks. Fuel plans should be updated hourly, at a minimum. If not using Zeus, calculate Joker/Bingo using aircraft cruise speeds and fuel flows for the amount of time required to RTB or transition to the task with required fuel reserves. For a more accurate calculation, place the control point over the LRE or new airspace and point at it while flying at planned transit airspeed to determine fuel flow and required transit time.

3.2.5.1.2 Emitters. Certain emitters need to be configured during the FENCE check to ensure compliance with applicable guidance. Common emitters are air handler, IFF, RVT, VORTEX, lights, AV transmitters, synthetic aperture radar (SAR), and Ku configuration and should be set up in accordance with area of responsibility (AOR), SPINS, squadron guidance as well as with TO 1Q-9(M)A-1 or applicable ASI.

3.2.5.1.3 Navigation. The intent of the navigation step of the FENCE check is to ensure proper routing to/from the operating area without any airspace violations, both with and without link.

3.2.5.1.3.1 Aircraft and Weather Avoidance. In order to maintain SA of air traffic and potential weather while transiting or operating in the target area, crews must ensure the nose camera is operational, configured, and displayed appropriately.

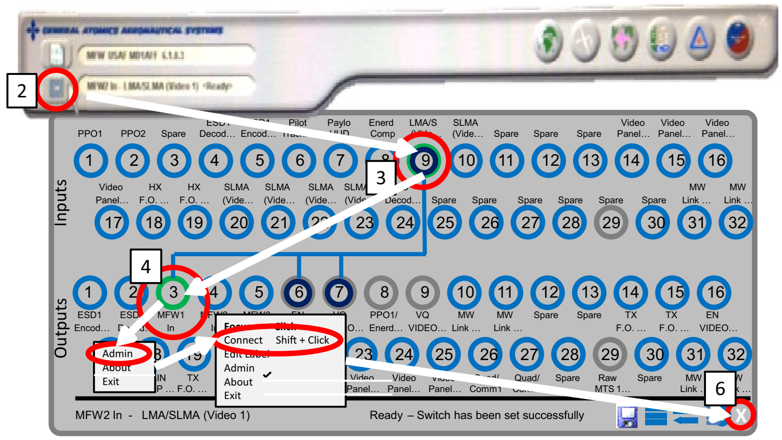
3.2.5.1.3.1.1 Flying from a Block 15 cockpit requires the use of the MFW Framegrabber application. Framegrabber can be set up to repeat the video from a variety of sources (e.g., pilot HUD, SO HUD, VQ, or Enerdyne). To enable this kind of persistent weather monitoring, set RL Rate Select to shared, change HUD video source to view Enerdyne, mux VQ to a nose camera, and then map the VQ source to the MFW running Framegrabber. See **Figure 3.1**, Framegrabber Setup, for a depiction of MFW setup for Framegrabber.

3.2.5.1.3.1.2 Flying from a Block 30 cockpit allows the pilot to display the nose camera on the safety, tactical, operation, reliability, and maintenance (STORM) console. In order for the nose camera to display within the STORM console, shared must be selected in the SATCOM Tab and then select the camera icon on the STORM Console.

3.2.5.1.4 TacSit Display. The TacSit Display (Zeus or equivalent) should be set up to provide the required fidelity for the current tasking in accordance with unit standards. During transit, it should normally be zoomed-out to see all applicable airspace, restrictions, and other traffic between the current position and destination. During tactical execution, the TacSit display should generally be zoomed-in as much as possible while still encompassing the AO. The Zeus magnification tool may also be used in order to display two different zoom levels at once.

3.2.5.1.5 Airspace Control Order (ACO). The current version should be loaded in the TacSit display after it is published. Tailor the applicable TacSit display filters to ensure the highest SA on restricted locations. Once established in the operating area, use features to highlight the active airspace in the immediate area to increase awareness on allocated airspace and relevant restrictions. Once departing an optimized area, reapply settings to ensure the previously deselected airspace is visible.

Figure 3.1 Framegrabber Setup.



1. Launch Framegrabber. (Not depicted)
2. On the GA Toolbar,-left click the button with a round blue circle.
3. Left-click on the desired input for Framegrabber:
   a. "Pilot Track…" = Pilot's HUD
   b. "Paylo HUD" = SO's HUD
   c. "LMA/S" = VQ
4. Right-click on MFW running Framegrabber:
   1. Select "Admin" if "Connect" is not an option.
   2. Select "Connect".
5. Verify desired video is playing in Framegrabber. (Not Depicted)
   1. If not, then verify Mux and input from step 3. (Not Depicted)
6. Click "X" in lower left corner to hide the menu.

3.2.5.1.6 Tracker Display. The tracker display map should be centered on the working airspace with the appropriate maps loaded that will be required to transit between the LRE and any known mission operating areas for that sortie. Open the Control Point window and set Coordinate System and "Load Tracker" overlays per squadron standards.

3.2.5.1.7 Lost Link Profile. The lost link profile includes the initial lost link altitude, initial lost link heading, and emergency mission. It should be set to return the aircraft to the LRE while avoiding restricted airspace and hazardous weather, and known threat locations along the appropriate routing to enter the LRE's airspace at a prior-coordinated point. Set and verify the correct IFF codes for each leg along the route in Waypoint Editor. Once in the objective area, the start point and its loiter should be inside the assigned airspace both laterally and vertically to ensure air traffic control (ATC) has the time to clear the lost link routing. If operating in a stack, the lost link profile should be communicated to the stack owner to ensure deconfliction with nearby aircraft if link is lost. Coordinate with other RPAs to ensure lost link routing is deconflicted, especially with aircraft returning to the same LRE, and in accordance with any applicable local guidance. Once set, the emergency mission should be saved in accordance with unit standards, sent to the aircraft, and verified the SO's rack populated the uploaded mission using the set-saved-sent-verify sensor mantra. Once verified, the SO should clear the old emergency mission from the tracker display. After selecting upload emergency mission from the tracker display mission drop-down panel, “upload selected mission,” verify the emergency mission-transmitting caution is displayed and then grayed-out in the HDD to ensure the mission was actually sent to the aircraft.

3.2.5.1.8 Minimum Safe Altitude (MSA)/Altimeter. The MSA should be set in accordance with AFI 11-2MQ-1/9V3. If flight is required below the MSA, the MSA in the HDD must be adjusted to allow use of altitude hold, while proper terrain clearance is ensured and the lost link profile is set up appropriately. The altimeter should be updated and set in accordance with applicable flight rules.

3.2.5.2 Communication. This step of the FENCE check ensures all available means of communicating are ready, optimized for the scenario at hand, and functioning properly. As applicable, set up the radios, ClearCom, tactical data links, mIRC, and telephones in accordance with communications contracts.

3.2.5.2.1 Radios. The ARC-210 is the MQ-9’s primary means of conducting aircraft deconfliction and tactical communication. All available ARC-210s (i.e., airborne ARC-210s and ground ARC-210s if cockpit is located within LOS of additional assets) should be checked in all modes as soon as possible. Unsecured communications should be checked shortly after gaining control of the aircraft from the LRE. Verify that secure voice works as soon as possible to allow time to troubleshoot any anomalies. When given the opportunity, check the ARC-210 across both frequency spectra (UHF/VHF) and both modulation patterns (AM/FM). If applicable, check the ARC-210 HAVE QUICK II (HQII) for proper functioning.

3.2.5.2.2 ClearCom, Audio MLS, or Similar. ClearCom is a commercial off-the-shelf (COTS) configurable fiber communications system that allows MQ-9 aircrew to communicate with other entities on the same network. Only cockpits resident to a single squadron (or possibly group) are likely connected via this system. However, AFSOC MQ-9 units and respective supported units are commonly connected via the same network. Low latency and clear communication makes either system very similar to normal intercom systems. See **Figure 3.2**, ClearCom.

3.2.5.2.2.1 MAIN. The top right knob controls the master volume. Generally, this should be set to the 12 o’clock position (middle).

3.2.5.2.2.2 VOL/PROG. The bottom right knob has multiple functions. It acts as a fine adjustment to the master volume and is used to adjust individual channel volumes. This is accomplished by pressing the knob in until it clicks once, then selecting the individual channel via the top green individual channel button, and then rotating the bottom right knob to adjust that specific volume. The knob also has additional functionality as a scroll wheel for the settings interface (accessible via pressing the number 7 on the keypad).

Figure 3.2 ClearCom.

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3.2.5.2.2.3 Transmit/Receive. To select and deselect which channels are receiving or transmitting, select or deselect the green (receive)/red (transmit) buttons corresponding to the channels desired. To select, quickly tap the button once. The button should light up and remain bright for a visual confirmation that the channel has been selected. To transmit/receive temporarily only, press and hold the button. When released, the channel will automatically deselect and the button will return to dim. In some squadrons, additional channels are available that are not listed on the main display. To access these, press the number 6 on the keypad. The next button press of number 0 through 9 will select the corresponding page of channels, if available.

3.2.5.2.3 Tactical Data Links. A large percentage of mission-related SA will come through TDL injects on the TacSit display. See **Chapter 10**, "Tactical Tools," for complete MQ-9 TDL capabilities. Verify aircraft surveillance tracks are present on the TacSit display and proper track correlation. Check J3.5 publishing capability by creating a corellator tracker track number (CTTN), publishing it to the network, verifying a joint track number (JTN) is assigned to it and then DROPPING it. Verify J28.2 message functionality with a test with TAC C2. If link connectivity is lost, contact the applicable communications representative.

3.2.5.2.4 Multi-User Internet Relay Chat (mIRC). mIRC is a cockpit-based communication text chat program, authorized for use on most classified networks, and can be set up and used prior to establishing link with the aircraft. Verify connectivity on the correct servers and that the correct nickname (i.e., call sign) is set in the Status window. Open mission-applicable chat rooms and conduct coordination when required. As a technique, set mIRC on the HUD-side of the lower auxiliary monitor with the primary chat rooms tiled closest to the HUD. This enables peripheral vision to notice movement in the chat rooms (i.e., new messages) while keeping the main cross-check on the HUD. Setting highlights, alerts and color schemes can aid in an effective and efficient mIRC cross-check.

3.2.5.2.5 Telephone. The telephone should be verified operational and encryption cards installed as required for the classification level and type of phone. Move the telephone as required for additional space on the center console.

3.2.5.3 Engage. This step configures and prepares the MQ-9's weapons and attack systems for employment. It includes SMS, HUD, TGP, Laser, RMIT, GWTS/GBIT and any other mission execution software setup.

3.2.5.3.1 Stores Management System. If not already accomplished by the LRE, inventory and verify the SMS after gaining the aircraft. Once verification is complete, check the Status page for any warnings. Go to the Air-Ground page and select the AGM-114 on the Select Store tab first to start the power-up and built-in-test (BIT) sequence for the M-310 rail and AGM-114s. Step through the tabs top-to-bottom and left-to-right to configure the weapons release settings, fuze options, PRF, and AGM-114 launch profile IAW RMIT and **Chapter 6**, "Basic Weapons and Employment Tools." If carrying GBU-38/49/54, select a GBU-38 JDAM, GBU-49, or GBU-54 LJDAM to power on and run internal BIT tests. After BIT, navigate to launch status page and observe transfer alignment (TXA) quality directly next to the "Ready to Release" status. Perform a series of S-Turns in order to drive down the TXA quality from 10 to 1 on either the GBU-38/49/54 then leave the weapons powered on. Cycle through each weapon type on the Launch Settings tab to verify status of a full stack of green containers with acceptable red containers (e.g., Master Arm Off with the master arm in the SAFE position).

3.2.5.3.2 Heads-Up Display. Switch the HUD from Navigation mode to Air-to-Ground (A/G) mode and turn on steering line caret and weapons graphics. Ensure the HUD reports A/G data appropriately, especially ranging data, weapons engagement zone (WEZ) data, and steering line cues.

3.2.5.3.3 Targeting Pod. The SO should always optimize the TGP picture for the desired effect. During the FENCE check, this is accomplished by establishing baseline settings and checking for TGP limitations and malfunctions. The SO should set up manual pictures for each camera and rate gain setting as described in the latest versions of the *MQ-9 AN/DAS-1 Sensor Handbook* and squadron standards. Finally, the SO should assess and correct any TGP drift or other anomalies.

3.2.5.3.4 Laser. Check laser range designator (LRD) and laser target marker (LTM) functionality. Coordinate with the pilot and sanitize the ground prior to firing the LRD and LTM. Verify proper lasing indications are present when checking the LRD. Verify LTM alignment and functionality of LTM blink modes if conditions are suitable for low-light television (LLTV) or shortwave infrared (SWIR) (if equipped). Enter the appropriate PRF in accordance with anticipated weapons deliveries or squadron standards and safe all systems.

3.2.5.3.5 R-Missile Impact Tool (RMIT). RMIT should be used for initial minimum and maximum WEZ numbers and the real-time footprint display. Input current or expected parameters to generate the WEZ and desired release (opt dot) for SMS input. Click on the aircraft tail number and select watch selection and verify watching is added to the aircraft tail number and disabled is removed from the real-time footprint tab. Set the display options to display preferred data on real-time footprint, set the "Hack Time," and move the RMIT Display so it is easily visible on an auxiliary screen.

3.2.5.3.6 GBU Bomb Impact Tool and GWTS. Open GBIT and/or GWTS and input the current or expected parameters and generate the zone and range launch acceptable release (LAR) distances for release. Move the GBIT and/or GWTS Display so it is easily visible on an auxiliary information display.

3.2.5.4 FENCE Check Flow. A logical flow to the FENCE check aids in efficiency and effectiveness when done correctly. There are slight differences between the pilot and SO FENCE check flows as each crew member has different priorities and considerations to maximize efficiency.

3.2.5.4.1 Pilot FENCE Check Flow. The FENCE check flow starts prior to sitting in the seat for a gaining handover or prior to a crew changeover. Items on the MFWs and center console should be set first and an ops check completed if link is already established with the aircraft. Once in the seat, the first priority is current aircraft parameters followed by the lost link profile. After the lost link profile is updated, stay on the tracker display to complete required items and then move to one of the auxiliary screens to set up mission execution software programs. Once items on the auxiliary screen are set, move to the HDDs to verify applicable systems and set up the SMS. If equipped, check the SAR functionality by commanding a 3M spot image and a GMTI command to complete the FENCE check. See **Table 3.2**, Pilot FENCE Check Itemized Flow, for suggested items to hit.

3.2.5.4.2 Sensor Operator FENCE Check Flow. The FENCE check flow starts prior to sitting in the seat for a gaining handover or prior to a crew changeover. Items on the MFWs and center console should be set first and an ops check completed if link is already established with the aircraft. Once in the seat, the general flow goes top-to-bottom and left-to-right. Start in IR and slew the TGP to the anticipated slant range that the mission will be primarily executed at ± 2 NM, and if possible, a similar target scene. Zoom in to narrow (NAR) field of view (FOV) and command a NUC 3. While the TGP is NUCing, move to the tracker display and set up all applicable FENCE items moving from the left to the right across the tracker drop-down menus. Once complete with tracker display items, and NUC is complete, move to the HUD and move TGP slant range within ± 2 NM of expected slant range on target, zoom in to ultra-narrow (ULTN) and command an additional NUC 3. While NUCing, set up applicable TGP toolbar items by moving left-to-right across the toolbar and move to the right HDD once complete. On the right HDD, begin with the top left menu and move left to right through the menus setting up applicable FENCE items. Next, set up the lower-right auxiliary monitor, radios/intercom and finish the FENCE check flow by setting-up the applicable manual IR/DTV/LLTV or SWIR (if equipped) pictures and testing the LRD and LTM. See **Table 3.3**, SO Fence Check Itemized Flow, for suggested items to hit.

3.2.5.5 Prioritized FENCE Check. Unforeseen tactical events may occur shortly after takeoff, gaining the aircraft, or crew changeover that may require immediate sensor and/or weapons employment. To prepare for immediate engagement use the following flow. These steps can be summarized with the mantra of Kill, See, Cleanup.

3.2.5.5.1 Kill. Kill includes all FENCE items required to effectively employ weapons from the aircraft. The pilot priorities are current aircraft parameters, communication and SMS setup. The SO priorities are to immediately establish a usable picture with appropriate slew control settings and ensure the LRD is ready for employment. Here are the specific items in the Kill portion of the prioritized FENCE check:

- Current aircraft parameters (P).
- HUD (P/SO).
- SMS (P).
- RMIT (P).
- GBIT (P).
- Usable picture (SO).
- LRD (SO).
- PRF (SO).
- Rate gain/deadband (SO).
- Radios/intercom (P/SO).

3.2.5.5.2 See. See includes FENCE items that enhance the battlespace picture for the crew and additional players. After the items from the Kill portion are complete, the See FENCE items can be accomplished as time permits and are related to the TGP, SAR, TacSit, and RVT. Here are the specific items in the see portion of the prioritized FENCE check:

- Optimized picture (SO).
- NUC (SO).
- Fusion (SO).
- TacSit Display (P/SO).
- TDL (P).
- ACO (P).
- AV transmitters/RVT/VORTEX (P/SO).
- CLAW/SAR (P/SO).

Table 3.2 Pilot Fence Check Itemized Flow.

MFWs prior to sit-down/crew changeover.
- VIT repeaters.
- In-flight Ops check.
- Whiteboard.
- CLAW.
- RMIT.
- GBIT.
- Framegrabber.
- Additional mission execution software (e.g., planning tool).

Center console prior to sit-down/crew changeover.
- Ground radios.
- Radios/Intercom.
- KY-100.
- Telephone.

HUD/Current Aircraft Parameters.
- A/C airspeed, altitude, and position.
- Hold modes status.
- Throttle quadrant status (speed lever, throttle, condition lever, flaps).

Tracker display.
- Emergency mission.
- ARC-210.
- IFF.
- RL rate select.
- Encryption key settings.
- AV transmitters.
- Control point.
- Coordinate system.
- Generic payload config A/R.
- Main auxiliary display.
- TacSit display.
- ACO.
- TDL.
- mIRC.

Right HDD.
- Lights.
- Pilot heat.
- Altimeter.
- HUD display.
- Clocks.
- SMS displayed.
- MSA.
- Initial lost link altitude (ILLA).
- Initial lost link heading (ILLH).

Left HDD.
- SMS.

Lower center auxiliary display.
- SAR (if equipped).

OVERALL NOTE:

* Locations of items on auxiliary displays can be set differently in accordance with unit standards.

Table 3.3 SO Fence Check Itemized Flow.

HUD.
- Slew to desired slant range, NUC as required.

Tracker Display.
- Maps loaded.
- Current emergency mission loaded.
- Lynx SAR interface.
- Collection list.
- Coordinate system.
- Control point.

HUD.
- Rate gain.
- LTM/LRD.
- Text graphics.
- Polarity.

HDDs.
- Display control.
    - Headsup.
    - VIT 18 check current Emer Msn.
    - Coordinate system A/R (only for cockpit graphics).
- Other switches.
    - IR beacons A/R.
- Payload and frequency control.
    - Airborne Video Mux—Set 1, 2, 1, 2.
    - TGP Source—A/R.
    - Video sensor payload menu.
        - IR control Menu—Gain/level settings.
        - DTV control Menu—Contrast/brightness settings.
        - Laser Menu—PRF code, LTM selection.
        - Functional Bit's—A/R.
    - LYNX SAR Menu—Enable external SAR control.
- Configuration.
    - Chart recorder configuration—Set to 18.
    - Log Flight Data—On.
- Diagnostics.
    - Deadband Set A/R.
    - DGCS Console Logger—On.
    - Calibrate touch screens A/R.

Lower Right Auxiliary Monitor.
- mIRC.
- TacSit display.
    - ACO.
    - TDL.

Center Console.
- Radios/Intercom.
- Telephone.

HUD.
- Set up manual DTV/IR/LLTV/SWIR pictures A/R.
- Verify LRD/LTM functionality.

3.2.5.5.3 Cleanup. Cleanup includes the remaining FENCE items that are not critical to the success of immediate employment or battlespace awareness. They should be accomplished as time permits after the Kill and See portions of the prioritized FENCE check are complete. The tactical situation at this point should allow sufficient time for the standard pilot/SO FENCE check to be accomplished. Reference remaining items from pilot/SO FENCE check flow.

3.3 Aircraft Handling Characteristics. The MQ-9 aircraft handling characteristics, climbs/descents and turns, vary due to the different autopilot hold modes, autopilot safety features and autopilot preference modes.

3.3.1 Autopilot Hold Modes. The MQ-9 has three autopilot hold modes that control aircraft heading, altitude, and airspeed. Commanding an autopilot hold mode on will set and maintain the current corresponding aircraft parameter into the hold mode. For further descriptions of each autopilot hold modes and standard up, reference TO 1Q-9(M)A-1 or applicable ASI and squadron standards.

3.3.2 Climbs/Descents. Climbs and descents can be accomplished with altitude hold modes on or off.

3.3.2.1 Altitude Hold On Climbs/Descents. Altitude hold on climbs/descents leave the altitude changes to the autopilot to fly the commanded climb/descent rate, airspeed, and level off at the newly commanded altitude. To execute climbs and descents using the autopilot function, ensure the commanded vertical velocity indicator (VVI) is updated in the HDD and then enter the new altitude. Before continuing to the next task, monitor VVI, airspeed, and altitude on the HUD to ensure the aircraft is responding appropriately to commanded altitude change.

3.3.2.2 Altitude Hold Off/Airspeed Hold On Climbs/Descents. When altitude hold is off and airspeed hold is on, the autopilot is no longer in a preference mode and will solely prioritize airspeed commanding a pitch to climb or descend the aircraft. To execute a climb, increase to full throttle. Conversely, if the throttle setting is decreased or the commanded airspeed increased, the aircraft will pitch-down and a descent is initiated. When at 10 percent of VVI from desired altitude, reverse the throttle and set 30 percent and adjust as required to maintain level flight.

3.3.2.3 All Hold Modes Off. To execute a climb without the aid of the autopilot, begin by annotating the pitch and power setting required to maintain level flight. To climb, increase the throttle to max power and command three degrees nose high pitch. To level off at desired altitude, when approaching 10 percent of VVI from desired altitude, slowly reverse the throttle back to level pitch and power setting (approximately 30 percent) and decrease pitch until established at new altitude. To descend, set flight idle and command a three degree nose low attitude. To level off, execute the opposite actions accomplished to level off from a climb. Use the flightpath marker (FPM) to assess deviations from level flight.

3.3.2.4 Gradual Rate Descent. In order to mitigate the aircraft's audible signature during a close pass, or reduce fuel burn during the descent, a gradual rate descent may be required. In order to accomplish a gradual rate descent, complete the following steps.

3.3.2.4.1 Step 1—when the decision has been made to execute a gradual rate descent, set the Power Lvr Cmd to 4 percent.

3.3.2.4.2 Step 2—set airspeed hold to Stall + 15 KIAS (legacy tail), or Stall + 22 KIAS (ER).

3.3.2.4.3 Step 3—disengage altitude hold. This should result in a VVI of approximately 600 to 900 feet per minute (fpm) for an MQ-9 between 7,500 to 8,500 pounds total AV weight, or a VVI of approximately 1,000 to 1,500 fpm for an MQ-9 with a total AV weight of 8,500 pounds or more. To minimize audible signature, disengage altitude hold at the minimum standoff range while inbound to target area.

3.3.2.4.4 Step 4—if time permits, use the descent rate to calculate the anticipated altitude loss during the actual maneuver, use typical ROT in "disengage altitude hold," above.

3.3.2.4.5 Step 5—prior to reaching the desired altitude, reengage altitude hold and command the desired altitude in the HDD. To minimize audible signature, it is recommended to turn parallel the target with the aircraft at minimum standoff range or greater before throttling up to deflect audible signature away from target away after having completed the maneuver.

3.3.2.5 Max Rate Descent. A max rate descent is designed to accomplish a descent faster than an altitude hold on descent provides. The pilot should use it as needed to deconflict from factor traffic, avoid weather, facilitate a losing handover, and to increase effectiveness during threat reactions. To accomplish a max rate descent, accomplish the following steps in order.

3.3.2.5.1 Consideration: If time and conditions permit, coordinate with other assets in the stack, update emergency mission, and set up the TacSit display prior to executing this maneuver.

3.3.2.5.2 Consideration: If time and conditions permit, reduce indicated airspeed (IAS) to stall +10 prior to executing this maneuver to maximize the aircraft descent throughout a longer period of time.

3.3.2.5.2.1 Step 1—command landing configuration.

3.3.2.5.2.2 Step 2—pull throttle to idle.

3.3.2.5.2.3 Step 3—pitch aircraft down to 10 to 15 degrees nose low attitude and trim out control stick pressure.

3.3.2.5.2.4 Step 4—When 1,000 feet above desired altitude and current VVI is greater than or equal to -5,000 FPM, pull up as required to reduce the descent rate so the HUD depicts actual VVI, typically 6 to 9 degrees nose low.

3.3.2.5.2.5 Step 5—begin level off at 10 percent of indicated vertical velocity above desired altitude by smoothly pulling-up and increasing power to approximately 25 percent.

3.3.2.5.2.6 Step 6—Time permitting and as desired, once established at new airspeed and altitude, enable altitude hold to capture current settings and return to "hand flying."

3.3.3 Turning. Taking into consideration performance characteristics of the MQ-9 as well as satellite limitations and autopilot parameters, there are costs and benefits to each type of turning technique. As an ROT, every 30 knots of tailwind/headwind increases/decreases the turn radius by 0.25 NM. The tactical situation will dictate the required MQ-9 turn performance, and the pilot will have to choose between hand-flying the aircraft, trimming in turns, turning with heading hold, and using an operational mission. Use the techniques, in **Table 3.4**, MQ-9 Turn Radius as a Function of Airspeed, and **Table 3.5**, Aircraft Turning Techniques, to execute and weigh these options.

Table 3.4 MQ-9 Turn Radius as a Function of Airspeed.

KTAS	Bank Angle (degrees)	Radius (km)	Radius (NM)	Rate (degrees per second)
140	10	3.0	1.6	1.4
	14	2.0	1.1	2.0
	20	1.5	0.8	2.8
	30	0.9	0.5	4.5
	35	0.7	0.4	5.5
	40	0.6	0.34	6.5
160	10	3.9	2.1	1.2
	14	2.8	1.5	1.7
	20	1.9	1.0	2.5
	30	1.2	0.65	3.9
	35	1.0	0.53	4.8
	40	0.8	0.44	5.7
180	10	5.0	2.7	1.1
	14	3.5	1.9	1.5
	20	2.4	1.3	2.2
	30	1.5	0.8	3.5
	35	1.3	0.7	4.3
	40	1.0	0.56	5.1
200	10	6.1	3.3	1.0
	14	4.3	2.3	1.4
	20	3.0	1.6	2.0
	30	1.9	1.0	3.2
	35	1.5	0.83	3.8
	40	1.3	0.7	4.6

Table 3.5 Aircraft Turning Techniques.

Holding Technique	Advantages	Disadvantages	Tactical Application
Hand Fly	• Near instantaneous aircraft control • More precise aircraft placement • Capability to max perform the aircraft	• Increased pilot workload • Smooth control inputs are imperative	• Weapons Employment • Dynamic Situations • Minimize rage change in hold
Heading Hold	• Increased multitasking • Precise drift correction	• Time delay when trimming in new heading • Aircraft turn directions is unpredictable at near 180-degree turns	• Operations in strong winds • Moderate to high admin workload
Trim-in Turn	• All advantages of hand flying • Slightly increased multitasking	• Potential to overturn aircraft • Pilot must remember rezero trim	• Precise holding required • Low to moderate admin workload
Operational Mission	• Increased multitasking • Precise flightpath control	• Operational mission creation is often time consuming • Operational mission mistakes can cause airspace/ altitude deviations • Lack of immediate aircraft control	• Precise or complex flightpath required • High admin workload
Direct To	• Quick application • Flies wind-corrected heading to point	• Does not warn or change course after reaching waypoint • Must clear flightpath for restricted airspace	• Long transit legs
Point and Click Loiters	• Quick application • Less formatting required than an op mission	• Easy to cause altitude deviations • Reduced functionality compared to op missions	• Temporary loiters for planning or transit pauses

3.3.3.1 Hand-Fly. Hand-flying the aircraft is defined as airspeed hold-ON, altitude hold-ON and heading hold-OFF. This allows the pilot instant control of the aircraft to turn while the autopilot maintains the desired airspeed and altitude. Smoothly move the control stick in the direction of the desired turn and establish approximate bank using the bank indicator in the HUD. If specific bank angle is required, then cross-check VIT 99's "Roll Stick" to refine the bank angle. To maintain a turn/bank while hand-flying the aircraft, the control stick deflection must be held throughout the turn as the aircraft will roll out of bank when the control stick is centered. Roll out of the turn in the same manner as rolling into a turn.

3.3.3.2 Trimmed Turn. A trimmed turn is executed when the pilot is hand-flying the aircraft and placing the aircraft in the desired bank angle while cross-checking the Bank/Roll Indicator at the bottom of the HUD and VIT 99. Place the commanded bank at the approximate desired bank angle then cross-check VIT 99 to refine if specific bank angles are required. Depress and hold the trim button on the control stick, return the stick to the neutral position, and release the trim button. The "Roll Stick" on VIT 99 will remain at the set bank angle. To roll out of a trimmed turn, smoothly move the control stick in the opposite direction of the indicated bank on the HUD towards the center of the roll scale and cross-check the "Roll Stick" value until it is approximately 0 degrees on VIT 99. Then depress and hold the trim button on the control stick, return the stick to the neutral position, and release the trim button. Once rolled-out, either turn-on heading hold to maintain the current heading, or cycle heading hold on and back off to zero-out any unintended control stick bank angle inputs.

3.3.3.2.1 "Roll Stick Inputs" of less than 5 degrees will typically not induce a link hit when cycling heading hold in order to zero-out "Roll Stick." If in a continuous trimmed turn for repeated 360-degree turns, manage wind drift by determining wind direction and speed from the tracker display, and temporarily rolling out on each turn to point the aircraft directly into the wind. With winds at or below 60 knots, the time required driving upwind to neutralize drift and maintain the same ground track is approximately 1-second/knot of wind.

3.3.3.3 Heading Hold. Heading hold is executed similar to hand-flying with the addition of heading hold-ON. Manipulate the control stick left or right and cross-check the compass rose on the Tracker Display. Once the purple tic mark is located in the approximate direction depress the trim button on the control stick and monitor the aircraft turn for expected turn indications. If refined headings are required, specific heading can be input using the HDDs under the Heading Hold menu path.

3.3.3.4 Direct To. To enable this technique, right-click on the map location on the tracker display and select "Direct To."

3.3.3.5 Operational Missions. This technique includes flying a manually created mission or loading a prebuilt mission.

3.3.4 Speed Lever Manipulation. The aircraft speed lever controls engine speed and consequently propeller speed. Inflight manipulation of the speed lever is used for fuel conservation measures and for ensuring maximum aircraft performance during airspeed and altitude changes.

3.3.4.1 Fuel Conservation Measures. When single redline exhaust gas temperature (SEGT) drops below 500 degrees C, slowly retard the speed lever until the SEGT reaches 550 degrees C. As fuel is burned, this process can be continued. Reducing the speed lever effectively leans out the engine. This technique allows for economic fuel consumption, while still allowing for anomalous performance requirements without unintended descent. ***Note:*** advance the speed lever prior to transit or climbs to inadvertently restrict aircraft engine performance.

3.4 Basic Aircraft Maneuvering. Basic aircraft maneuvering incorporates the aircraft handling characteristics to specifically maneuver the aircraft to achieve a desired effect. The MQ-9 basic aircraft maneuvers include holding, nadir, close pass, and energy management.

3.4.1 Point-to-Point Navigation. Point-to-point navigation is defined as the process to take the aircraft from its current position and placing it in another location, accurately and expeditiously. The transit to the target and/or desired hold location should be as direct as possible, within applicable restrictions. Exchange fuel for additional speed to transit expeditiously to get to the target area, time-critical taskings, or desired hold location. During transit, speed up the aircraft to transit speeds if the target is outside of 10 NM. A good rule of thumb is 165 KTAS, but for longer transits, reference the performance charts in the 1-1 for best endurance speeds. Plot and label the new target in the TacSit display in order to enhance SA of the airspace restrictions en route. Modify the routing if the direct route takes the aircraft through airspace coordination measures, restrictions, insufficient terrain clearance, threats and/or hazardous weather. The emergency mission should be updated to reflect the desired routing and the start point kept up-to-date inside cleared airspace while in transit.

3.4.1.1 Control Point (CP) Navigation. The CP tool on the tracker display provides the pilot with aircraft navigation and timing solutions. For targets not near current location or current working area, plot the CP at the desired location and match the aircraft "Course" and the "Heading to CP" on the tracker display to track directly to the new target. The CP data on the tracker display will also provide an estimated time of arrival (ETA) that can be relayed to the SO and if required, applicable supporting assets. ETA is most accurate when pointing at the target with a wind drift corrected heading established. Alternatively, it is permissible to use the Direct To function to consistently fly a course-corrected heading, regardless of changes in crosswind component throughout the transit.

3.4.1.2 Operational Mission Transits. Operational missions are opportune for long transits. When maneuvering amongst terrain or restricted airspace, ensuring the aircraft adheres to a specific flightpath is recommended. Create an operational mission which avoids conflicting terrain and restricted airspace by plotting in the TacSit and transferring points to the tracker display. Depending on the level of precision required, plot directly on the tracker display. Additionally, consideration needs to be paid to how the aircraft will maneuver in a lost link scenario. Use Lost Link-OK waypoints when transiting through areas requiring strict adherence to the flightpath. When aircraft maneuvering is permissible, ensure that the corresponding waypoints are set Lost Link-Not OK. The emergency mission waypoints should mirror the locations of the operational mission's waypoints. As the aircraft progresses through the transit, update the emergency mission entry waypoint to lead the aircraft. When the aircraft is progressing through a series of Lost Link-OK waypoints, the emergency mission entry waypoint should be set to the same location as the next operational mission Lost Link-Not OK waypoint. This methodology ensures that the aircraft does not engage in undesired maneuvering, putting the aircraft in a dangerous situation.

3.4.1.3 Direct To. Direct To is another technique for accomplishing long transits. This technique will fly a wind corrected heading directly to a point, user-defined, on the tracker display. The pilot can enable this feature by right-clicking on the map in the tracker display and selecting “Direct To.” After the initial engagement by the pilot, the pilot/sensor operator (PSO) and aircraft can take up to 8.67 to 10 seconds to make its initial turn toward the indicated point. Once the aircraft reaches the pilot-defined navigation point, there is no warning or indication the aircraft has reached the point and the “Direct To” function will remain enabled. Also, the aircraft will continue to fly the previous wind-corrected heading past the point. To combat this, pilots should use the control point method above and communicate an ETA to the defined point with the SO. Additionally, the point should disable Direct To approximately 1 to 2 NM prior to reaching the defined point to ensure required aircraft handling.

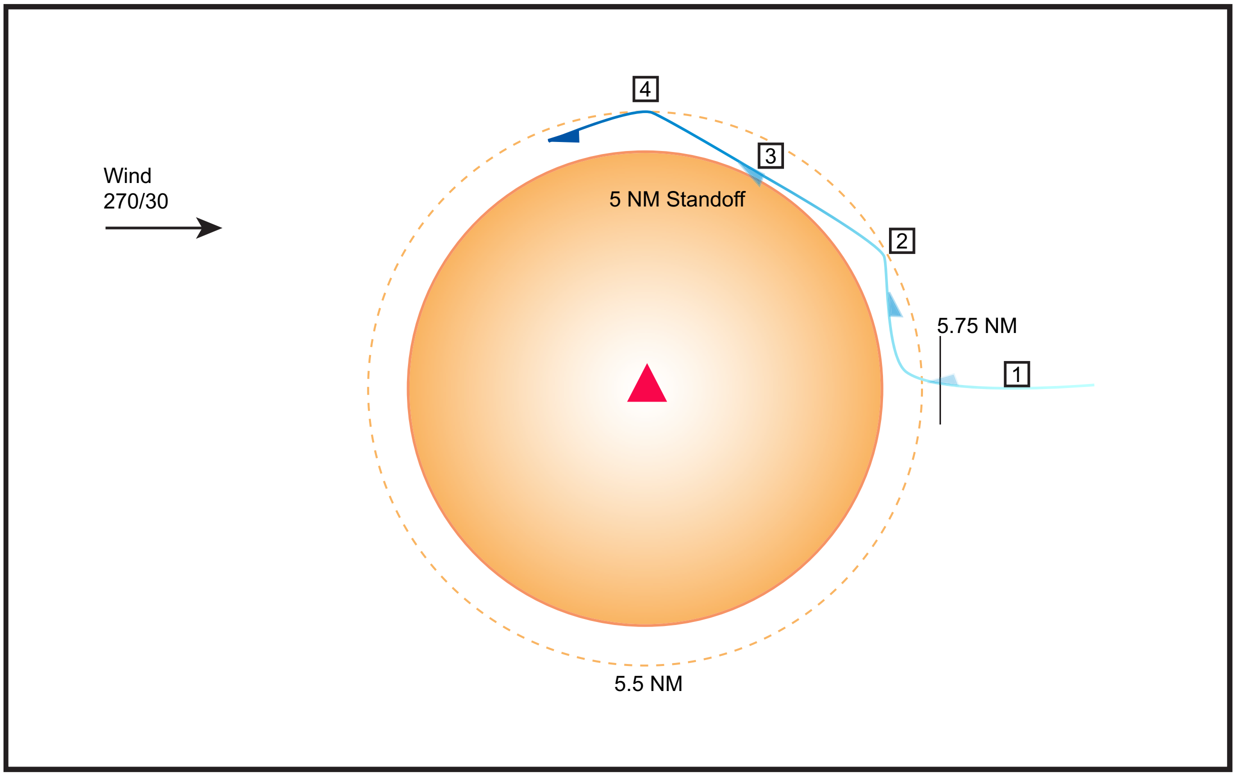
3.4.2 Holding. It is critical to optimize the balance between high-quality FMV and standoff, regardless of the reason for the standoff. Although any of the aircraft handling techniques can be used, the most effective holding is accomplished with heading hold off (with or without trim-in turns) at stall speed plus 15 KIAS (Legacy) or 22 KIAS (ER), minimum. Plan on using a minimum of 30 degrees of bank to expedite turns, if Ku SATCOM limitations allow. For all holding patterns, wing masking is a potential factor at increased slant ranges and decreased depression angles, but should be given greater consideration at low altitudes. Unless otherwise noted, all basic holding pattern examples that follow assume no winds; pilots must adjust the ROTs presented for any winds to ensure precise holding is achieved. A recommended technique is to start with a conservative distance from desired standoff until the wind conditions have been fully assessed. Aircraft positional awareness is required to fly the four basic hold patterns of the Wheel, Figure Eight, modified Figure Eight, and Racetrack.

3.4.2.1 Positional Awareness. This can be provided through the use of TGP graphics, TacSit display, and the tracker display. With crosshairs on the target, use TGP graphics in the HUD or VIT 99 to determine range and bearing to the target. Use the TacSit display for trend analysis and spatial awareness of other factors where the TGP is not currently looking. TacSit displays have an inherent delay and should not be used for a precise cross-check of aircraft position. If crosshairs are off the target, use the tracker for real-time positional SA. One technique is to place an operational mission with a circular loiter around the target for reference use. Pilots must realize that the input loiter range is a radius from the center point and should double the distance input into the operational mission loiter for accurate ground distances. The circle tool is another acceptable technique manipulated in the same manner as operational mission loiters. Finally, the CP can be used, if accurately placed on the target coordinates, to position at an appropriate standoff. Regardless of the technique, if maintaining a specified slant range, crews must translate to the correct ground range based on height above target (HAT) prior to placing a loiter on the tracker; using the planning tool is one way to make this conversion.

3.4.2.2 Wheel. A Wheel is a circular hold pattern centered on the target area. Wheel holding is simple to fly and provides SA on the target area from all aspects. TGP FOV changes and image manipulation are minimized due to a constant slant range from the target. Targets requiring a specific look angle or attack run-in can preclude the use of a Wheel pattern. To execute a Wheel hold, the pilot must set up and then enter and maintain the hold pattern and standoff.

3.4.2.3 Wheel Setup. Once passed a target location and desired standoff, battle track the target and set the desired minimum/maximum hold ranges in the TacSit display. If the crews' objective is to maintain standoff +0.5 to -0 NM, minimum range would be the desired standoff range (translated to ground range) and maximum range would be standoff +0.5 NM. After battle tracking is complete, compute the aircraft's distance to the target. If still several miles away, turn to place the target on the nose, check the tracker for current winds, and calculate the range at which to initiate the turn into holding. See **Figure 3.3**, Wheel Holding.

Figure 3.3 Wheel Holding.



EXAMPLE: An MQ-9 is 10 NM east of a new imagery intelligence (IMINT) tasking with a 5 NM directed standoff. After plotting the start grid on the TacSit display, the pilot turns to put the target on the nose while the SO gets crosshairs on the target. The pilot increases airspeed to 110 KIAS (140 KTAS) and sees on the tracker that winds are 270/30. According to **Table 3.4**, MQ-9 Turn Radius as a Function of Airspeed, a 30-degree bank turn at 140 KTAS yields a 0.5 NM turn radius. Using the wind ROT, 30 knots of headwind will shrink the radius by an additional 0.25 NM. With the target at 0 degrees azimuth, the pilot knows that the TGP range can decrease to 5.75 NM before initiating the turn into holding to meet the 5.0 to 5.5 NM objective range.

3.4.2.3.1 Entering and Maintaining the Wheel. Turn into the wind using 30-degrees angle of bank minimum. Initiate rollout as TGP azimuth increases through 75 degrees. The goal is to catch 90 degrees azimuth within 0.5 NM of the standoff range. Once established at 90 degrees, move cross-check between range and azimuth. Use 5 degrees of bank either toward or away from the target to keep azimuth between 80 degrees and 100 degrees and range between standoff and standoff +0.5 NM.

EXAMPLE: After the MQ-9 rolls out from its turn into holding, the pilot sees -92 degrees azimuth and 5.25 NM slant range. The pilot flies straight-and-level until either the azimuth reaches -100 degrees or the range reaches 5.4 NM, at which point initiate a 5-degree left bank into the target. The pilot holds this bank until azimuth decreases to -80 degrees and then rolls out, observing the range decrease as the azimuth starts to increase again. If the range decreases to 5.1 NM, the pilot initiates a 5 degrees right bank away until azimuth passes 90 degrees and the range starts to increase.

3.4.2.3.1.1 Wind Considerations. The above values will change with aircraft crab due to winds. The “steady-state” azimuth, where range is neither increasing nor decreasing, will be 90 degrees for a direct head- or tailwind, but will fluctuate as the crosswind component increases. A ROT for estimating amount of azimuth offset from 90 degrees required is for every 30 knots of direct crosswind, use 10 degrees of azimuth change into the wind. The basic relationship and cross-check between azimuth and range should continue. After the ROT is applied, if range is increasing, then decrease azimuth. If range is decreasing, then increase azimuth.

3.4.2.4 Figure Eight. A Figure Eight is typically flown from a designated point off the target area with turns primarily into the wind. Figure Eight holding is used when geographic borders, weather or terrain are limiting, or when a specific look angle is desired/required. It allows for a consistent look angle throughout maneuvering. The pilot should establish a holding area based on the desired effects (e.g., 5 NM, East to West look, ±30 degrees, centered on a 270-degree run-in at 1+00 time to release). To maximize time spent at the desired hold range, the pilot should execute turns into the wind. If turns cannot be made into the wind, the pilot will have to adjust the hold to account for the increased turn radius. Sensor operators can expect increased TGP FOV and image manipulation proportional to the variance in slant range.

3.4.2.4.1 Entering Holding and Maintaining Standoff. The pilot should enter holding at the desired holding point using the same methods described for Wheel holding. The Figure Eight pattern requires the pilot to execute turns for a significant percentage of the hold. The pilot needs to calculate a lead bearing to begin the turn to keep the aircraft in a precise airspace location for turns into and away from the target.

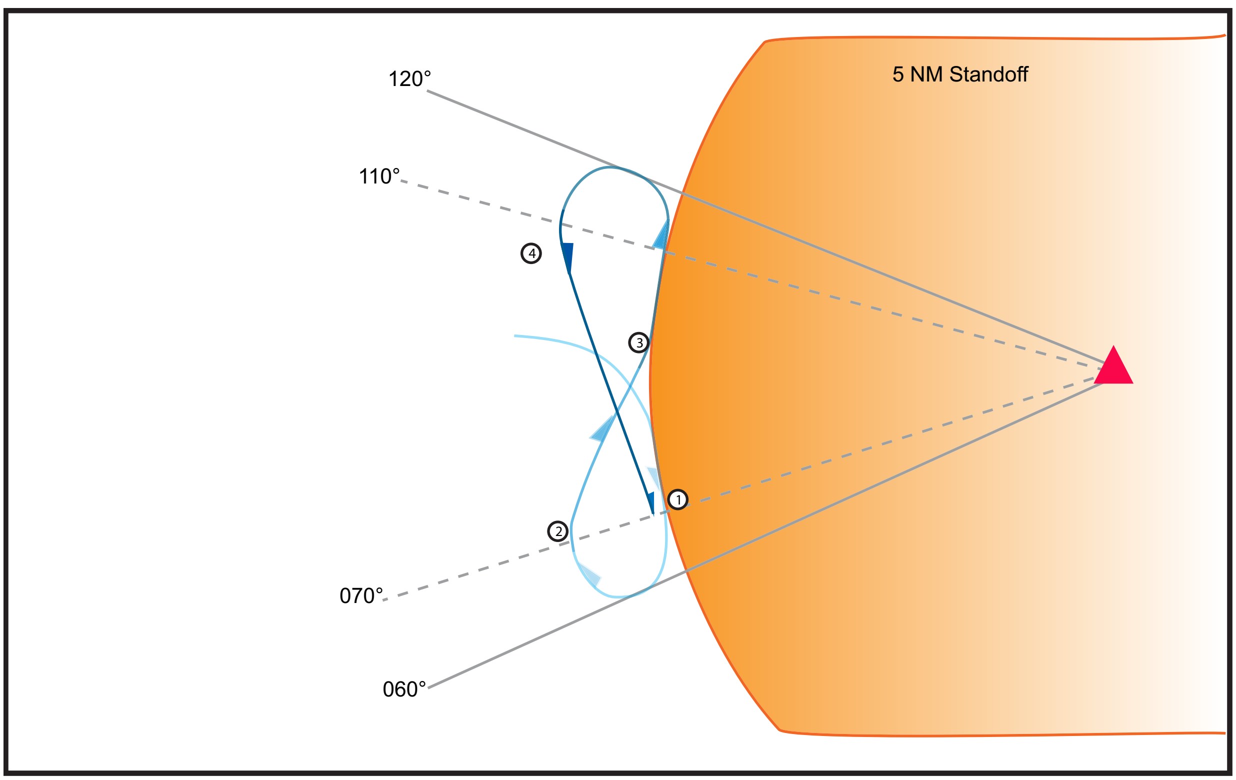
3.4.2.4.1.1 Lead Radial Calculation. Use the flight performance figures from **Table 3.4**, MQ-9 Turn Radius as a Function of Airspeed, and the 60-to-1 rule to calculate a lead radial. For example, on an East to West look within 30 degrees, the turn radius is 0.5 NM and range is 5 NM. 60-to-1 indicates that there are 12 radials per mile at 5 NM, so the aircraft will need 6 radials to complete a turn. Rounding this to 10 radials accounts for delays in rolling into and rolling out of bank. The current radial is displayed as “BRG” in the lower right corner of the TGP graphics.

3.4.2.4.1.2 Turns Away from the Target. If restricted to the upwind side, a turn into the wind will be away from the target. Once the initial turn into holding is complete, the pilot should arc the target at the minimum desired range until reaching the lead radial. Initiate an outbound turn using a 30 degree bank turn through 180 degrees of heading change, to approximately ±70 degrees azimuth. Check aircraft heading on the HUD and hold this heading until intercepting standoff or crossing the opposite lead radial. If the aircraft intercepts the standoff first, the next turn should be executed to roll out at approximately ±75 degrees azimuth. Conversely, if the aircraft crosses the lead radial before getting to the minimum desired range, adjust rollout to ±65 degrees azimuth.

EXAMPLE: The pilot establishes a 5 NM standoff and a hold area with a West to East look ±30 degrees. See **Figure 3.4**, Figure Eight—Turns Away From the Target.

- The pilot establishes an arc Southbound cross-checking the TGP bearing until reaching a bearing of 50 degrees.
- The pilot turns away from the target using 30 degrees of bank and rolling out to establish 70 degrees of azimuth.
- Continuing on the same heading, the pilot intercepts the standoff prior to a bearing of 110 degrees and arcs until reaching this point.
- The pilot turns away from the target again, this time establishing -75 degrees of azimuth.

Figure 3.4 Figure Eight—Turns Away From the Target.



3.4.2.4.1.3 Turns Into the Target. If restricted to the downwind side, turns will be into the target. The pilot needs to build enough turning room to ensure standoff is not violated during the turn. A full turn diameter is required (i.e., two turn radii) for sufficient turning room. In the example, 1 NM would be needed (no wind). The initial turn into holding should be made near the planned boundary of the hold to roll out at approximately ±110 degrees of azimuth. Cross-check and continue on the established aircraft heading to allow the aircraft to build spacing/turning room. Similar to upwind holding, the turns should be executed at the lead radial prior to the planned hold boundary. The aircraft slant range should be greater than minimum standoff range + 1 NM before executing the turn inbound. Using the same correction techniques from turns away from the target, adjust azimuth as required to cross the lead radial when slant range is at least minimum standoff range + 1 NM.

EXAMPLE: The pilot establishes a 5 NM standoff and a hold area with an East to West look ±30 degrees.

3.4.2.4.1.3.1 Step 1—the pilot enters the hold from a 240-degree bearing and initiates a turn South, rolling out at 110 degrees of azimuth. Continuing on aircraft heading, the pilot cross-checks the TGP bearing and slant range until reaching a bearing of 290 degrees at a slant range of 6.5 NM.

3.4.2.4.1.3.2 Step 2—the pilot turns toward the target using 30 degrees of bank and rolling out to establish -105 degrees of azimuth.

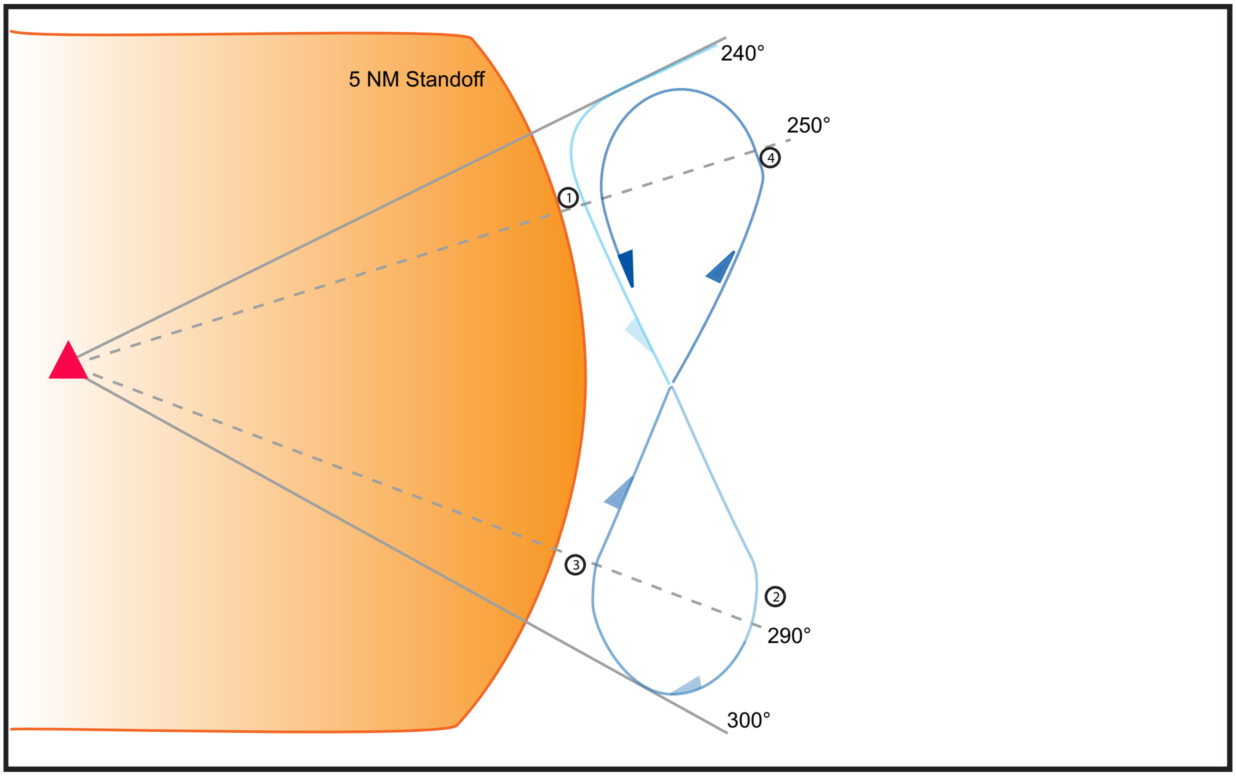
3.4.2.4.1.3.3 Step 3—the pilot cross-checks the slant range at 5.7 NM and realizes that the turn radius for current conditions is 0.8 NM. Continuing on the same heading, intercept a bearing of 250 degrees at 6.5 NM.

3.4.2.4.1.3.4 Step 4—from this point, the pilot continues to use ±105 degrees of azimuth to maintain the Figure Eight, but adjusts the position of the hold to move it closer to the standoff to improve collection. See **Figure 3.5**, Figure Eight—Turns Into the Target.

3.4.2.5 Modified Figure Eight. A modified Figure Eight is typically flown at a designated distance from the target area when the desired effects, geographic borders, or terrain do not accommodate a Wheel hold, but are not so restrictive that a Figure Eight is necessary. Hold with turns into the target or into the wind based on winds and target considerations. Modified Figure Eight patterns allow for long, straight or arcing legs at a set distance from the target area with minimal time in the turn. TGP manipulation is reduced during the time the aircraft is arcing the target.

3.4.2.5.1 Entering Holding and Maintaining Standoff. The pilot should enter holding along the desired holding arc using the same methods described for Wheel holding. Maintaining the hold involves using the above details for executing a Wheel hold along the allowable arc and incorporating concepts from the Figure Eight hold to maintain the planned holding area using turns into and away from the target.

Figure 3.5 Figure Eight—Turns Into the Target.



3.4.2.5.1.1 Turns Away from the Target. If restricted to the upwind side, a turn into the wind will be away from the target. Maintain the standoff arc until reaching the lead bearing/radial. Initiate a 30-degree bank turn away, holding the turn through 180-degrees of heading change until the azimuth reads 45 degrees. Hold this intercept heading until within minimum standoff range +0.5 NM and then maintain the arc as described in Wheel holding while flowing in the opposite direction to the opposing lead radial when the process repeats itself.

3.4.2.5.1.2 Turns Into the Target. If restricted to the downwind side, turns will be into the target. Similar to Figure Eight holding, the pilot needs to build enough turning room to ensure standoff is not violated during the turn. Using the same conditions as Figure Eight holding (1 NM turn diameter required), if the pilot simply establishes 110 degrees of azimuth and flies straight for 40 degrees prior to the lead radial, allows aspect and range to build, the range should increase at least 1 NM.

EXAMPLE: The pilot has calculated a 260-degree lead radial to initiate a turn to avoid masking. At 220 degrees bearing to the target, the pilot stops maintaining the arc and establishes 110-degree azimuth and flies straight. Approaching 260 degrees of bearing, the pilot confirms that range is at least 6 NM, and initiates a 30-degree bank turn into the target. See **Figure 3.5**, Figure Eight-Turns Into the Target.

3.4.2.6 Racetrack. A Racetrack hold contains two 180-degree turns in the same direction with straight legs between the turns, similar to the instrument holding procedure. It is used when a constant slant range for the TGP is not required or the priority (e.g., attack holding, SAR employment, airspace restrictions, etc.), as the range to the TGP sensor point of interest (SPI) will change more than in the other hold patterns. The orientation and length of the straight legs can be modified to meet the desired effect. If one of the straight legs of the hold is aligned with an anticipated flightpath once departing the hold (e.g., restricted run-in, ingress routing), the Racetrack is said to be on-axis. If the straight legs of the hold are not aligned with an anticipated flightpath once departing the hold, the Racetrack is said to be off-axis.

3.4.2.6.1 On-Axis Racetrack Hold. Set up the on-axis hold with the straight legs parallel with the desired flightpath once departing hold. The straight leg when on the desired run-in is referred to as the inbound leg, and the straight leg when on the reciprocal heading is referred to as the outbound leg. Choose an inbound point and outbound point in the hold that will be the ranges to initiate the 180-degree turn. The inbound point should account for the turn radius to prevent exceeding the minimum standoff range (e.g., minimum desired range in WEZ, minimum time on final, detection concern, etc.). The outbound point should also account for the turn radius, but be chosen to prevent excessive distance that limits effectiveness (e.g., TGP fidelity cannot maintain custody of the target, excessive time on final for an attack). If the straight legs are aligned with the wind, a constant bank angle can be used to maintain parallel legs as the turn diameter will be the same turning to the inbound and outbound legs. If the straights legs have a crosswind component, then either the bank angle or the outbound leg must be adjusted to ensure the inbound leg is on the desired run-in. Decrease bank angle when turning into the headwind component to increase the turn radius to match the downwind turn radius. This results in parallel legs and constant, but larger, turn diameter between the turns to the inbound and outbound legs. If keeping the legs in the hold parallel is not a requirement, then the heading of the outbound leg can be adjusted to intercept the maximum range point in the hold that is offset by the anticipated turn diameter to the inbound leg. This results in an asymmetrical hold, but the bank angle is constant in the turns and turn diameter is minimized.

EXAMPLE: A stationary vehicle is parked in an alley and the crew needs to maintain custody of it. The surrounding buildings only permit a West-to-East or East-to-West look and the minimum standoff range is 4 NM with negligible winds. To maintain the East-to-West look angle, set up the tracker to have the GBU-12 run-in or ruler tool on the desired look angle, in this case 270 degrees. The minimum standoff range is 4 NM, so the inbound point to turn is 4.5 NM to account for the 0.5 NM turn radius to turn to the outbound leg. To maintain custody of the vehicle, the aircraft cannot exceed 8 NM from the target. This yields the outbound point in the hold to be 7.5 NM to start the turn to the inbound leg and stay within 8 NM. To center the hold around the desired look angle, place the control point on the run-in and use the edges as a reference to ensure 1 NM of turning room with a joint operations graphic (JOG) map loaded on the tracker display.

3.4.2.6.1.1 Step 1—fly inbound offset 0.5 NM from the run-in line or ruler tool on the tracker display.

3.4.2.6.1.2 Step 2—execute a 30 degree banked turn at 4.5 NM for 180 degrees.

3.4.2.6.1.3 Step 3—roll out on the outbound heading and correct the ground track to ensure turning room for the turn back to the inbound leg.

3.4.2.6.1.4 Step 4—at 7.5 NM, execute a 30 degree banked turn back to the inbound leg while cross-checking depression angle and azimuth for aircraft masking potential and repeat this process until departing the hold. See **Figure 3.6**, Racetrack Holds.

3.4.2.6.2 Off-Axis Racetrack Hold. Setup the off-axis hold to place the hold pattern at the desired range and orientation. The inbound leg will reference the leg closest to the TGP SPI or point of interest, with the outbound leg referencing the leg furthest from these points. The inbound and outbound turnpoints in an off-axis hold will typically equate to a look angle boundary for the TGP or the SAR. Determine the bearing to the target to bound the length of the straight legs of the hold and calculate the lead radial to not exceed those boundaries. Enter the off-axis Racetrack hold as described in the Wheel hold and track directly towards the inbound hold point. At the inbound turnpoint (i.e., lead radial), execute a 180-degree turn to the outbound leg. Track the outbound to the outbound turnpoint, cross-check range for required turning room and execute a 180-degree turn to the inbound leg if turning room allows. The same wind considerations from the on-axis Racetrack hold apply to the off-axis Racetrack hold. The decision to execute an offset Racetrack hold typically requires the inbound and outbound legs to be parallel to each other.

EXAMPLE: An area 26 NM to the northeast of the TGP SPI needs to be imaged using the SAR. The target the TGP is required to look at has 5 NM minimum standoff range. The pilot determines the bearing from the TGP target to the SAR target to be 0-2-5 degrees and orients the hold perpendicular to this bearing to enable use of the SAR Brickmap mode. To maximize TGP fidelity, the inbound leg will be at 5 NM and the outbound leg a turn diameter away, 6 NM. At 5 NM, the lead radial is 6 degrees prior for a 0.5 NM turn radius. The pilot determines that staying between a 180-degree and 230-degree bearing will satisfy both the TGP and SAR requirements.

3.4.2.6.2.1 Step 1—Intercept the inbound leg on a heading of 295 degrees.

3.4.2.6.2.2 Step 2—At 186 bearing to the target, execute a 30-degree banked turn to the outbound leg.

3.4.2.6.2.3 Step 3—Fly the outbound leg on a 115-degree heading and execute the SAR brickmap.

3.4.2.6.2.4 Step 4—At 224 degrees bearing to the target, cross-check range to be at least 6 NM and execute a 180 degree turn to intercept the inbound leg and adjust as required to maintain the minimum standoff range required. See **Figure 3.6**, Racetrack Holds.

3.4.3 Nadir. Nadir can cause a serious issue for target custody. Become familiar with the relationship between aircraft position, bank angle, depression angle, and field of view inclination. Use the techniques below to avoid potential nadir scenarios. See **Figure 3.7**, Potential Nadir Situations.

Figure 3.6 Racetrack Holds.

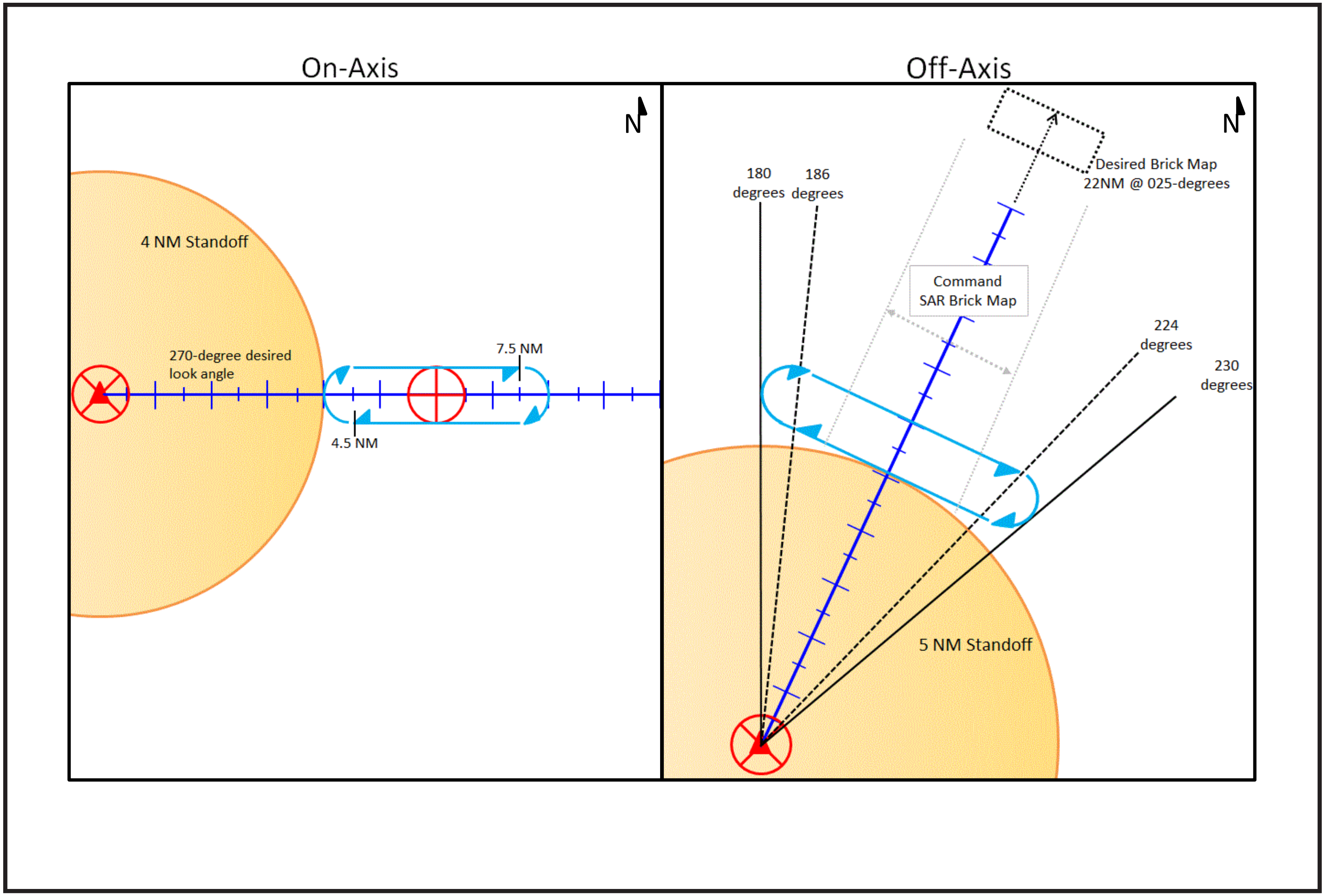
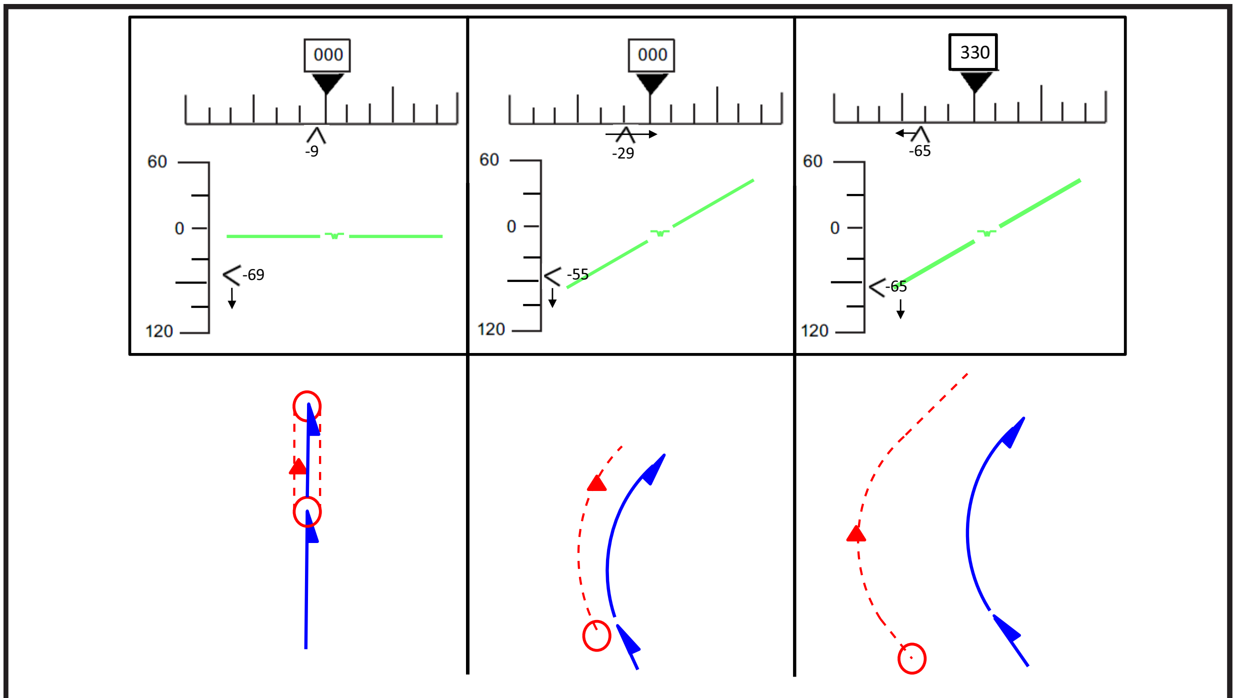


Figure 3.7 Potential Nadir Situations.



FOUO

3.4.3.1 Save. A nadir save maneuver is accomplished when a potential nadir situation is recognized with depression angle greater than 65 degrees. As systems and proficiency increase, this may be amended to greater than 69 degrees. It is designed to save nadir by decreasing the range to the target and use bank angle to move the nadir cone. The crew contract to have the SO call out 69 degrees depression angle is typically the trigger into a nadir save maneuver if the pilot's cross-check is not on the azimuth and depression angle. The nadir save maneuver varies between an aircraft wings-level or in bank at recognition. Regardless of the maneuver variant, the pilot must assess azimuth prior to initiating any aircraft maneuvering to ensure incorrect inputs are not made to induce nadir. See **Figure 3.8**, Nadir Save Maneuvers.

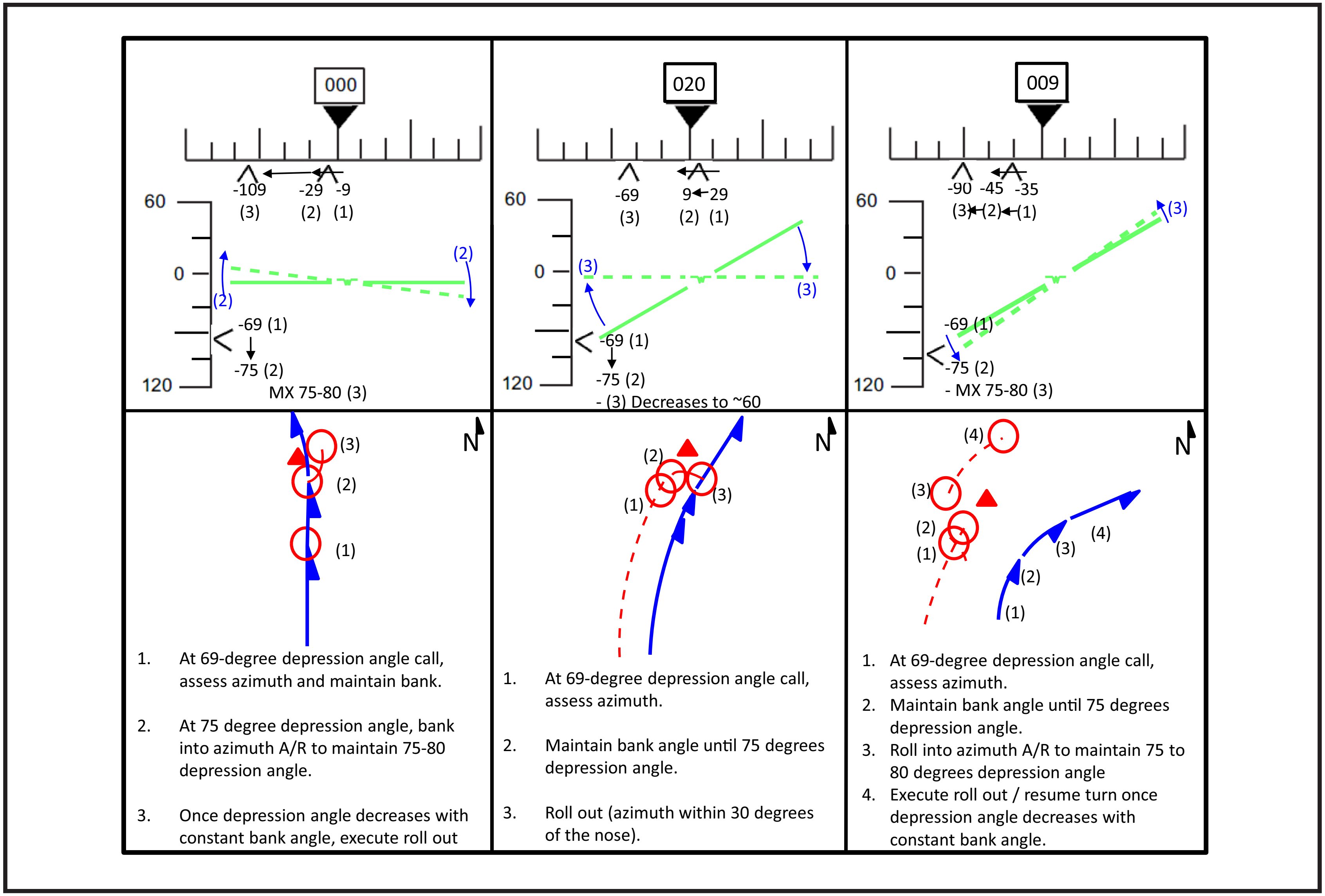
3.4.3.1.1 Wings-Level Nadir Save. The wings-level nadir save is a benign maneuver. Once a potential nadir situation is recognized or the SO calls out 69-degree depression angle, accomplish the following steps:

3.4.3.1.1.1 Step 1—assess azimuth.

3.4.3.1.1.2 Step 2—as depression angle approaches 75 degrees, bank into azimuth as required to maintain 75 to 80 degrees of depression angle.

- If depression angle increases above 80 degrees, increase bank angle.
- If depression angle decreases below 75 degrees, freeze bank angle inputs to allow depression angle to increase back into the 75- to 80-degree window.

Figure 3.8 Nadir Save Maneuvers.



3.4.3.1.1.3 Step 3—once depression angle decreases with constant bank angle, roll out to wings-level at a rate to prevent exceeding 80 degrees depression angle. “FOV Inclination” VIT 99 and/or 135 degrees of azimuth can be used as a reference for an immediate roll-out.

3.4.3.1.2 In Bank Nadir Save. The in bank nadir save requires more aggressive maneuvering than the wings-level nadir save. Bank angle can either be increased to send the nadir cone long of the TGP SPI, or it can be decreased to send the nadir spot short of the TGP SPI. If the nadir cone is sent long of the TGP SPI, it results in a more abrupt rotation in the TGP than if the nadir cone is sent short. The in bank nadir save takes advantages of increased azimuth induced by bank angle with high depression angles. Once a potential nadir situation is recognized, or the SO calls out 69-degree depression angle while established in bank, accomplish the following steps.

3.4.3.1.2.1 Assess azimuth.

- Azimuth within 30 degrees of the nose:
- Roll out.
- If depression angle subsequently increases above 69 degrees, accomplish the wings level nadir save or level straight through.
- Azimuth greater than 30 degrees of the nose:
- As depression angle approaches 75 degrees, roll into azimuth as required to maintain 75 to 80 degrees depression angle.
- If depression angle increases above 80 degrees, continue to roll into azimuth until less than 80 degrees.
- If depression angle decrease below 75 degrees, freeze roll inputs to allow depression angle to increase back into the 75- to 80-degree window.

3.4.3.1.2.2 Once depression angle decreases with constant bank angle, roll out to wings-level at a rate to prevent exceeding 80 degrees depression angle. VIT 99 and/or 135 degrees of azimuth can be used as a reference for an immediate roll-out.

3.4.3.2 Straight Through. A Straight Through maneuver uses bank angle and rudder to cross-control the aircraft to fly straight over the target and slow the rate of rotation in the TGP, when compared to the nadir save maneuver. Based on the situation, the Straight Through maneuver should be executed no later than 75 degrees depression angle or post weapons release. For a Straight Through maneuver do the following.

3.4.3.2.1 (FOUO) Establish and note current heading towards the target.

3.4.3.2.2 (FOUO) Smoothly bank to 10 to 15 degrees in the direction the FPM is in the HUD or TGP azimuth (e.g., FPM on right half of HUD or right TGP azimuth = 10 to 15 degrees of right bank) while accomplishing the next step.

3.4.3.2.3 (FOUO) Smoothly apply 5 to 10 degrees of rudder opposite the direction of bank (e.g., right bank = left rudder).

3.4.3.2.4 (FOUO) Cross-check heading after establishing bank and rudder inputs. If heading is increasing or decreasing, make appropriate bank and rudder inputs to arrest heading change and correct back to the original heading.

3.4.3.2.5 (FOUO) Cross-check depression angle. If depression angle increases above 80 degrees, smoothly increase bank angle to keep depression angle at 85 degrees.

3.4.3.2.6 (FOUO) Provide the SO time to impact (TTI) calls every 10 seconds if executing post weapons release.

3.4.3.2.7 (FOUO) At Splash or passing the target, assess depression angle and azimuth. Once clear of 135 degree azimuth or "FOV Inclination" on VIT 99 decreases past 80, smoothly roll out of the bank that is set, and slowly return to straight-and-level flight. If executing post weapons release, move to the egress step of the attack.

3.4.3.3 Recovery. When a nadir is imminent and unavoidable, the SO should retard zoom level to be the widest practical FOV that enables the SO to maintain custody of the desired SPI, typically at least 300 meters. Once it is apparent that the TGP is going to go nadir, and there is no corrective course of action, the crew should minimize inputs in order to not exacerbate the problem. After the TGP rotation, the SO should slew back to the desired SPI and zoom in to the desired FOV. If the custody of the desired SPI was lost, funneling features should be used to reacquire the desire SPI as fast as possible. If the custody of the desired SPI is lost and funneling features are unidentifiable, the SO can use the target lock feature to quickly reacquire the desired SPI if the target was previously designated by the pilot in manual update mode. If target lock is not available, the SO should use the most efficient target acquisition technique to get back onto the desired point of interest. After the nadir position has been passed, use the TGP targeting mode to reacquire the target expeditiously.

3.4.3.4 Snowplow. A snowplow exists when the TGP reaches beyond 90 degrees depression and locks in the 120 degree depression position. If 90-degrees depression angle is exceeded, the SO must slew the TGP to decrease the depression angle to less than 90 degrees in order to prevent the snowplow to start dragging the crosshairs across the ground (when the depression angle reaches 120 degrees). This will result in loss of the desired SPI custody. To recover from an impending snowplow (i.e., depression angle greater than 90 degrees but less than 120 degrees), the SO should zoom out no further than MED FOV or 1,000 meters FVW, whichever comes first, and then select targeting mode. By selecting targeting mode the TGP will automatically drop a point on the current crosshair position, reorient the TGP to bring it out of snowplow, and slew back to the marked location. If targeting mode is unsuccessful, zoom out to ultra-wide FOV and manually slew the pod up until the depression angle is less than 90 degrees and reacquire the desired SPI. In 12.0020 and beyond, the TGP automatically executes snowplow recovery when depression passes 95 degrees.

3.4.4 Close Pass. The close pass is flown when a steep look angle or overflight of the target for IMINT/signals intelligence (SIGINT) purposes is prioritized over audible signature. There are multiple considerations, a specific flow, and contingencies to account for in order to ensure close pass success within a tactical scenario.

3.4.4.1 Communicate. The communicate step begins any time the crew received a new tasking or information about an existing tasking. In this instance, once the requirement of overflying the target for IMINT or SIGINT is communicated, the crew must possess a good sight picture on expectations and the environment before proceeding to the next phase. The amount of time required over the top of the target and the required look angles must be known to ensure the intent is met.

3.4.4.2 Build. The build step begins once the crew obtains all required information and understands its tasking. Close pass considerations relate to maximizing sensor fidelity to achieve a desired effect while avoiding nadir situations.

3.4.4.2.1 Winds. Flying into the wind increases time over the target, while flying with a tailwind will decrease time over the target. Therefore, the decision to fly into or with the wind should be prioritized to satisfy the tactical situation with reference to time over target. The primary factor in determining run-in direction should be the desired collection over the target and crews should assess how winds will factor into the close pass.

3.4.4.2.2 Airspeed Management. Crews should attempt to fly as slow as possible, but sufficient enough for the required turn performance of the aircraft. Crews should fly no lower than stall plus 15 KIAS (Legacy MQ-9s), and stall plus 22 KIAS (ER MQ-9s).

3.4.4.2.3 Sensor Game Plan. The sensor game plan consists of an environmental effects assessment, camera/FOV selection, automatic video track (AVT) selection, and anticipated manual iris/focus settings. The predominant environmental effect that will factor into every aspect of the sensor game plan is the sun angle. Since the close pass usually begins at the standoff range and ultimately places the aircraft directly over the target, the SO needs to anticipate FOV changes to maintain the desired FVW/field of view height (FVH) and the corresponding changes in manual iris/focus settings as the slant range decreases. Camera selection should prioritize essential elements of information (EEI) satisfaction and could include daytime television (DTV), IR, and LLTV/SWIR pictures on the same, or over multiple close passes. An AVT should be used to maximize stability on the target during the close pass; however, environmental effects and manual iris settings will affect track survivability as slant range decreases. SOs should also anticipate high depression angles during the close pass maneuver and prioritize obtaining the best picture possible versus zooming out when concerned about nadir.

3.4.4.3 Execute. The close pass should be conducted using the straight through procedure to provide a top-down look of a target. This maneuver can be flown in any direction over the target and should be chosen primarily based on the desired look angle to the target. It requires airspace on opposing sides of the target for the planned ingress and egress routing.

3.4.4.3.1 Ingress Positioning. The first step in setting up a close pass is to determine the direction of the pass. The priority should be to determine the desired look angle which will drive the ingress/egress; once that has been decided the next priority should be maximizing time over the target. Set up the tracker display by placing the control point on the target or slightly offset (e.g., place the edge of control point on the target). Set up the HUD by selecting A/G mode with steering lines enabled and either manually updating on the target or by placing target update into auto mode with the TGP staring at the target.

3.4.4.3.2 Maneuvering. To execute a close pass, turn and point directly at the target or the desired offset point from the target. Track directly towards the target using the target steering line (TSL), TGP graphics, or the control point. If flying directly over the target, execute the applicable anti-nadir technique at 75 degrees depression angle, as discussed in **paragraph 3.4.3**, Nadir. If flying to an offset point, bank into the target as required maintaining a depression angle less than 80 degrees. The SO should execute the sensor game plan derived from the considerations in **paragraph 3.4.4.2.3**, Sensor Game Plan, and anticipate constant picture manipulation throughout the entire maneuver. The following techniques should be used to track directly to the target or to the offset point.

3.4.4.3.2.1 Bomb Steering Line (BSL). Intercept and track the BSL until 75 degrees depression angle. At this point, the pilot must choose to accomplish a nadir save technique. See **paragraph 3.4.3**, Nadir, for a detailed description of how to execute an anti-nadir technique. As proficiency is gained, a depression angle up to 85 degrees can be maintained to provide a steeper look-down of the target as long as the TGP remains stable. Egress as necessary, depending on the tactical situation.

3.4.4.3.2.2 TGP Graphics. At the turn inbound for the ingress, roll out in order to maintain zero-degrees azimuth. If a steering correction is needed to reset zero-degrees azimuth, turn in the direction of the azimuth offset equal to the amount of offset while wings-level (i.e., if the current heading is 269 with 10 degrees of right azimuth, turn right to a heading of 279 degrees to zero-out azimuth). Solely using TGP graphics to fly direct to a target results in homing to the target when executed with a crosswind component. To mitigate homing, match the aircraft course from the tracker display to the reciprocal of the TGP bearing. This results in a non-zero azimuth while inbound to the target, but the aircraft tracks directly towards the target, as long as the azimuth is constant. If the azimuth is drifting, then the heading needs to be corrected in the direction of the azimuth drift. This will arrest the drift and the aircraft will track directly towards the target. Approaching the target, move the cross-check to depression angle and at 75 degrees depression angle execute the appropriate nadir save recovery technique as discussed in the previous paragraph. Once depression angle decreases with a constant bank angle or rudder input, smoothly remove the respective input at a rate that limits depression angle to 80 degrees or less. Egress as necessary, depending on the tactical situation.

3.4.4.3.2.2.1 TGP Graphics With an Offset. TGP graphics can also be used to track directly to a point offset of the target to permit a close range view of one side of the target. The homing mitigation technique must be used in order to track directly to a specific offset point. Start the maneuver by tracking directly towards the target by matching the aircraft course from the tracker display to the reciprocal of the TGP bearing. Choose the desired amount of offset from the target. At 5 NM, a 5-degree offset results in just under a 0.5 NM lateral offset once abeam the target. A 10-degree offset results just under a 1 NM offset. At 5 NM, adjust the aircraft course by the amount of desired offset and in the direction of the offset point and maintain the corresponding aircraft heading. Depending on the amount of offset, an anti-nadir technique may be required. Egress as necessary, depending on the tactical situation.

3.4.4.3.2.3 Control Point. The control point can be used to track directly over a target or to an offset point. To track directly over a target, place the control point on the target either by using the SPI on the tracker or by manually entering the coordinates into the control point container. On the turn inbound, cross-check the tracker display for "Heading to CP" and roll out on that heading. Once wings-level, adjust the aircraft heading to make the aircraft course on the tracker display match "Heading to CP" to track directly towards the control point/target. Approaching the target, move the cross-check to depression angle and at 75 degrees depression angle execute the appropriate anti-nadir technique. Once depression angle decreases with a constant bank angle or rudder input, smoothly remove the respective input at a rate that limits depression angle to 80 degrees or less. Egress as necessary, depending on the tactical situation.

3.4.4.3.2.3.1 Control Point With an Offset. To fly to an offset point, place the control point at the desired offset and track directly towards it using the same procedures as outlined in the previous paragraph. With a JOG map selected, the control point diameter is approximately 1 NM and should be used to estimate offset. Depending on the amount of offset, an anti-nadir technique may be required. Once the depression angle decrease with a constant bank angle, begin the egress as necessary, depending on the tactical situation.

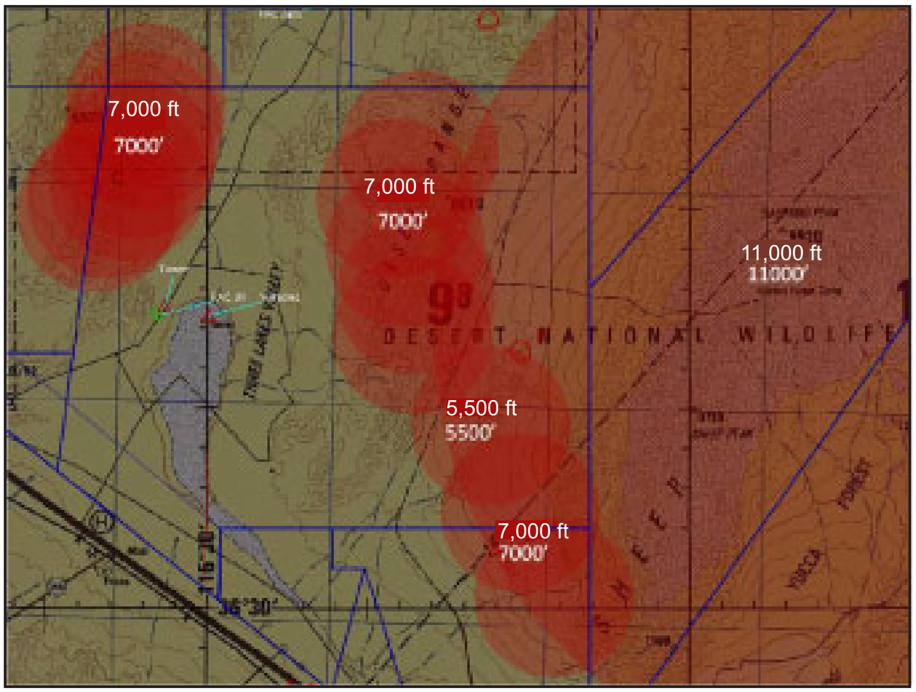
3.4.4.3.2.3.2 Tracker Display with an Offset. The close pass can also be accomplished using the tracker display as the primary reference for an offset. If the tracker is already set up with a 60-degree depression angle ring on an operational mission on the desired TGP SPI for the close pass, then a close pass with an offset can be flown by flying between the center point of the loiter and the 60-degree ring. Move the cross-check to the TGP data once depression angle is above 65 degrees and complete the maneuver with the same anti-nadir techniques as previously discussed.

3.4.4.4 Assess and Report. The report step begins at the completion of the execute step, or when something triggers an immediate report back to the crew and outside assets. Upon completion of the close pass, information should be reported back in a clear, concise and correct manner IAW the established communication contracts. Once the information is reported back, the crew members execute the communicate, build, execute, assess, report (CBEAR) loop over again. If the crew is going to continue with the previous tasking and the listen and build steps are still accurate, they should pick-up with the execution step where they left off prior to reporting back information. If the tasking is modified or a new tasking given, the crew should start at the beginning of the loop and modify, or create, a new game plan prior to beginning the execute step.

3.5 Low Altitude. Low altitude (LOWAT) operations for the MQ-9 are defined as operating at or below 5,000 feet AGL as defined by AFI 11-2MQ-19V3.

3.5.1 Mission Planning. In addition to standard mission planning items, LOWAT mission planning should result in a game plan to ensure terrain clearance and products to back up said game plan. Design an overlay for the TacSit display that ensures 1 NM clearance from terrain within 1,000 feet of the planned altitude and a buffer from that line, if desired. The operating altitude cannot be below 1,000 feet AGL. Develop a lost link profile that also remains within terrain clearance requirements and allows for air traffic control coordination for the climb portions of the emergency mission. See **Figure 3.9**, Low-Altitude Mission Planning.

Figure 3.9 Low-Altitude Mission Planning.



3.5.1.1 Terrain Clearance Requirements. During mission planning, crews should determine regions within the planned operating areas that provide a minimum of 1 NM lateral clearance from any terrain from 1,000 feet below to the planned minimum operating altitude. Crews should ensure that the aircraft will continue to maintain that clearance even during the worst-case condition of lost link maneuvering and accounting for wind drift. Crews should annotate these areas on the low-altitude chart of depict safe areas on the TacSit display.

3.5.1.1.1 LOWAT Standoff Calculations. **Table 3.6**, Low-Altitude Standoff Calculations, provides a quick reference lookup based on true airspeed and winds to determine the horizontal distance required to ensure a minimum 1 NM clearance from factor terrain. These calculations are based on the fact that during a lost link situation, the aircraft will execute a turn towards the emergency mission start point. The standoff distance required is dependent on airspeed, winds at altitude, and the amount of turn required. Slower airspeeds give aircrews more flexibility in valleys due to the decreased turn radius. The winds column of the diagram is built for worst-case winds (pushing towards factor terrain). In addition, crew should ensure the emergency mission airspeed matches or is slower than the airspeed being flown.

Table 3.6 Low-Altitude Standoff Calculations.

	Turn Required and Wind Speed					
	180 Degrees			135 Degrees		
TAS	0 Knots	15 Knots	30 Knots	0 Knots	15 Knots	30 Knots
120	2.6	3.0	3.2	1.2	1.2	1.2
130	3.0	3.3	3.6	1.2	1.2	1.2
140	3.2	3.6	4.0	1.2	1.2	1.3
150	3.6	4.0	4.4	1.2	1.3	1.3
160	3.9	4.3	4.8	1.3	1.3	1.3
170	4.3	4.8	5.2	1.3	1.3	1.4

3.5.1.1.1.1 180-Degree Column Assumptions. The 180-degree column assumes a worst-case turn requiring a full 180-degree turn to the emergency mission start point. To use this chart, crews should determine the airspeed they plan on flying and the expected winds to look up the standoff requirement. For example, if the crew is planning on flying at 130 KTAS with a 30 knot wind, standoff would be 3.0 NM, meaning the aircraft should fly no closer than 2.0 NM, required turn, plus 1.0 NM, required lateral clearance, from the factor terrain. If unsure of what direction they will be flying with respect to the terrain, use the 180-degree tab.

3.5.1.1.1.2 135-Degree Column Assumptions. Crews can minimize the required standoff distance by not pointing directly at the factor terrain. As an example, executing a Figure Eight orbit with turns away from the terrain where the aircraft never points more than 45 degrees relative to the terrain. Use this tab if not exceeding 45 degrees relative to factor terrain. If the crew is planning on flying at 160 KTAS with a 30 knot wind, the standoff should be no closer to factor terrain than 3.3 NM.

3.5.1.1.1.3 Operational Missions. If operating on a point-to-point preplanned route, with a properly built and updated operational and emergency missions, a lost link scenario will not result in the aircraft deviating from the preplanned routing. In this case, there is no requirement to account for additional terrain standoff due to lost link aircraft maneuvering. Crews should use 1 NM for the required standoff distance.

3.5.1.1.2 Low-Altitude Charts. On all low-altitude flights, each aircraft will contain a minimum of one Chart Updating Manual (CHUM) updated map of the low-altitude route or training area. The map will be available either digitally or in hard-copy during low-altitude flight and of sufficient detail to allow navigation and safe mission accomplishment. One technique for building a LOWAT chart is to use a TacSit display overlay and label the chart with the MSA calculation. Crews can place circles with a radius equal to the required standoff calculation. See **Table 3.6**, Low-Altitude Standoff Calculations and center point on the closest factor terrain. See the example in **Figure 3.9**, Low-Altitude Mission Planning.

3.5.2 Mission Briefing. During briefings, emphasis should center on LOWAT flight maneuvering and terrain clearance procedures and include the following.

- Effects of task saturation.
- Time to ground impact.
- Emergency landing sites.
- Terrain features/obstacles along the route of flight.
- Lost link profile and associated planning considerations for terrain clearance and routing.

3.5.3 In-Flight Operations. The focus for in-flight operations is cockpit setup to maintain SA on terrain, managing the lost link profile, and extended transits requiring a satellite migration.

3.5.3.1 Maintaining SA on Terrain. Pilots should have a readily available forward-facing camera (nose camera or payload in Position mode) visible at all times to reference terrain immediately in front of the aircraft. The forward-facing camera may be displayed on either the pilots HUD, the STORM console, or on the auxiliary monitors via Framegrabber or other video display capability. Set up the STORM console repeater in accordance with **paragraph 3.2.5.1.3**, Navigation. Set up the Framegrabber in accordance with **paragraph 3.2.5.1.3**, Navigation, and **Figure 3.1**, Framegrabber Setup. In the absence of Framegrabber, mux the nose camera to VQ and set VQ to the pilot's video source for the HUD. The pilot should cross-check the HUD for telemetry and terrain awareness and cross-check the SOs HUD for target SA.

3.5.3.2 Lost Link Profile Management. The lost link profile should be continuously updated, ensuring the aircraft remained clear of terrain during a lost link situation/exit the LOWAT environment and properly transit back to the LRE location. The emergency mission start point will need to be updated when transitioning between ridgelines, ensuring the terrain clearance if the aircraft goes lost link. The remainder of the emergency mission should climb in a coordinated airspace, ensuring deconfliction prior to its RTB.

3.5.3.3 Ku-to-Ku Satellite Transfer. Current software allows in-flight migration of satellite command link (CL) and return link (RL) between separate satellites on both geostationary and inclined orbit satellites.

3.5.3.3.1 This upgrade does not require the aircraft to be gained by a launch and recovery element (LRE) in order to accomplish the satellite-to-satellite migration.

3.5.3.3.2 Satellite migration allows operations far from the LRE that require multiple satellite footprints to reach the AOR.

3.6 Abnormal Procedures. Abnormal procedures include low-level abort procedures and emergency procedures.

3.6.1 Low-Level Abort Procedures. Compute and brief low-level abort altitudes. Compute the abort altitude for the entire route/area using minimum safe altitude numbers. MSA will provide a clearance of 1,000 feet above the highest obstacle/terrain feature (rounded to the next highest 100 feet) within 5 NM of the planned course, route boundary, or operating area (e.g., military operating area [MOA], low fly area, or restricted area).

3.6.2 Emergency Procedures. During all LOWAT operations, the immediate reaction to task saturation, diverted attention, or an emergency is to climb. Unless one is able to maintain positive visual terrain clearance using the available aircraft sensors, immediately climb to, or above, the briefed minimum altitude and transition to known flight reference display to ensure expected aircraft attitude while climbing to the abort altitude. The aircrew must ensure positive terrain clearance before diverting attention to deal with an emergency. Remember to aviate, navigate, communicate.

3.6.3 Aircraft Deconfliction. Aircraft deconfliction ensures the MQ-9 does not violate airspace restrictions or pose a midair collision hazard to other aircraft with and without link. Since the MQ-9 has a ground-based cockpit, the ability to quickly scan around the aircraft or pick up movement in the peripheral is lost and makes deconfliction difficult. In addition to the training rules (TR) outlined in AFI 11-214, *Air Operations Rules and Procedures*, local range procedures and tactical airspace have different considerations for aircraft deconfliction.

3.6.4 Range Procedures. Entering, maintaining and exiting the range airspace is important when flying continuation training (CT) or formal training missions to ensure deconfliction. Collision avoidance and terrain avoidance require special attention in addition to the applicable TRs for the sortie. Written procedures and guidance can be found in command directives, applicable supplements, and local directives. In addition to these, exercising professional airmanship and maintaining strict flight discipline will help the aircrew avoid breaches of safety and aid in the conduct of proper range operations.

3.6.4.1 Collision Avoidance. Collision avoidance is an emphasis item as MQ-9s, if collocated, are typically assigned into the same minimal lateral and vertical airspace. Units not equipped with TDL tracks or radar surveillance tracks injected onto the TacSit display face increased midair collision potential. A thorough review of assigned airspace and local procedures is required to enhance collision avoidance. During coordination briefs, address airspace entry, lost link profile, airspace exit, and expected tactical operations to manage expectations of MQ-9 operations. Prior to airspace entry, request an update for all factor traffic through the controlling agency. If required, adjust the aircraft's operating altitude to ensure adequate vertical separation from other aircraft. Set the emergency mission loiter in the working area and route it out of the airspace in accordance with the coordination brief and/or local procedures.

3.6.4.2 Terrain Avoidance. Terrain avoidance is ensured by calculating and setting the correct MSA for the area of operations. Setting the "Minimum Altitude MSL" in the HDD to the MSA will prevent an autopilot descent below the MSA. It also changes the altitude container in the HUD to yellow when the altitude is within 1,000 feet of the altitude set in "Minimum Altitude MSL" and to red when current altitude is below the "Minimum

Altitude MSL" altitude. If flight is planned below the MSA, then ensure the "Minimum Altitude MSL" altitude is set at or below planned operating altitude and flight is conducting with the applicable terrain avoidance requirements as outlined in this chapter.

3.6.5 Tactical Airspace. Tactical airspace is characterized by competing deconfliction priorities driven by the ever-changing nature of combat operations. During combat operations, many of the same airspace considerations from training apply, but the aircrew must also consider threats and the dynamic nature of airspace coordinating measures in combat airspace.

3.6.5.1 Threats. Threats to the MQ-9 include both air-to-air (A/A) and surface-to-air (S/A) threats. The SO should scan known and anticipated areas for threats during ingress and egress to the assigned tactical working area. Once in the assigned airspace, the available MQ-9 sensors should make a thorough sweep of the immediate operating area, particularly in the vicinity of the target and under the MQ-9s anticipated ground track, to ensure no threats are present. Cross-cuing with additional intelligence, surveillance, and reconnaissance (ISR) assets is vital to increase MQ-9 survivability in a contested environment. During tactical breaks, accomplish threats sweeps in addition to weather sweeps to enhance battlespace SA. As the mission allows, continually sweep for threats and surface-to-air fires (SAFIRE) with the TGP in a variety of zoom levels.

3.6.5.2 Airspace Coordinating Measures. As changes in the air and ground picture develop, airspace control measures are required to deconflict aircraft from other aircraft and friendly surface-to-surface fires. Airspace control measures can be preplanned or implemented/rescinded on a moment-by-moment basis. The aircrew must adhere to airspace restrictions applicable to the current operating airspace as well as the airspace along the emergency mission. TacSit displays should be updated with the current ACO to provide the depictions necessary to adhere to the current airspace coordinating measures (ACM).

3.7 Communication. Effective communication is a cornerstone for mission effectiveness. It enables mission success, while ineffective or nonexistent communication can hinder or prevent mission success. Communication discipline over all of the MQ-9 communication capabilities leads to effective communication. Use joint publications and the mantra "clear-concise-correct" to avoid miscommunication instances.

3.7.1 Communication Discipline. Communication discipline refers to C3 comm through adherence to brevity and communication contracts. This prioritizes communication, prevents communication saturation, and ensures critical communication is provided in a timely manner. Operating in Ku and RSO require additional communication discipline in order to ensure transmission and receipt of radio communications through the airborne ARC-210.

3.7.2 Communication Capability Application. Communication over the radio, phone, mIRC and data link all require the discipline as previously discussed to maximize effective communication during a mission. Timely application of each capability is required to further enhance effectiveness. Become familiar with all communication methods to reach outside the cockpit depending on the tactical scenario.

3.8 MATL. Due to the nature of flying an MQ-9, limited sensory indications in identifying emergency situations exist. An MQ-9 crew must have a repeatable process in order to identify and recover aircraft emergency situations in a timely fashion. This process is not inclusive and applicable checklists still need to be accomplished. CRM is critical for ensuring a safe recovery of the aircraft and clear, concise, correct communication must continually occur throughout the situation. Successfully resolving emergency procedures requires that the crew will aviate, navigate, and communicate during each phase. See Table 3.7, MATL Example.

Table 3.7 MATL Example.

Recognize.

- Audible Recognition: beeps
- Visual Recognition: red on HDD/repeaters, blinking words on HUD
- Other sensory recognition:
  - Cross-check: Check HDDs and VITs; switch to Mil-Std HUD
  - Confirm that you have an EP with second (preferably independent) source
- Example: rpm goes to 0 percent
  - Use a secondary indication to confirm engine failure or tachometer generator failure
  - Are we losing altitude?
    - If yes, engine failure
  - And/or check VIT 65 EFIU Prop Speed per TO 1Q-9(M)A-1, Section 3

Maintain Aircraft Control.

- CAPS (as required)
- Level Out/Abort/KIO
  - Fly the airplane
- Turn towards LRE or towards the largest part of your cleared airspace
- Deconflict from assets
- Assess energy state
- Update emergency mission

Analyze the Situation.

- VITs and Mil Std HUD displayed
- Determine what happened and what checklists are required to troubleshoot
- Red/out of limit values and what they mean
- Assess overall system parameters

Take Proper Action

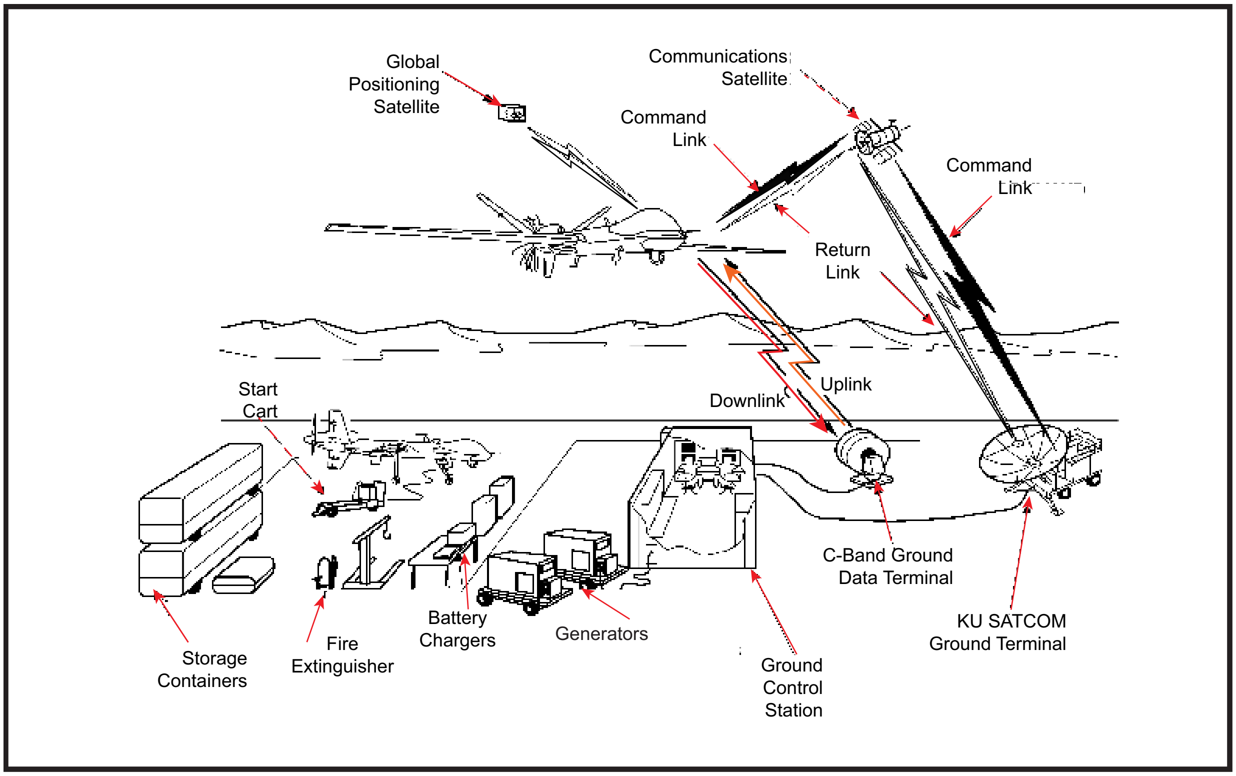
- Clean up with the checklists
- Open/close all applicable checklists

Land as Soon as Conditions Permit

- Declare emergency (as required)
- Re-evaluate energy state
- Coordinate airspace and squawk (as required)
- Update emergency mission
- Coordinate with LRE and appropriate agencies
  - Type of emergency, ETA, furthest handover point

3.9 Data Links. Data links consist of an uplink and downlink signal (LOS, C-Band) or command and return link (Satellite Link, Ku) that establish communication between the aircraft and the cockpit. A continuous stream of control commands is uplinked to the aircraft and the aircraft downlinks a continuous stream of telemetry and imagery data. The data link is maintained through a C-band LOS/DLOS system, Ku-band SATCOM system, or RSO. Each data link system has corresponding data link latencies. See **Figure 3.10**, The MQ-9 System, for a depiction of the data link systems' interconnectivity. It is just as important for aircrew to understand the systems that make up the data link infrastructure as it is to understand the data link itself. Necessary information is referenced below in order to have a better understanding of the data link system.

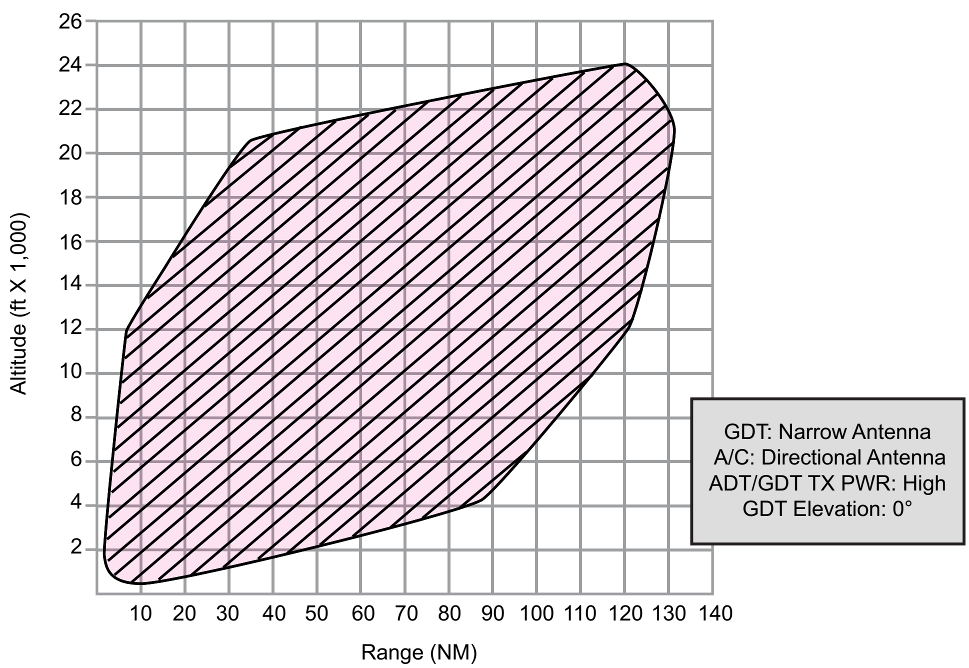
Figure 3.10 The MQ-9 System.



3.9.1 Line of Sight/Digital Line of Sight. For C-band LOS/digital line of sight (DLOS) operations, the Block 1 has one omnidirectional lower antenna and two directional antennas (one upper and one lower) on the aircraft. The Block 5 has two omnidirectional antennas (one upper and one lower) and one directional upper antenna. Two directional (one wide and one narrow) and one omnidirectional antenna are located on the ground data link terminal (GDT). The aircraft receives a single uplink signal and transmits two downlink signals. The redundant control module (RCM) on board the aircraft selects the antenna receiver combination with the best uplink data stream, which is not necessarily the strongest radio frequency (RF) signal. Each downlink signal includes aircraft telemetry data plus a selectable video feed. Maximum effective range for LOS/DLOS GDT narrowband operations is approximately 120 NM at 24,000 feet (terrain/LOS dependent). See **Figure 3.11**, LOS Data Link Performance—GDT Narrow/Aircraft Directional, for a depiction of the complete range of narrowband GDT operations. Maximum effective ranges with the GDT wide or omni antenna decrease significantly and are only useful for pattern operations and local area base defense missions.

DLOS is a modulated mode, which allows the transmission of digital data along the analog data link. The digital data transmitted includes one or two video sources, aircraft performance data, and audio from the ARC-210 on board the aircraft. Analog data includes the same, but lacks the audio component. The data link latency induced by operating via C-Band data links is approximately 180 milliseconds. Data link latency refers to the delay between command inputs and perceived feedback in the cockpit. To determine the exact latency for a specific aircraft, aircrew may reference the DL Delay output on VIT 10. The relatively imperceptible delay while operating in LOS makes it the primary data link type when conducing launch and recovery operations.

Figure 3.11 LOS Data Link Performance—GDT Narrow/Aircraft Directional.



3.9.1.1 Ku-Band SATCOM System. For Ku-band operations, the aircraft is equipped with a 30-inch satellite dish in the nose of the fuselage. The Ku-band SATCOM system allows the MQ-9 to conduct beyond line of sight (BLOS) operations with minimal degradation. The aircraft has a Ku-band SATCOM antenna and the cockpit is connected to a Ku-band SATCOM terminal, also referred to as the "relay." The aircraft's SATCOM antenna and the relay, called a fixed site satellite terminal (FSST), communicate via transponders on a single communications satellite. A transponder gathers signals over a range of frequencies and re-transmits them on a different set of frequencies to receivers on Earth. Ku-band SATCOM transmissions are called command link (CL) and return link (RL). The system operates the command link at a data rate of 200 kbps and the return link at a selectable data rate of 1.6, 3.2, or 6.4 (high definition [HD]) mbps. The SATCOM channels typical of MQ-9 use support 10 mbps of total bandwidth. Reduced bandwidths can cause noticeable delays in aircraft and sensor control and degraded FMV image quality. The Ku-band SATCOM system has prominent data link delay. The delay is approximately 1.2 seconds each way (the exact delay is visible on VIT 10). To mitigate the Ku-band delay for aircraft control, the pilot should cross-check VIT 99 (2408 and newer) for instantaneous feedback of control stick inputs using a “control versus performance instrument” concept. The SO must anticipate the delay to accurately start, stop, and adjust TGP slewing. The Ku-band delay also affects radio transmissions and induces a perceived delayed response time to others within LOS of the aircraft. Normal launch and recovery operations should not be accomplished with the Ku-band SATCOM system due to the delay.

3.9.1.1.1 Ku-band SATCOM Limitations. Ku-band operations are restricted by the aircraft’s Ku-band SATCOM antenna LOS to the selected satellite, Ku-band antenna slew rates, aircraft attitude, and aircraft within the satellite’s footprint. The dish radiation pattern is a 2-degree cone that can be rotated 360 degrees in azimuth and pointed -10 degrees to +85 degrees in elevation to track a satellite. Reliable link performance at various aircraft attitudes (i.e., pitch, roll, and yaw) is limited by the combination of the satellite location and dish elevation limits if the aircraft attitude causes the dish to exceed the elevation limits in order to remain pointed at the satellite. If exceeded, the aircraft will, at a minimum, receive a link hit (i.e., temporary loss of data link that does not result in the aircraft flying its lost link profile), or go lost link. Under these circumstances, the maximum bank angle away from, and/or into, the satellite will have to be reduced to ensure dish LOS to the satellite and constant data link. See **Figure 3.12**, Ku-Band Bank Angle Restrictions Induced by Satellite Location, for a generic depiction of these restrictions for level flight. Dish slew rates limit the possible rate of attitude changes and, if exceeded, result in a link hit. See **Table 3.8**, Ku-band Aircraft Attitude Rate Limits, for recommended attitude rates to maintain link in Ku-band operations.

3.9.1.1.2 Effective Isotropically Radiated Power (EIRP) (pronounced “erp”). Maximum amount of power that could be radiated from an antenna measured in decibel-watts (dBW). The lowest minimum EIRP ever observed for the MQ-9 is 35 dBW. Conventional MQ-9 operations operate at approximately 40 to 50 EIRP; HD requires a minimum of 46 dBW while standard definition (SD) requires a minimum of 42 dBW.

3.9.1.2 Remote Split Operation. RSO is when the aircraft is controlled by a cockpit that is not collocated with the FSST/SETSS. The same restrictions from Ku-band SATCOM operations and data link latencies apply for RSO, but the RSO cockpit can be located anywhere on Earth and requires the data link information to be relayed between the SATCOM Earth terminal subsystem (SETSS)/FSST and the cockpit. A fiber optic data network relays the command and return link information between the RSO cockpit and the FSST located within the data linked satellite’s footprint. The SETSS or FSST is called the “forward site” in RSO. RSO requires the use of a LRE and MCE due to the data link latency inherent to Ku-band operations.

Figure 3.12 Ku-Band Bank Angle Restrictions Induced by Satellite Location.

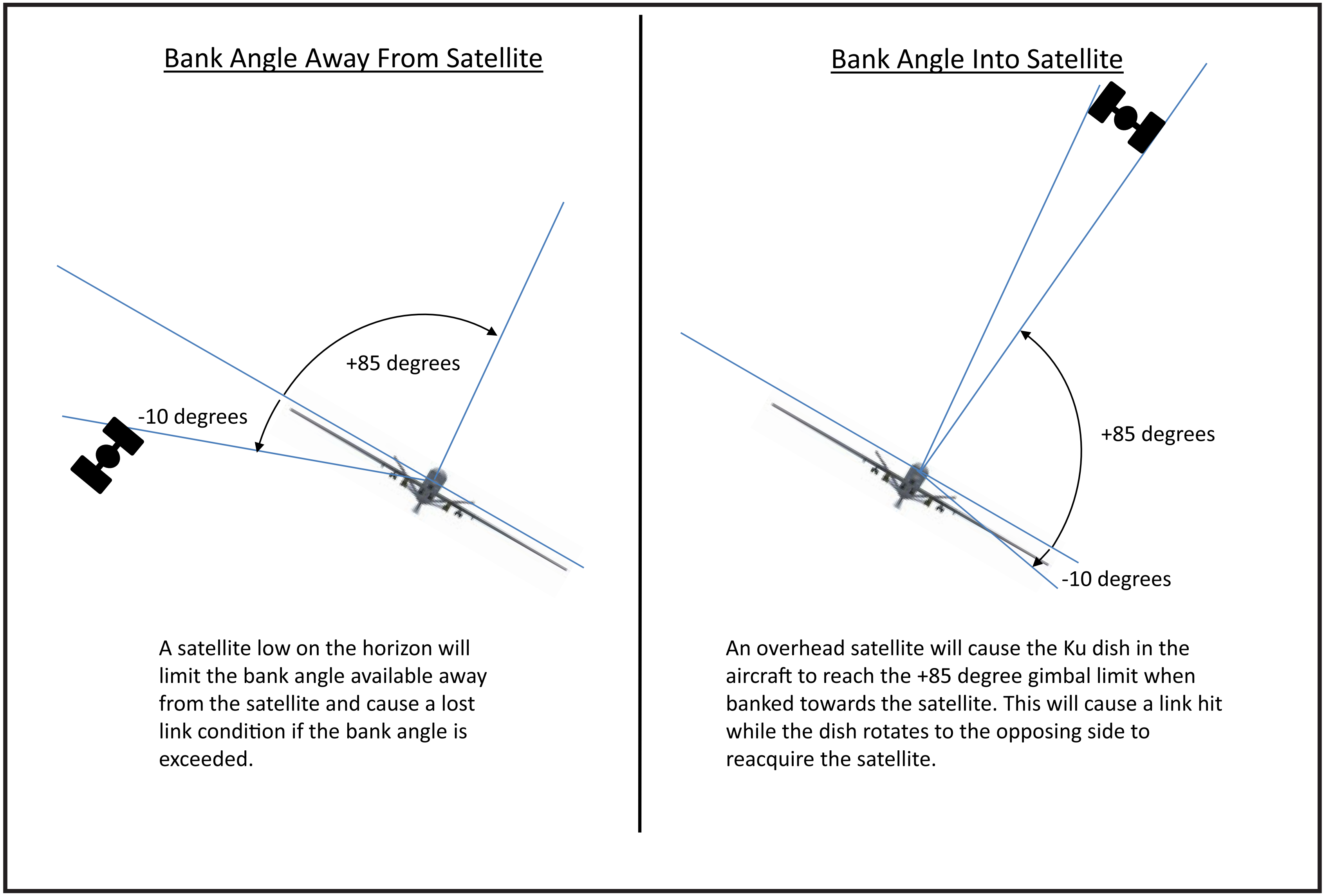


Table 3.8 Ku-Band Aircraft Attitude Rate Limits.

Angular Velocity	Rate
Pitch Rate	± 2 degrees per second
Roll Rate	± 15 degrees per second
Yaw Rate	± 1 degree per second
Ku-Band Antenna Slew Rate Performance	
50 degrees per second azimuth	
60 degrees per second elevation	

3.9.1.3 SATCOM Earth Terminal Subsystem. The SETSS is a tactical/mobile SATCOM terminal, designed and updated in 2010. The SETSS is a mixed commercial/military system that is presently set up for eight transmit/receive (TX/RX) links. SETSS has complete redundancy in the RX/TX path and is currently set up to operate only in X-Pol configuration. In order to change to Co-Pol configuration this will take some time and effort. In addition to the updates referenced above, the SETSS has been wired to accept two primary/predator modem assemblies (PMA) and the up and down converters, allowing the operation of up to eight aircraft. Direct connection for BLOS occurs via MM tactical fiber optic cable assembly (TFOCA) fiber cables between cockpit (MM secure link manager assembly [SLMA]) and SETSS. To enable RSO from the SETSS, an RSO modification must be accomplished where the PMAs are taken out of the SETSS and placed in the relay-site server room racks and wired through multiple converters to behave like that of a FSST. See **Figure 3.13**, SATCOM Earth Terminal Subsystem, for image familiarization of a SETSS.

3.9.1.3.1 Cross Polarization (X-Pol). The polarization orthogonal to the polarization being discussed. For instance, if the field is meant to be horizontally polarized, the X-Pol will be the vertical polarization.

3.9.1.3.2 Co-Polarization (Co-Pol). Desired polarization component (i.e., transmitting on vertical—receive on vertical).

3.9.1.3.3 The Primary/PMA. Modulates the CL and demodulates the RL signals via binary phase shift key (BPSK).

3.9.1.3.4 Fixed Site Satellite Terminal. The FSST debuted in 2010 and is not trailer mounted, nor is it mobile. The FSST is mounted to a concrete foundation, hence the term "fixed." It is virtually identical to SETSS from an RF and performance perspective, and it can support eight simultaneous aircraft operations. The FSST is capable of 70 MHz and/or L-Band. L-Band conversion allows the SATCOM technicians at the relay site to use SAT-Monics. Other major differences is that the FSST is newer, more commercial, and has auto-switching redundancy for most of its major devices (i.e., high power amplifiers [HPA], low noise amplifiers [LNA], block converters, tunable converters); therefore, the FSST has higher mission availability due to multiple redundancy in its system. Failed devices are switched offline in less than a second and are rarely noticed by the user. The FSST has a larger graphical user interface (GUI) than SETSS that allows for the control of up to 20 FSSTs in a single interface. The SETSS are currently being added to that larger GUI so a larger dashboard of FSSTs and SETSS can be seen at once. A FSST can operate in either Co-Pol or X-Pol configuration by moving a single patch cable. It can support both MQ-1/9 and Global Hawk missions. See **Figure 3.14**, Fixed Site Satellite Terminal; **Figure 3.15**, Fixed Site Satellite Terminal (Rear Aspect); and **Figure 3.16**, FSST Equipment Rack, for image familiarization of the FSST.

3.9.1.3.5 Low-Noise Amplifier (LNA). Located inside the FSST dish; designed to amplify the Ku signal prior to pushing to the spectrum analyzer. Allows for signal health monitoring.

3.9.1.4 Tactical Field Terminal (TFT). The TFT looks like a SETSS with the same performance characteristics. However, the TFT only has up and down converters for two simultaneous aircraft versus the eight seen in the SETSS/FSST, and the TFT has zero redundancy in its system. It is dedicated to the RQ-4 Global Hawk. TFTs are not currently configured for MQ-9 operations. See **Figure 3.17**, Tactical Field Terminal, for image familiarization of a TFT.

Figure 3.13 SATCOM Earth Terminal Subsystem.

Figure 3.14 Fixed Site Satellite Terminal.

Figure 3.15 Fixed Site Satellite Terminal (Rear Aspect).

Figure 3.16 FSST Equipment Rack.

Figure 3.17 Tactical Field Terminal.

3.9.1.5 Cross Polarization (X-Pol). The polarization orthogonal to the polarization being discussed. For instance, if the field is meant to be horizontally polarized, the X-Pol will be the vertical polarization.

3.9.1.6 Co-Polarization (Co-Pol). Desired polarization component (i.e., transmitting on vertical-receive on vertical).

3.9.1.7 SAT-Monics. SAT-Monics is a distributed satellite communications monitoring system used at most operational relay sites. From a central network operations center (NOC) (e.g., the PAROC Network Operations Branch [NOB]) or relay site, technicians can monitor data and spectrum from an unlimited number of remote monitoring sites. Each local network server allows the local (or remote) site to function as part of the network or autonomously. Measurement data and spectral traces are stored for viewing via a digital spectrum analyzer. This allows the relay site technicians to operate/manage all MQ-9 data links from the desktop rather than constantly running back and forth to the server room, the patch panel for a mute/unmute, and the spectrum analyzer for signal health/wellness. Current requirements to run SAT-Monics at a relay site is to have a Ku or L-band conversion kit.

3.9.1.8 Barret Asymmetric Digital Computer (BADDC). BADDC allows for simultaneous use of multiple payload systems such as Air Handler and the Lynx Block 20A SAR. The BADDC accomplishes this by splitting the data being routed over the External 1 data channel between the various payloads. In order to take full advantage of the BADDC capabilities, a BADDC must be installed on the aircraft and in the cockpit. This allows the management of data entering and exiting the payload systems and routes that data over digital data link between the aircraft and the cockpit. The BADDC is controlled by a separate computer connected to the cockpit BADDC enclosure and is not directly controlled by the aircrew.

3.9.1.8.1 BADDC Operation. The BADDC has two modes of operation: Legacy and BLOS. The legacy mode allows for the support of legacy pods and allows the bypassing of the BLOS architecture to take place. In order for the BADDC to operate in the Legacy mode, the LRE must install a bypass plug that connects the legacy pods to the SATCOM system directly. In order to finalize the legacy mode operation, the MCE crew should set the BADDC in the cockpit to switch A. In BLOS mode the BADDC is able to use the BLOS architecture. The aircraft BADDC is powered through the payload power distribution module (PPDM) switches and may be monitored from VIT 53. PPDM 1 switch number 15 is the switch that provides power to the aircraft BADDC. The MCE aircrew should set the cockpit BADDC to switch B in order to operate in BLOS mode. It should be noted that when an aircraft has BADDC the RSM should be set to LYNX and the MCE cockpit must have a BADDC equipped in order for payloads to send data on External 1.

3.9.1.9 Ku-to-Ku Satellite Transfer. Current software allows in-flight migration of satellite CL and RL between separate satellites on both geostationary and inclined orbit satellites.

3.9.1.9.1 This upgrade does not require the aircraft to be gained by a LRE in order to accomplish the satellite-to-satellite migration.

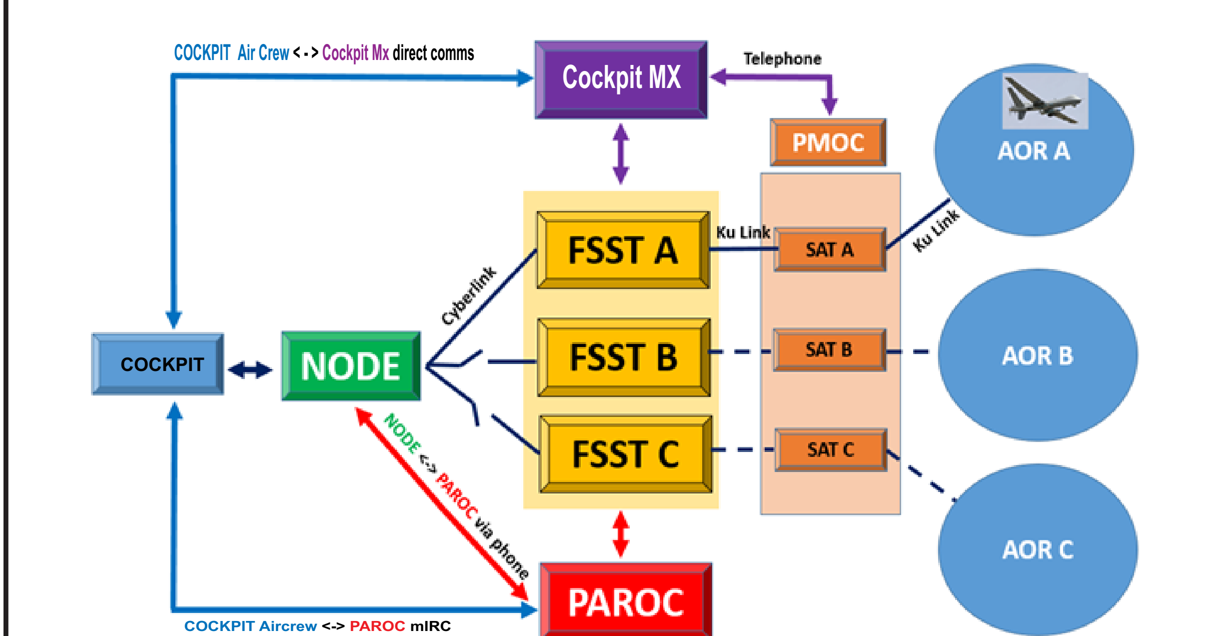
3.9.1.9.2 Satellite migration allows operations far from the LRE that require multiple satellite footprints to reach the AOR.

3.9.1.9.3 Successful Ku-to-Ku migration procedures require coordination and planning beyond the explanation in the TO. Aircrew should be thoroughly familiar with all the facilities involved. It is important to understand that the aircraft, satellite, and FSST (or SETTS) must all be within the same satellite footprint. The PAROC and Node geolocations are agnostic. The following paragraphs explain the PAROC, Node, FSST, and PMOC facilities involved.

3.9.1.9.3.1 Persistent Attack and Reconnaissance Operations Center (PAROC). This facility provides the C2 function when conducting a satellite transfer. See Figure 3.18, 2406 Satellite Transfer CONOP Diagram. This diagram indicates the flow of information during the satellite transfer. Most of the communication is transparent to the crew so they can focus on flying the aircraft.

3.9.1.9.3.2 Node. The network Circuit to Packet (CTP) control facility. The Node performs network routing of the IP network between the cockpit and the FSST locations, also known as the CTP pathway. The PAROC will coordinate with the Node to change the IP RSO path to the gaining FSST during the transfer.

Figure 3.18 2406 Satellite Transfer CONOP Diagram.



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3.9.1.9.3.3 FSST. There may be two geographically separated FSST locations necessary to switch satellite footprints. They will be referred to as the gaining FSST (SAT B GUI Tab) and losing FSST (SAT A GUI Tab). FSSTs do not have to be geographically separate for a satellite migration. Depending on satellite footprints, two geographically separate FSSTs may be required.

3.9.1.9.3.4 Payload Management Operations Center (PMOC). Civilian agency that coordinates with the satellite owners/providers. Cockpit MX will call them during the unmuting and muting process. Applies for CONUS operations only otherwise accomplished by the relay site.

3.9.1.9.4 Premission Planning for Satellite-to-Satellite Transfer.

3.9.1.9.4.1 Significant preflight planning is required in order to successfully conduct satellite-to-satellite transfers. This process should be a part of normal mission planning within the unit's mission planning cell (MPC). To conduct transit operations over/through host nation airspace properly, coordination with the host nation(s) is appropriate. This process should also include emergency mission management during host nation transit.

3.9.1.9.4.2 The AOR that the aircraft transits to may include overflight of several host nations, requiring multiple country-appropriate COAs. Normally, the FAA is not involved in any of the COA coordination since the MQ-9 operates almost exclusively from deployed locations. The exception in this case might be disaster relief such as Haiti (or other Caribbean nations) with LRE operations conducted from Puerto Rico, which would fall under the FAA's oversight.

3.9.1.9.4.2.1 Aircrew should plan on a minimum of seven days prior and determine/coordinate the following items.

- LRE location and mIRC channel.
- MCE AOR location and mIRC channel.
- FSST Location and POC.
- PAROC POC and mIRC channel.
- Coordinate with PAROC NOAD to determine satellites available for migration.
- Node POC (as a backup; direct communication with the Node is not required).
- Local cockpit comm POC.

3.9.1.9.4.2.2 The 556 TES designed a coordination sheet that can be modified/adjusted to best suit individual operational units and/or squadron operations. To assist with items in **paragraph 3.9.1.9.4.2.1**, the form should be submitted to the PAROC NLT seven days prior to execution. See **Figure 3.19**, PAROC SAT to SAT Transfer Request Form.

3.9.1.9.5 Determining the Satellite-to-Satellite Transfer Point.

3.9.1.9.5.1 In order to properly determine the location where satellite-to-satellite transfer should be successful, the aircrew must determine an acceptable EIRP geographic region. The required minimum EIRP for the MQ-9 is 35 dBW. Conventional MQ-9 operations operate at approximately 40 to 50 EIRP. Above 50 EIRP is wasted energy. EIRP can be manipulated by changing FSST or cockpit attenuation. Manual manipulation of EIRP is important in regions of geographically extended footprints where EIRP drops below 40.

3.9.1.9.5.2 SATBEAMS and BaTars. There are two techniques for determining the EIRP level for effective satellite-to-satellite transfer requirements. The two techniques are SATBEAMS and BaTars. ***Note:*** BaTars is a satellite planning tool only available on JWICS. The procedure to use BaTars is outlined after the SATBEAMS description.

3.9.1.9.6 SATBEAMS.

3.9.1.9.6.1 SATBEAMS Setup. Using NIPR, go to **www.satbeams.com**. Click "Footprints" on the menu bar. See **Figure 3.20**, Footprints. On the footprints menu, select which satellite to use. Also, select which beam on that satellite to view. See **Figure 3.21**, Select Your Satellite. The desired satellite footprint will now populate the screen. Ensure the AOR falls underneath the displayed footprint. Satellite location will also populate the same screen. See **Figure 3.22**, Satellite Footprint. Click on a contour line to view signal strength in EIRP dBW. See **Figure 3.23**, Contour Line. Repeat steps for the second mission satellite.

3.9.1.9.6.2 Using **www.satbeams.com**, the aircrew should make clipping-tool copies of each of the two satellites they are attempting to transfer between. See **Figure 3.24**, ARSAT2, and **Figure 3.25**, ECHOSTAR105, the example figures show both ARSAT2 and ECHOSTAR105 satellites overlaying the Nevada Test and Training Range (NTTR).

3.9.1.9.6.3 The available EIRP level is readily available on **www.satbeams.com** by clicking on the geographic location. The EIRP level for ECHOSTAR105 is 40 dBW and the EIRP level for ARSAT2 is 38 dBW. This information tells the aircrew that a successful transfer is feasible since both EIRP levels are greater than 35 dBW.

Figure 3.19 PAROC to SAT Transfer Request Form.

PAROC SAT to SAT Transfer Request Form			REV: alpha 4 Current as: 3/9/18
Instructions: Missions requiring a second satellite will complete this form and submit it to the PAROC at least 7 days prior to planned mission execution. The PAROC will return the request at least 4 days prior to the mission to provide time to complete adequate time for pre-mission planning.			
AIRCREW COORDINATION			
SECTION I - REQUESTING AGENCY INFORMATION			
a. POC NAME (*Last, First*)	b. GRADE	c. SQUADRON	d. POC DSN
e. POC VOSIP	f. POC E-MAIL (*SIPR*)		
g. Squadron (Ops Sup/MD) VOSIP	h. Squadron E-MAIL (*SIPR*)	i. Squadron DSN	
SECTION II - MISSION INFORMATION			
a. GCS	b. CALL SIGN	c. DATE(S) REQUIRED (*mm/dd/yyyy*) From: To:	
d. Estimate SAT A -> B Transfer Date/Time (Zulu)		e. Estimated SAT B -> A Transfer Date/Time (Zulu)	
f. LAUNCH LRE (*Geographic Location/DIP #*)	g. LAND LRE (*Geographic Location/DIP #*)		h. RO CAPABLE: Yes / No i. RL DATA RATE: 3.2 / 6.4
j. ROUTE ATTACHED? Y/N	Provide proposed flight routing (Zeus or other flight planning tool)		
k. DEFINE OPERATING AREA (*Provide a general location for the operational area driving the need for a second satellite*)			
NOTES (*Additional information the PAROC may need to provide suppo*)		m. Email completed Sections I and II to PAROC ORG box at NIPR Hyperlink SIPR Hyperlink	
PAROC COORDINATION			
SECTION III - SATCOM INFORMATION			
a. PAROC POC (*Last, First*)	b. DSN	c. VOSIP	
SECTION IV - SATELLITE A			
a. FREQUENCY NAME	b. ORBIT (*GEO or Inclined Orbit*)	c. INTELSAT	d. POLARIZATION
f. COMMAND LINK (*In megahertz*)	g. RETURN LINK (*In Megahertz*)	h. RELAY PHONE - VOSIP	
SECTION V - SATELLITE B			
a. FREQUENCY NAME	b. ORBIT (*GEO or Inclined Orbit*)	c. INTELSAT	d. POLARIZATION
f. COMMAND LINK (*In megahertz*)	g. RETURN LINK (*In Megahertz*)	h. RELAY PHONE - VOSIP	
SECTION VI - SATELLITE C			
a. FREQUENCY NAME	b. ORBIT (*GEO or Inclined Orbit*)	c. INTELSAT	d. POLARIZATION
f. COMMAND LINK (*In megahertz*)	g. RETURN LINK (*In Megahertz*)	h. RELAY PHONE - VOSIP	
		SECTION VII - ADDITIONAL NOTES	
SECTION III, IV, V, AND VI COMPLETED			
SAT TRANSFER-CTP PLANNING COMPLETED			
RETURN FIRST PAGE TO AIRCREW			

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Figure 3.20 Footprints.

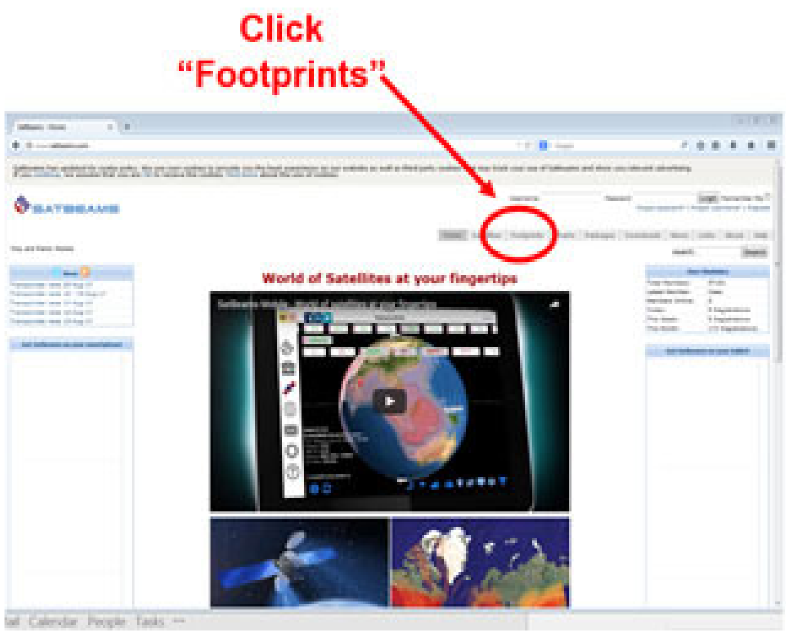

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Figure 3.21 Select Your Satellite.

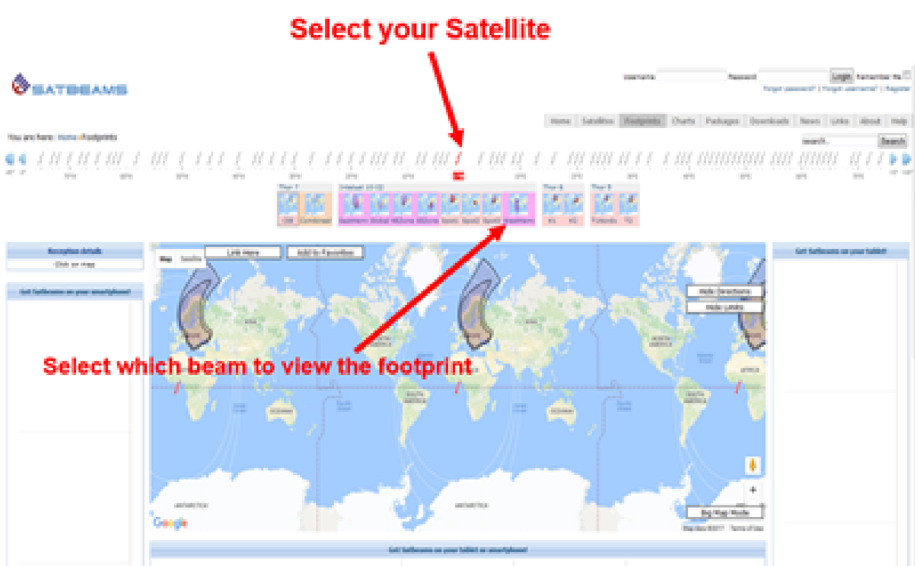

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Figure 3.22 Satellite Footprint.

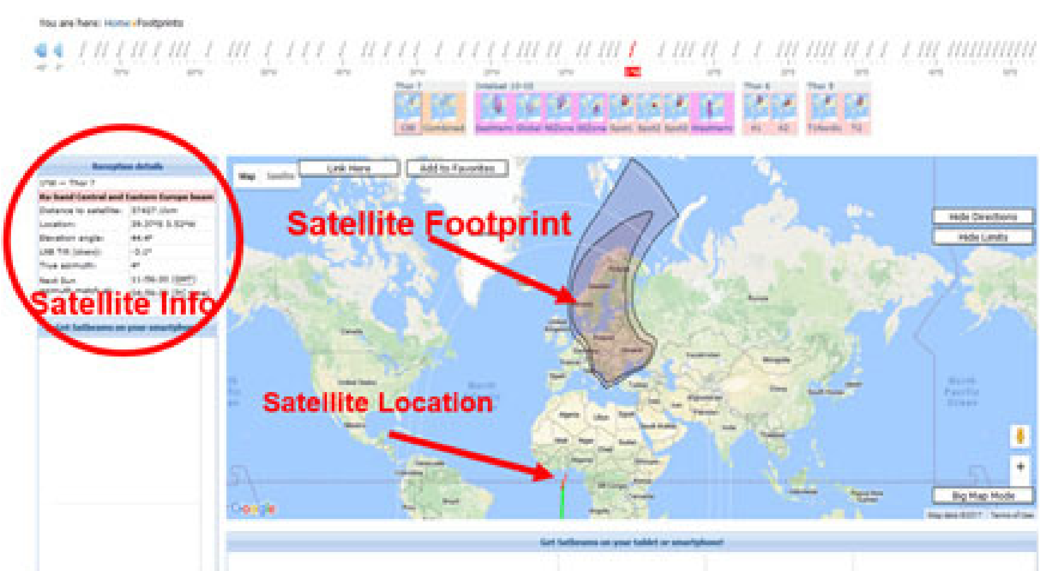

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Figure 3.23 Contour Line.

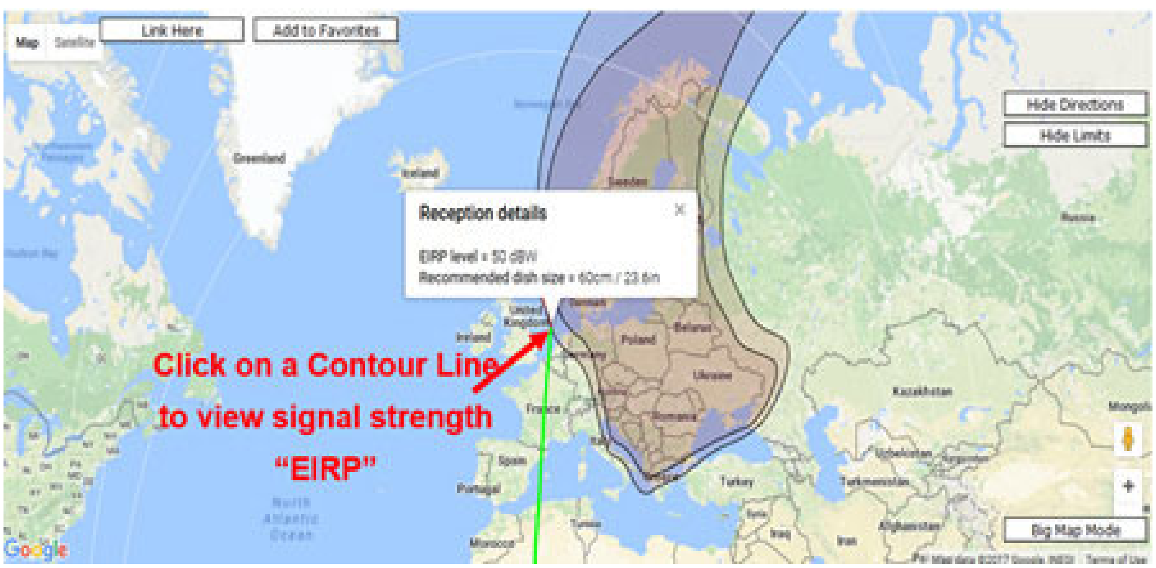

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Figure 3.24 ARSAT2.

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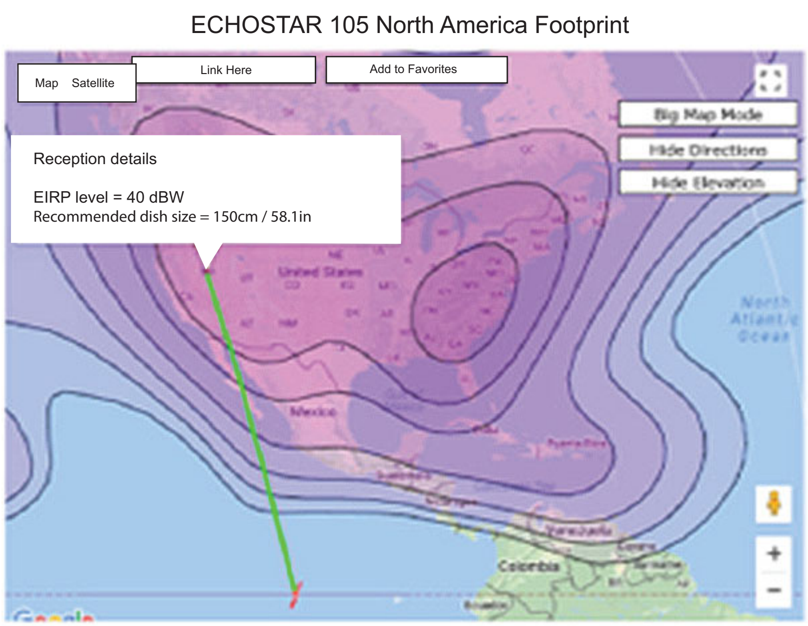
Figure 3.25 ECHOSTAR105.



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3.9.1.9.6.4 The aircrew should determine based on operational, routing, COA, country boundaries, restricted operating zones (ROZ), restricted airspaces, etc., where an acceptable transfer point can occur. The aircrew should allow up to 60 minutes for Cockpit-PAROC-NODE-FSST coordination to occur. If pre-coordination is planned, the process can take less than 30 minutes. This is a technique for satellite migration, but is not required due to current software capabilities. These techniques are best for preplanned missions, such as if going to an AOR outside the range of the satellite covering the LRE or if airspace is restricted. Satellite migrations can happen real time without requiring an op mission. The crews can auto-swap to Tab B or C after doing the coordination. The aircrew should plan for either a 30 to 60 minute loiter transfer point, or a 30 to 60 minute straight-leg transfer point, taking into consideration winds at altitude and all the previously mentioned items. The transfer loiter point or transfer leg should be accomplished on a preprogrammed mission with the transfer loiter point or leg set to the gaining satellite. The transfer point should be coincident with overlapping satellite footprints greater than 35 EIRP.

3.9.1.9.6.4.1 It is critical that the aircrew understand that the emergency mission should be set to the losing satellite, so that in the case of an unsuccessful transfer, the aircraft regresses to the losing satellite and an attempted Ku regain can occur. The last six of the emergency mission should be at a location that the LRE can gain the aircraft in line of sight should the regression procedure fail. See **Figure 3.26**, Satellite Transfer Preprogram Mission With Loiter; **Figure 3.27**, Satellite Transfer Preprogram Mission with Straight Leg; **Figure 3.28**, Satellite Transfer Emergency Mission; and **Figure 3.29**, Emergency Mission after Successful Satellite Transfer.

3.9.1.9.7 BaTars. This can only be accomplished on JWICS.

3.9.1.9.7.1 Determine satellite transfer will be necessary based on planned mission routing.

3.9.1.9.7.2 Complete the PAROC coordination sheet and submit form as soon as possible. (https://intelshare.intelink.sgov.gov/sites/paroc/noad).

3.9.1.9.7.3 Confirm the PAROC request transfer form has been filled out by the PAROC and initialed at the bottom of page 1.

3.9.1.9.7.4 Determine the XML file names representing the satellite footprints of the assigned Ku frequencies (https://intelshare.intelink.sgov.go/sites/paroc/noad).

3.9.1.9.7.5 Open the KML files in Google Earth on JWICS.

3.9.1.9.7.6 Deselect/declutter all footprint rings except for the outermost ring with greater than 35 EIRP for each satellite.

Figure 3.26 Satellite Transfer Preprogram Mission With Loiter.

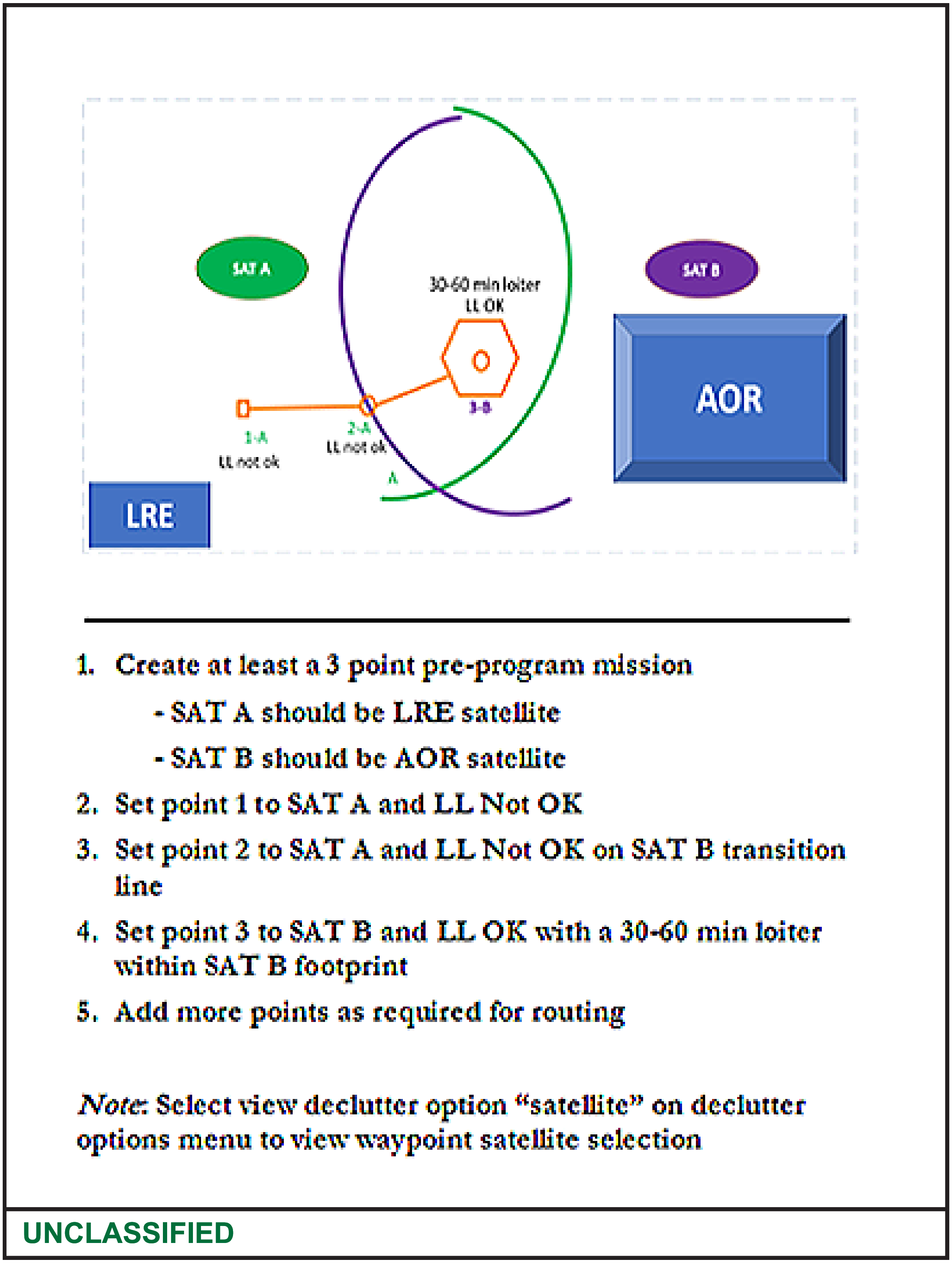
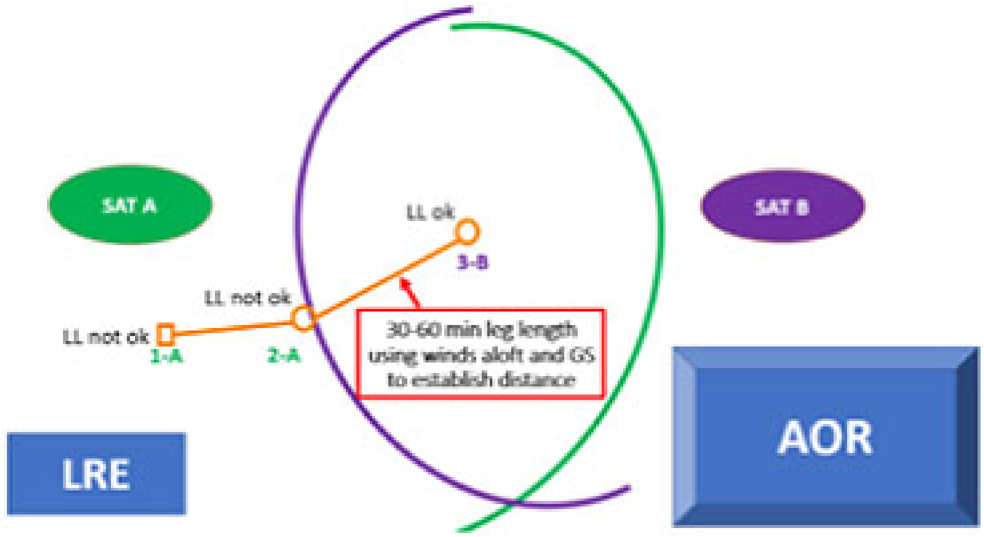


Figure 3.27 Satellite Transfer Preprogram Mission With Straight Leg.



1. Create at least a 3 point pre-program mission
   - SAT A should be LRE satellite
   - SAT B should be AOR satellite
2. Set point 1 to SAT A and LL Not OK
3. Set point 2 to SAT A and LL Not OK on SAT B transition line
4. Set point 3 to SAT B and LL OK within SAT B footprint. Determine the leg length from point 2 to point 3 for 30-60 minutes, given current groundspeed.
5. Add more points as required for routing

Note: Select view declutter option "satellite" on declutter options menu to view waypoint satellite selection

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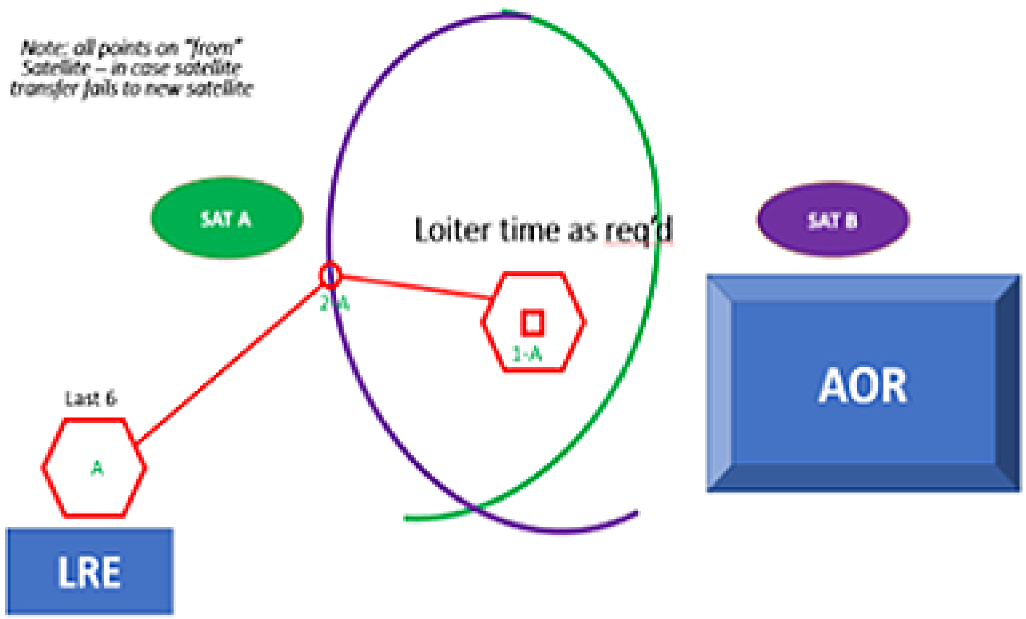
Figure 3.28 Satellite Transfer Emergency Mission.



1. Create at least a 3 point emergency mission
   - SAT A should be commensurate with LRE satellite footprint
   - *SAT A should be set in all points*
2. Set point 1 to SAT A near the satellite migration point
3. Set point 2 to SAT A on SAT B transition line
4. Set point 3 to SAT A within SAT B footprint
5. Add more points as required for routing

Note: Select view declutter option "satellite" on declutter options menu to view waypoint satellite selection

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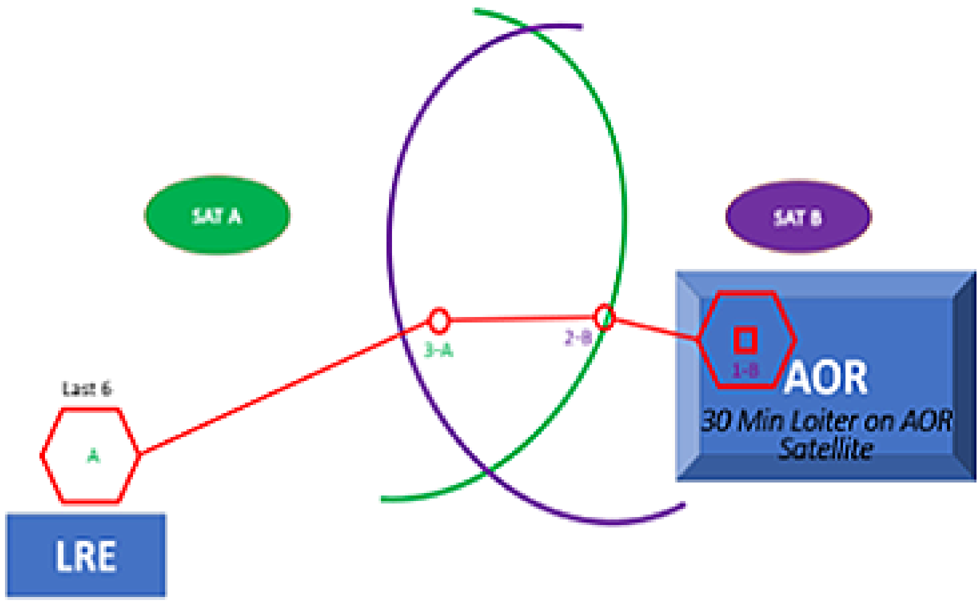
Figure 3.29 Emergency Mission After Successful Satellite Transfer.



1. Create an emergency mission with a 30-60 minute loiter in the AOR on SAT B
2. Set entry waypoint to point 1
3. Set point 2 on SAT B at the boundary of SAT A footprint
4. Set remaining routing points back to last 6 at LRE on SAT A

Note: Select view declutter option "satellite" on declutter options menu to view waypoint satellite selection

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3.9.1.9.7.7 Plot flight plan routing into Google Earth.

3.9.1.9.7.8 Compare flight plan routing with overlap of the satellite footprints to identify the handover boundary.

3.9.1.9.7.9 Determine start point of the operational mission with lost link OK by balancing the distance and time possibly spent without return link against the probability of successfully completing the handover. A successful handover will be determined by two primary factors. First, the strength of the gaining satellite (SAT B) at the handover boundary must be strong enough for Ku operations (greater than 35 EIRP). Second, the time required to execute the satellite transfer time line as well as all external coordination actions (recommend at least 30 minutes for this process). Use the higher distance estimate considering both factors (estimate operational mission between 60 to 80 NM, if possible).

3.9.1.9.7.10 Plan operational mission points with appropriate satellite tab, lost link status, airspeed, and loiters. Recommend that the view -> declutter option be used on the tracker and enable the satellite at each point. This will ensure the mission properly reflects the plan to cross the transition boundary since the crew will be unable to change the mission after reaching the first satellite transition point.

3.9.1.9.7.11 Determine and record the time from the first satellite transition point to SAT B (Aircraft loses RL) until the aircraft executes the emergency mission using Zeus or other planning tool. This time will be used during execution to determine if the satellite regression procedures need to be run in the event of an unsuccessful satellite transfer.

3.9.1.9.7.12 Plan the follow-on emergency mission points with the new satellite (e.g., SAT B), airspeed, altitude, and loiters if the transfer is successful. If the emergency mission will transition back to the losing satellite (e.g., SAT A) in the event of a return to the LRE, then determine and record the time until the satellite regression to SAT A.

CHAPTER 4

GROUND OPERATIONS, LAUNCH, AND RECOVERY

4.1 Introduction. In order for an MQ-9 to be mission successful, it must get airborne safely, and land safely. The remote split ops (RSO), beyond-line-of-sight (BLOS) capabilities, and growing number of payloads organic to RPA demands a special focus devoted to launch and recovery. Whether in the launch or recovery phase, a high level of situational awareness and crew coordination is paramount.

4.2 Ground Operations. Diligent ground operations and preflight inspections of the aircraft ensure it is configured to complete combat air tasking order (ATO) or garrison flying mission (e.g., fuel, weapons, specialized equipment, etc.).

4.2.1 Walk-Around. Follow the exterior inspection, weapons, and payload checklists. Tires should have even wear and have enough tread to disperse water and avoid hydroplaning in wet conditions. Bald spots can cause hydroplaning and maintenance should be notified. Furthermore, it is unacceptable for tires to be worn down to the second layer of ply, which appears as a crosshatch pattern. A single layer of exposed ply is acceptable. See **Figure 4.1**, Singly Ply Acceptable Tire for Dry Conditions. Worn brake pads are indicated by lack of a wear indicator on the back side of the caliper. If unable to catch a fingernail on the indicator, notify maintenance. See **Figure 4.2**, Brake Pad Wear Indicator. Spin the propeller to ensure free of binding and feel the leading edge of the blades. Surface nicks in the paint are fine, however nicks or dents that have displaced the metal of the prop (stress risers) require maintenance. See **Figure 4.3**, Prop Damage, Paint Chips, and Blends.

Figure 4.1 Single Ply Acceptable Tire for Dry Conditions.

Figure 4.2 Break Pad Wear Indicator.

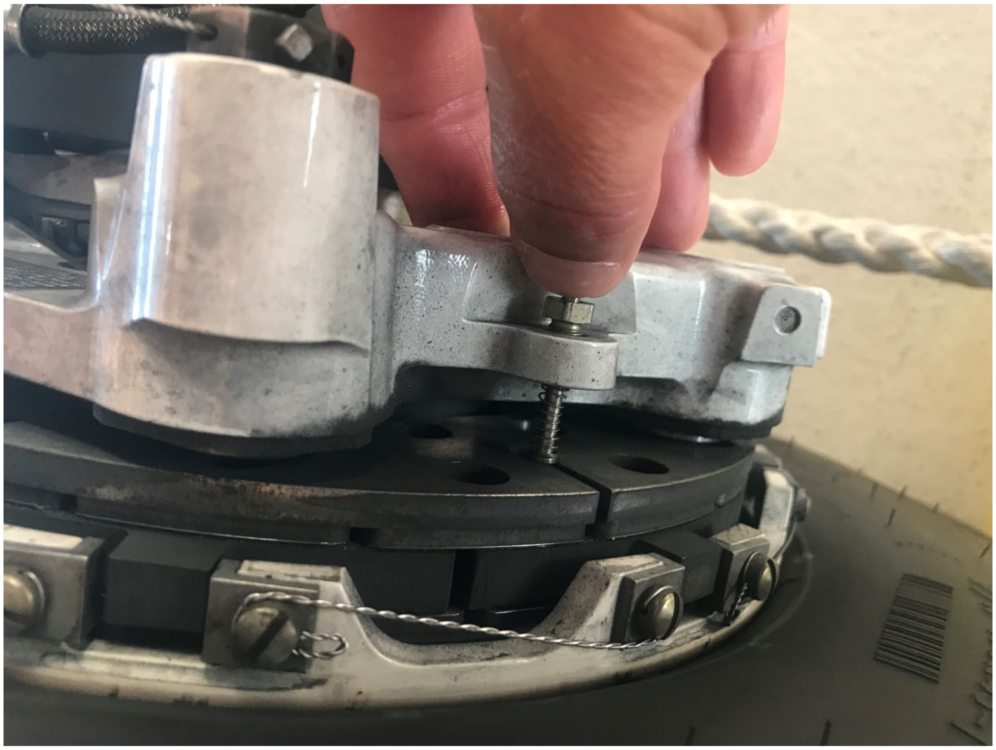


Figure 4.3 Prop Damage, Paint Chips, Blends.

4.2.2 AFTO Forms 781. 781 F contains aircraft weight and software version. 781 H has the signatures of maintenance preflight (required to be within 72 hours for aircraft and 48 hours for ground control station [GCS]) and the exceptional release by the maintenance supervisor. A red "X" indicates equipment is unsafe or unserviceable for flight and corrective action is needed. A "-" indicates the condition of equipment is unknown and a more serious condition may exist. A "/" indicates a discrepancy exists but is not sufficiently urgent or dangerous to warrant grounding or discontinued use. The 781 H also contains aircraft time, fuel and oil levels. 781 A contains maintenance and service notes: corrective actions, oil and fuel servicing, tire servicing (within 6 hours), battery charging (within 12 hours), Mode 4 crypto loading and weapons loads. At the end of the list, ensure there is a red line with the initials of the maintenance supervisor, this confirms the extent of the exceptional release. 781 K and J contains the required hourly and periodic inspections. Ensure aircraft, engine, propeller, alternator times, or other periodic inspections have not been exceeded prior to flight. Certain inspections can be overflown by a certain percent, or are "end of day" inspections. Ask maintenance if unsure.

4.3 Weapons Preflight. Proper preflight of ordnance is critical. Conduct the weapons preflight check while referencing the appropriate sections of the Dash 34 checklist. Coordinate with maintenance personnel to correct any deviations.

4.3.1 Bomb Rack Unit-71 Suspension Rack. The BRU-71\A, housed entirely within the wing pylon, has two independent, self-latching suspension hooks and two pneumatically operated ejection pistons. It also contains three zero-retention arming units (fore, center, and aft) and four positive attaching points (two per side). See **Figure 4.4**, BRU 71 (BRU-71\A) Suspension Components. A safety flag will always be at the 12 o'clock position. If the flag is not in position, notify weapons maintenance. When checking the pneumatic system, ensure the pressure is at 3,250 psi ±150 for releasable ordnance (live GBU or heavyweight inert). For simulated or training munitions (T) ensure the pressure reads "0" and the hooks are in the open position. See **Figure 4.5**, BRU-71 (BRU-71\A) Hardware Components. Cannon plugs within the rear access panel connect to the J1 plug for free-fall munitions, or to the D1 plug for forward-firing munitions. See **Figure 4.6**, BRU-71 (BRU-71\A) Rear Access Panel Plugs.

4.3.2 M310 (2 place)/M299 (4 place) Launch Rails. The M310/299 mounts directly to the BRU-71 in the same manner as a suspended GBU. As with a GBU, maintenance will install a safety pin on the right side of the BRU-71. Additionally, there will be a cannon plug at the front of the BRU-71 attached to the front of the M310/299, external to the pylon. This is the main communication interface between the aircraft SSIU and the AGM-114 missiles on the rail. On the front face of the launch rail is a SAFE/ARM switch. During ground ops, the switch should be in the SAFE position.

4.3.3 GBU-12 Preflight. During the GBU-12 preflight, the aircrew is concerned with five main areas: integrity and security, safety pins, lanyards, fuzing, and the computer control group (CCG).

4.3.3.1 Integrity and Security. Looking at overall suspension of the bomb, check for alignment along the axis of the pylon. The suspension sway braces should be in contact with the bomb body and snug. The bomb, particularly the tailkit and nose section, should be free from dents, deep scrapes, and any other obstructions.

Figure 4.4 BRU 71 (BRU-71\A) Suspension Components.

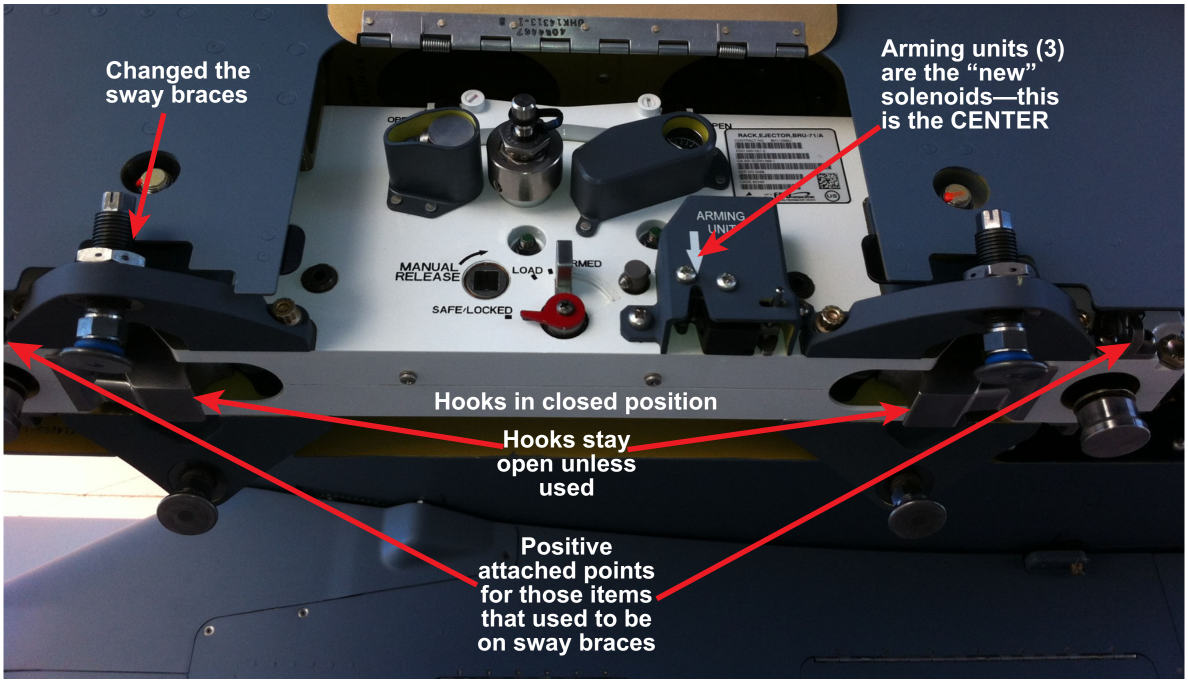


Figure 4.5 BRU-71 (BRU-71\A) Hardware Components.

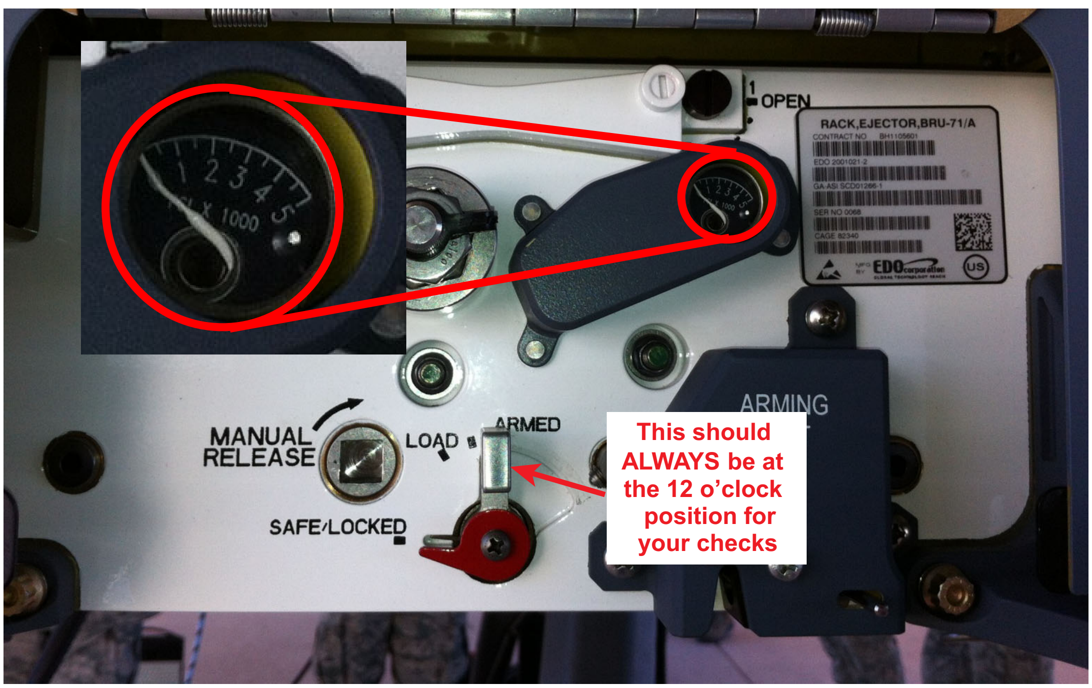
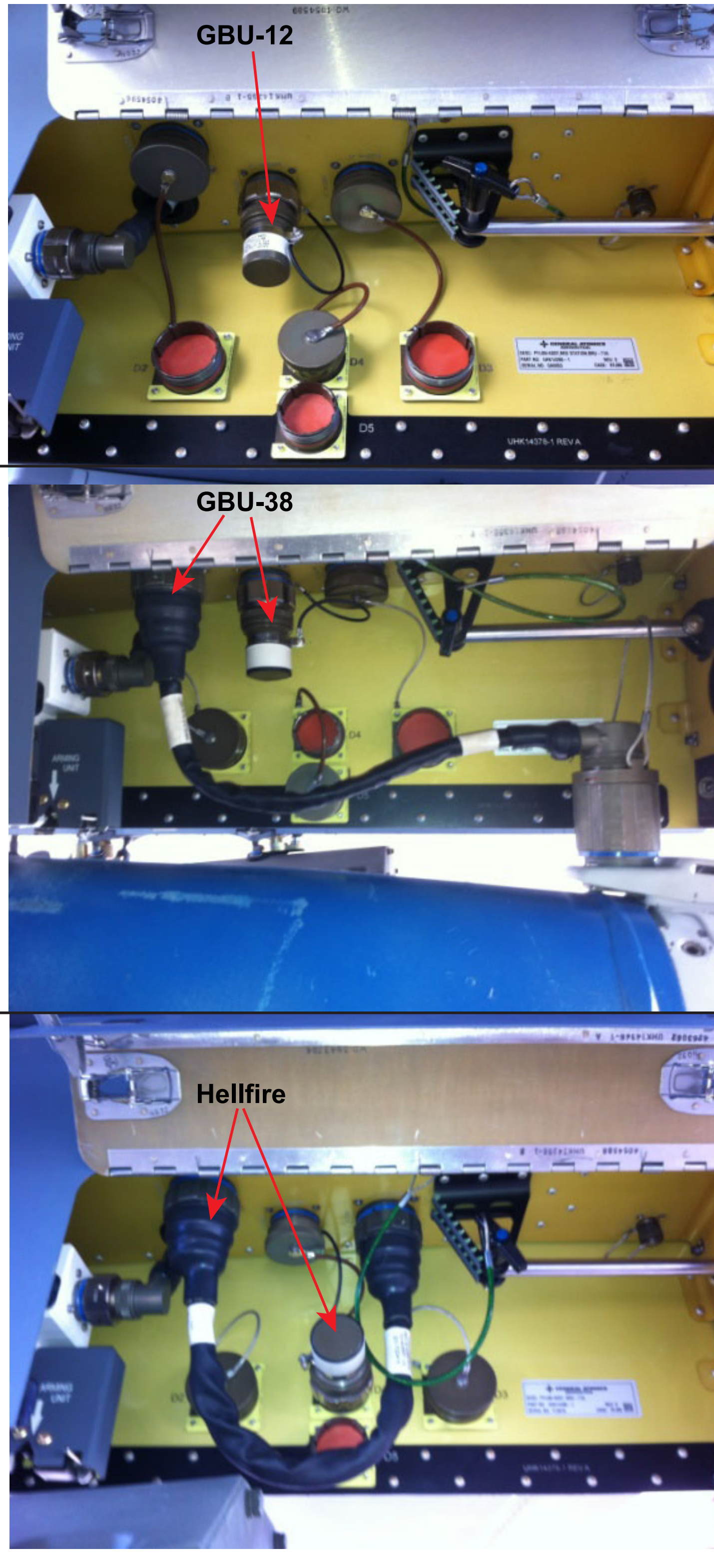


Figure 4.6 BRU-71 (BRU-71\A) Rear Access Panel Plugs.



4.3.3.2 Safety Pins. There are five safety pins installed for the GBU-12 preflight (not counting the BRU-15/71 safety pin). From nose to tail, these are the CCG dust cover pin, battery-firing device (BFD) safety wire pin, latch frame safety pin, aft fin assembly pin, and the fuze safety clip. Ensure that installed pins have enough play for removal on the explosive ordnance ramp (EOR) but not so much that they fall out accidentally and be a foreign object damage (FOD) hazard. Should one of the pins be missing, come loose, or appear to be stuck, contact weapons maintenance.

4.3.3.3 Lanyards. There will be up to three wires running between the GBU-12 and the BRU-71. As the bomb falls away from the aircraft, these wires pull pins on the bomb that, in turn, actuate different systems. Therefore, it is important to make sure that the wires connect at the appropriate points and route properly through the equipment, so that each system on the bomb will actuate in the correct sequence.

4.3.3.3.1 The longest lanyard runs from the forward attach point, along the bomb body, through the BFD and attaches to the forward guide post. This lanyard, when pulled, activates the CCG. Failure of this lanyard will most likely result in a no-guide condition.

4.3.3.3.2 A second, much shorter lanyard runs from the aft attach point to a position approximately 120 degrees under the bomb to the tailfin kit. To deploy the tailfins, adequate force is required to remove the lanyard due to heavy spring load on the tailfin kit. Failure of this lanyard will result in an uncontrollable bomb.

4.3.3.3.3 The third lanyard runs from the FZU-63 fuze initiator to the center arming unit. Failure of this lanyard would result in a dud.

4.3.3.4 Fuzing. At present, the fuze options for MQ-9 GBU-12 is the fuze munitions unit (FMU)-152 (with FZU-63). MQ-9 GBU-12s are typically a single-fuze weapon with the FMU-152 only in the tail. Due to the GBU-12 CCG over the nose fuze well, only the tail fuze will be visible. To see the tail fuze, stand at the back of the bomb and look-through the tailfin kit. A flashlight is helpful to see the fuze settings if using a tail FMU-152. Typically, munitions personnel will write the settings on the tailkit and/or bomb body to show the actual tail fuze settings for both nose and tail.

4.3.3.5 The FMU-152 is the joint programmable fuze (JPF) which can be installed in the tail well of the GBU-12.

4.3.3.6 Munitions storage area personnel, those who built the bomb, should have written the fuze settings on the bomb case. The nose fuze settings cannot be verified, but ensure that the tail fuze settings match what the mission requires and what has been written on the bomb body. If fuze settings need to be changed, contact the production supervisor to have the munitions storage area representative report to the aircraft for changes.

4.3.3.7 Computer Control Group. The CCG (enhanced CCG on the GBU-49) is the brains of the GBU-12. Check the general condition of the seeker to include cleanliness of the nose lens, stabilization of the laser receiver (inside the lens), Styrofoam packing blocks removed, and control fins unobstructed. Ensure the appropriate PRF code is set in the dial at the aft end of the CCG. On older CCGs, the numbers can be rubbed off or missing. If this is the case, a common technique used to ensure the appropriate code is set is to return the wheel all the way to “1” position (counter-clockwise). Then count the clicks ensuring the correct code is set (e.g., to set 1,511, turn the second wheel all the way to the left [counter-clockwise to 1] and then back to the right [clockwise] four clicks to the "5" position). On some of the MAUs available, there is a selection for long last pulse logic (LLPL) and short last pulse logic (SLPL) for the laser code to be set. Set the laser code on the LLPL side. For further information, consult the AFTTP 3-1.MQ-9 and the SECRET supplement of the TO 1M-34.

4.3.4 GBU-38 Preflight. During the GBU-38 preflight, the aircrew is concerned with four main areas: integrity and security, safety flag, lanyards, and fuzing.

4.3.4.1 Integrity and Security. Looking at overall suspension of the bomb, check for alignment along the axis of the pylon. The suspension sway braces should be in contact with the bomb body and snug. The bomb, particularly the tailkit and nose section, should be free from dents, deep scrapes, and any other obstructions.

4.3.4.2 Safety Flag. Ensure one safety flag installed for the GBU-38 preflight. Ensure that installed flag has enough play for removal on the EOR but not so much that they fall out accidentally and be an FOD hazard. Should the flag be missing, come loose, or appear to be stuck, contact weapons maintenance.

4.3.4.3 Lanyards. The arming lanyard between the GBU-38 and the BRU-71 should be connected directly to the center arming solenoid and the FZU-63B in the fuze well of the bomb. As the bomb falls away from the aircraft, this wire pulls the turbine into the slipstream, enabling spin-up of the turbine and power generation to begin. Failure of this lanyard will result in a dud.

4.3.4.4 Fuzing. There is only one fuze option for MQ-9 GBU-38s—the FMU-152B/B JPF. Maintenance needs to open the cover to view the actual fuze settings. Munitions personnel may mark the fuze settings on the tailkit and/or bomb body.

4.3.4.4.1 The FMU-152B/B is a more complex electrical fuze. This allows the GBU-38 to be employed at the relatively slow release speeds of the MQ-9 but still maintain programmable features. The FZU-63B is the only fuze initiator authorized for us on the MQ-9. The FZU-63B can be identified by the stencil on the side of the bomb (MQ-9 use only) below the fuze well as shown in **Figure 4.7**, FZU-63B Stencil; and by the faceplate of the initiator visible when the access panel to the BRU-15/71 has been opened.

4.4 Start-Up Through Departure.

4.4.1 Ground Data Terminal Power. When powering on the ground data terminal (GDT), remain cognizant of other aircraft operations in the area. Local procedures and/or directives may provide additional information on C-band frequencies allocation to mitigate issues in congested signal environments. Using the GDT narrow antenna in conjunction with low AV transmitter power can aid in LOS frequency deconfliction.

Figure 4.7 FZU-63B Stencil.

4.4.2 Engine Start. Conduct an engine start brief that includes safety considerations and abort criteria aligned with operational limits. After commanding engine start, look for an increase in rpm. Between 10 and 18 percent rpm, note an increase in fuel flow, accompanied by a rise in EGT. Verbalizing these indications as "ROTATION," "FUEL FLOW," and "LIGHT-OFF" will build situational awareness as both crew members monitor engine start. Consider guarding the condition lever in case a shutdown is warranted. At 65 percent rpm, the pilot moves the throttle from flight idle to ground idle and verbalizes the maximum EGT observed during engine start. The SO verbalizes rpm acceleration through startup (e.g., "10 PERCENT," "18 PERCENT," "28 PERCENT," "40 PERCENT," "50 PERCENT," "65 PERCENT"). The crew verifies max EGT and the SO passes to maintenance, "THROTTLE 65 PERCENT, MAX EGT WAS XXX." This helps maintenance monitor engine health.

4.4.3 Departure Brief. After checking ATIS (if available), brief the crew IAW 11-2MQ-9, Volume 3, required departure briefing items.

- The following mnemonic may be used to assist in brief completion: WET: weather, emergencies (ground, takeoff, departure, data link), type of procedure/TOLD.

4.5 Taxi.

4.5.1 Throttle/Speed Lever Considerations. Taxiing with the speed lever set to 85 percent or greater enables a smooth application of power in the ground torque range. After initial aircraft movement, set the speed lever back to low as required unless taxiing a heavyweight aircraft. Engaging Flight mode when advancing the throttle past the flight idle gate will cause a surge in thrust and taxi speed. Verbalize all throttle and speed lever position changes (i.e., “FLIGHT IDLE,” “GROUND IDLE,” “REVERSE”). (SO) Visually confirm all positions announced by the pilot.

4.5.2 Brake Check. Check aircraft brakes after initial forward movement from parking. Maintain awareness of taxiway gradients during the brake check. If the aircraft rolls backward, apply forward thrust to bring the aircraft to a stop. Applying brake pressure while rolling backward may result in a tail strike.

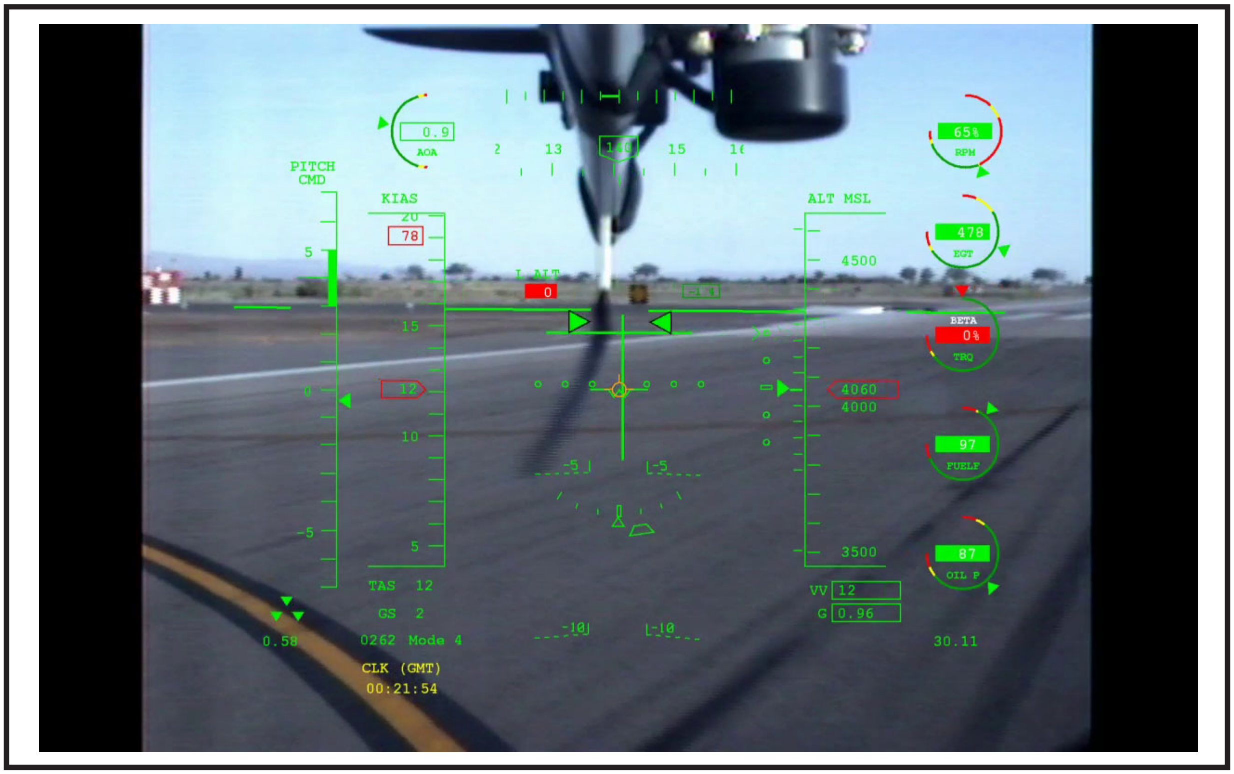
4.5.3 Steering Offset. Steering offset corrections aid in runway alignment in the event of a high speed lost link takeoff emergency. Consider yaw trim settings and winds before adjusting steering offset. Unintentional yaw trim input and gusty surface winds could lead to erroneous nosewheel steering corrections. If a change is required, notify the follow-on crews of the setting change.

4.5.4 Obstacle Clearance. Refer to AFI 11-218, *Aircraft Operations and Movement on the Ground*, for obstacle clearance requirements. Always prioritize aircraft control while clearing for potential FOD and obstructions. It is difficult to judge distance from obstacles with the nose and TGP cameras. Use wing walkers as required to ensure required separation while taxiing. Stop the aircraft and contact ground personnel for assistance if obstacle clearance is in question.

4.5.5 Turns. When approaching a turn, slow down as required and wait until the taxi line nearly disappears in the lower corner of the HUD before beginning the turn. Apply smooth, even pressure to the rudder pedal of desired turn. Use caution, as the last 10 percent of rudder pedal deflection controls over 60 percent of the nosewheel steering. Slow the aircraft while turning with the outside brake. Using the inside brake during a turn will pivot the aircraft faster and increase turn rate. Use the gear indicator in the bottom left, or altimeter setting in the bottom right of the HUD as guides to hold the taxi line while turning. See **Figure 4.8**, Taxi Turn. If the pilot loses the line from the HUD, the SO should place the TGP to Position mode to confirm the location of the taxi line. If the taxi line is not visible in the SO HUD with the TGP in position mode, with the aircraft stopped, the SO will slew the TGP to acquire the taxi line and relay the location to the pilot.

4.5.5.1 Vision. The field of view of nose cameras does not allow adequate visibility to clear in the direction of turns. (SO) Slew the TGP to clear both directions prior to starting a turn. Enhance crew SA by verbalizing obstacles, or lack thereof (e.g., “CLEAR LEFT AND RIGHT FOR THE RIGHT TURN” or “CLEAR RIGHT, VEHICLE HOLDING POSITION AND CLEAR LEFT FOR THE LEFT TURN”). At night, adjusting manual gain and level on the nose IR camera on legacy Nose IR cameras may be required for the best picture. Brightness and contrast settings of 150 and 69, respectively, will generally provide an optimal setting from which the pilot can start adjusting.

Figure 4.8 Taxi Turn.



4.5.5.2 180-Degree Turns. Unintentional yaw trim may prevent full nosewheel deflection and increase turn radius. Use the TGP to confirm the position the aircraft to one edge of the runway/taxiway ensuring the outside tire does not depart the prepared surface. Slow to under 5 knots ground speed and begin the turn with full-scale rudder deflection in the desired direction. Slower turn speed allows for a more controlled turn and decreases the turn radius. Higher speed and less than full-scale deflection will significantly increase turn radius.

4.5.5.3 Incline/Decline Turns. Approaching a decline turn, slow to 2 knots GS. Starting decline turns slower than normal allows for a slight acceleration, and easier speed control during the turn. When taxiing up an incline, add power as required to avoid stopping in the turn.

4.6 Takeoff and Departure.

4.6.1 Line-Up. If runway length is a concern, back taxi as required or to allow maximum usable runway. If selecting a GLS setting different from that of the takeoff runway due to emergency return considerations, at least one crew member should set takeoff runway GLS settings.

- The following mnemonic can be used as a safety check prior to takeoff: WARNSELF: Warnings, Start Point, Emergency Mission, Links, Flaps.

4.6.2 Takeoff Roll. The aircraft may pull slightly to the left initially due to P-factor. Use the rudder pedals to maintain centerline. As airspeed increases, the wing and tail control surfaces will become more effective. As the aircraft continues to accelerate and lift off, adjust control stick position to set a pitch angle that maintains the desired climb speed. The SO should make a "50 KIAS, good acceleration check" call when the acceleration check parameters are met and to indicate when the aircraft transitions to high speed lost link logic.

4.6.2.1 Rotation. To rotate, smoothly move the control stick aft to command the desired pitch angle. Typically, setting a 3- to 5-degree nose-high attitude provides smooth acceleration and lift off. (SO) Make a "Rotate" call based on TOLD, and "Airborne" once the laser altimeter and AGL increases.

4.6.2.2 Crosswind Takeoffs. For crosswind takeoffs, maintain directional control by commanding roll input on the control stick into the wind and use opposite rudder to help control drift. Use caution since any roll input will result in the aircraft banking to the commanded angle upon liftoff. Exceeding 9-degrees of roll may result in a wingtip strike. Once airborne, crab as required to track runway centerline.

4.6.2.3 Climb. Approaching climb speed, adjust pitch and/or power as required to maintain the desired airspeed.

4.6.2.4 Raise the gear when at a safe altitude that allows for extension if engine failure occurs upon takeoff. Delaying gear retraction during takeoff when heavyweight, will significantly decrease rate of climb.

4.6.2.5 GDT Slew Limits. Flying airspeeds may exceed GDT slew rates. Avoid over-flying the GDT to minimize the risk of a lost link situation.

4.6.3 Departure. Expedite departures before accomplishing the Climb, Level-Off, Cruise Checklist with the following mnemonics: ATEAM: Altimeter, Tracker, Emergency Mission, Antenna, MSA.

4.6.4 Emergency Mission Planning. Launch and recovery emergency mission planning requires additional consideration due to low altitude and high traffic density around the airfield. Before takeoff and while in the pattern, set the first waypoint off the departure end of the runway in use. To preclude an airspeed preference dive while close to the ground, consider reducing the speed for all waypoints to no faster than approach speed but greater than glide speed for the aircraft's gross weight and drag index.

4.7 Descent and Arrival.

4.7.1 Descent. Descents can be accomplished in landing configuration (manual), or with some of the autopilot hold modes engaged. Analyze distance from the airfield, altitude, fuel requirements, and aircraft configuration, when determining which descent method is preferred. Both the descent and arrival checks should be completed prior to pattern entry.

4.7.1.1 Descent Point. Attempt to establish a descent point that will allow descent into the pattern while maintaining energy for glide back.

4.7.1.2 Landing Gear Down Descent. Lowering the landing gear will increase drag and can expedite descents. Gear down descents also ease transition into the landing pattern. Announce the indicated airspeed, check that it is stable and less than the in-transit limit, and then verbally confirm preparation to lower the gear (i.e., "SPEED IS XXX, GEAR DOWN" or "SPEED CHECKS, GEAR DOWN").

4.7.1.3 Landing Gear Up Descent. Descents with the gear up allow for recovery at higher speeds. Without the additional drag of extended landing gear, the aircraft will accelerate more quickly in similar dive angles and power settings.

4.7.2 Arrival. After checking ATIS (if available), and considering the landing runway factors, brief the crew IAW AFI 11-2MQ-1&9, Volume 3, required approach briefing items. Also, include a pattern entry plan, barrier configurations, and crosswind considerations.

- The following mnemonic may can assist in brief completion: WET: Weather, Emergencies, Type of Landing/TOLD.

4.7.2.1 Checklist Clean-Up. If multiple steps of the Descent, Arrival, and Before Landing checklists are postponed, the following mnemonics can assist in checklist completion.

- A-TEAM: Altimeter, Tracker, Emergency Mission, Antenna (Wide), MSA.
- LAGS: Links, Autopilot, Gear, Start Point.

4.8 Patterns. Consistent stable patterns are the foundation of safely landing the MQ-9. Between patterns, re-accomplish any changed portions of the approach brief and Before Landing checklist. In this chapter, the aircraft pitch reference symbol refers to as the whiskey marker.

4.8.1 Situational Awareness and Deconfliction. Maintaining a sterile cockpit improves situational awareness. Listen to radio calls from ATC and other aircraft in the pattern to build a crew shared mental model. Be directive, then descriptive with ATC if unable maintain a clearance, or a potential traffic conflict arises. Tactical data link aids (e.g., Zeus) are helpful if kept current and at appropriate zoom levels.

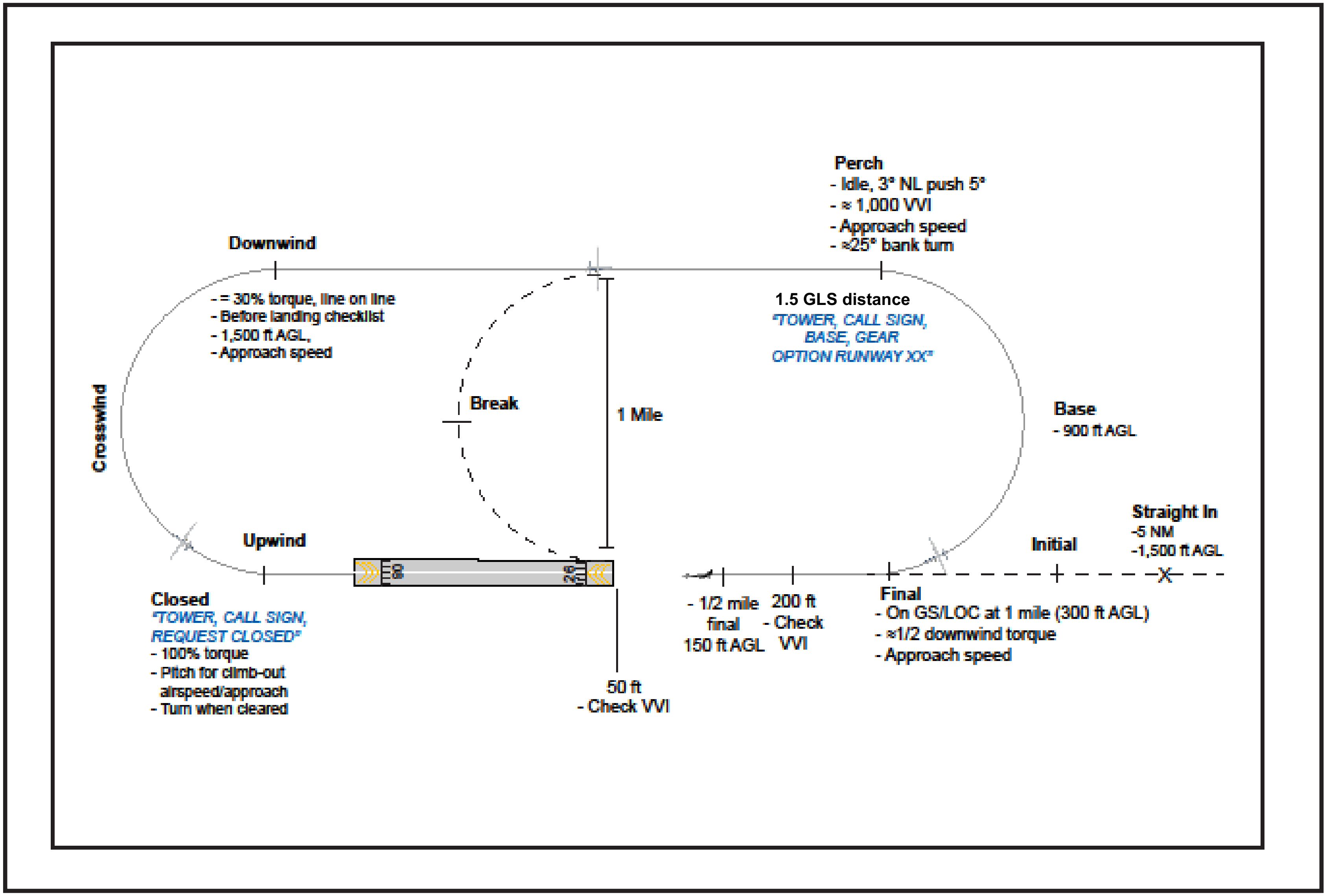
4.8.2 Visual Flight Rules Traffic Pattern. The visual flight rules (VFR) traffic pattern is used to coordinate and sequence air traffic as shown in **Figure 4.9**, Visual Flight Rules Traffic Pattern. The upwind leg (sometimes called departure leg) extends from the departure end of the runway until the crosswind leg begins. The downwind leg is parallel to, but in the opposite direction of the active runway. The base leg connects the downwind leg to final. Final connects the end of the base leg to the approach end of the landing runway. At military installations, “Closed” and the “Perch” are common pattern positions. Closed is defined as a climbing 180-degree turn from the departure end of the runway to downwind. The Perch is where the pilot initiates the base turn.

4.8.3 Pattern Entry Methods. There are several methods an aircraft can enter/remain in the VFR traffic pattern to include the following: direct, VFR initial, straight in, and closed.

4.8.3.1 Direct. Direct pattern entries are typically associated with adherence ATC guidance (e.g., “REAPER 01, REPORT ESTABLISHED ON DOWNWIND RUNWAY 26”).

4.8.3.2 VFR Initial. Initial is a reporting point located 1 to 3 NM prior to the approach end of the active runway-often defined in the local AFI 11-250 or as instructed by ATC. Flying to initial is used in several ways: to begin a recovery, build spacing with other traffic, allow time for terminal descent, or reduce the amount of time spent outside glide back. Plan to report initial at pattern altitude and at speeds meeting local procedures and directives (e.g., “REAPER 01, INITIAL”). Between the approach end to midfield, initiate a 20- to 30-degree bank turn towards the downwind leg, called the break. Adjust bank as required for winds and aircraft speed.

Figure 4.9 Visual Flight Rules Traffic Pattern.



4.8.3.3 Straight-In. The straight-in approach is the least complicated way to enter the traffic pattern. To fly a straight-in approach, align with the runway centerline, and achieve the desired glide slope outside of the normal traffic pattern. For example, a 5-mile straight-in means the aircraft is aligned with the landing runway 5 NM prior to the active runway threshold and 1,500 feet above touchdown for a 3-degree glide slope.

4.8.3.4 Closed. Initiate a climb closed turn following takeoff, low approach, or touch-and-go, and request closed from ATC. Unless cleared "PRESENT POSITION CLOSED," fly runway centerline until the departure end, and initiate a climbing turn to downwind ground track. Adjust bank as required for winds and aircraft speed. Maintain the takeoff pitch attitude until the aircraft accelerates to climb speed. Approaching climb speed, adjust pitch and/or power as required to maintain desired speed. Reducing power can produce a more manageable climb rate for intercepting pattern altitude. A 4- to 6-degree nose high trim works well for reduced power settings. Approaching pattern altitude, reduce power and level off to roll out wings level, on speed, and on altitude aligned with the desired pattern ground track. If remaining in the pattern, consider reducing power to approximately 60 to 70 percent torque for a more manageable climb rate when intercepting pattern altitude.

4.8.4 Runway Changes. Airfield active landing runways change for a variety of reasons. Crews must reconfigure settings quickly when required to switch runways. The mnemonic below will ensure correct cockpit configuration for the new runway. Verbalizing changes will build situational awareness.

- MIGS: Map, Initial Lost Link Heading, GLS, Start Point.

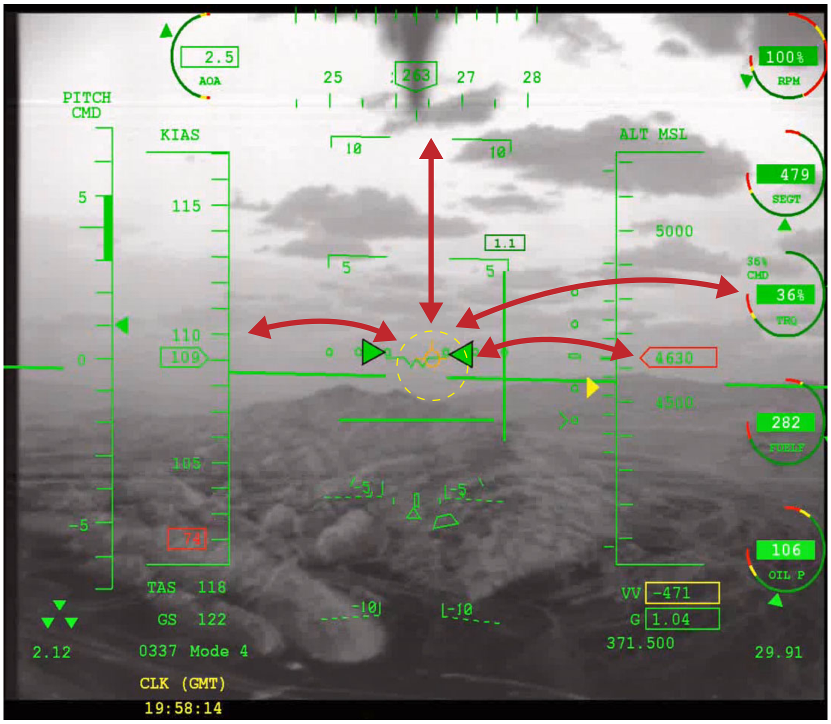
4.8.5 Cross-Check. A cross-check is the continuous and logical observation of instruments for attitude and performance information. The lack of auditory cues, peripheral vision, and somatosensory ("seat-of-the-pants" feel) indicators can delay recognition and response to aircraft changes by several seconds. Maintain a disciplined cross-check in the pattern and landing phases. Distractions or a momentary breakdown in the cross-check can lead to a rapid loss of situational awareness and an unsafe situation.

4.8.5.1 An effective MQ-9 cross-check is the "hub and spoke" method. See **Figure 4.10**, Pattern Hub-and-Spoke Cross-Check. The "hub" is the flightpath marker, and the "spokes" include airspeed, altitude, torque, heading, and ground track. One check of each of these parameters should only take one to two seconds. Do not fixate on any one instrument. Input corrections as required, and then continue the cross-check.

4.8.5.1.1 Aircraft Handling. See **Table 4.1**, Pitch and Power Settings for Common LR Flight Phases. Local atmospheric conditions or aircraft configurations may require adjustments to known pitch and power settings.

4.8.5.1.2 Throttle Considerations. Small throttle movements can result in large power changes as the travel between flight idle and 100 percent torque is only a 70-degree range. It is difficult to achieve a desired torque setting by feel alone. Throttle adjustments of only 3 percent torque can lead to fast or slow approaches.

Figure 4.10 Pattern Hub-and-Spoke Cross-Check.



4.8.5.1.3 Pitch and Power Settings. See **Table 4.1**, Pitch and Power Settings for Common LR Flight Phases. Actual torque setting required will depend on a variety of factors to include aircraft weight and drag, and the pilot must adjust from these reference points to achieve the desired performance. While known pitch and power settings are a starting point, they are not a replacement for a disciplined cross-check.

Table 4.1 Pitch and Power Settings for Common LR Flight Phases.

Flight Phase	Power Setting (Torque Percent)
Level Flight	25 to 30
3-Degree Nose Low Approach	14 to 15
5-Degree Nose Low SFO	4 to 6
5- to 8-Degree Nose High (Departure)	70 to 100

4.8.5.1.4 Flightpath Marker. The FPM displays the aircraft velocity vector on the HUD and represents a visual depiction of where the aircraft is traveling. It is calculated from both INS and air data, and it is useful in evaluating actual aircraft performance. In a normal control/performance cross-check, pilots set a desired pitch with the Pitch Command Marker, and then evaluate performance with the flightpath marker. See **paragraph 4.8.5.1.1**, Aircraft Handling.

4.8.5.1.5 Pitch Command Carets and Commanded Pitch Ladder. The Commanded Pitch Ladder bar on the left side of the HUD is useful in setting a precise pitch in the departure, recovery, and pattern phases of flight. It also serves as a quick pitch reference when recovering from oscillations associated with a bounce or pilot induced oscillation (PIO). The pitch carets in the center of the HUD correlate to the climb/dive bars and can become unusable when trying to recover the aircraft in these conditions.

4.8.6 Perch. The perch is the point downwind, when the final turn is initiated and correlates to 1.8 to 2.2 NM on the GPS landing system (GLS) distance to touchdown indicator. Request landing clearance at 1.5 NM on the GLS or in the base turn.

4.8.6.1 Talk, Trim, Torque, Turn Cross-Check. At 1.5 NM on the GLS, request and receive landing clearance from ATC. At the Perch, trim 3 degrees nose down and simultaneously reduce the torque to flight idle. Increase nose down pitch and torque as required to maintain desired VVI and airspeed. When trimming nose down ensure zero bank to avoid trimming in bank. Maintain an effective cross-check throughout the turn.

4.8.6.2 Pitch and Power. From the perch to final, set the desired pitch and adjust torque to maintain approach speed or greater up to 134 KIAS. With a 3-degree glide path set, this equates to the pitch carets at 5 to 6 degrees nose low with torque set at 4 to 6 percent. When the GLS glide slope indicator begins rising, adjust pitch and add power to capture a 3-degree glide slope, see Table 4.1, Pitch and Power Settings for Common LR Flight Phases.

4.8.6.3 Bank and Ground Track. Adjust bank to compensate for overshooting or undershooting winds when turning base to final. Cross-check the tracker display and roll wings level when on final, align with the runway. Use the GLS course indicator as an aid to achieve runway alignment.

4.8.6.4 Transition-to-Final. Verbalize “RWY IN SIGHT” and roll out within 1 dot laterally and vertically on the GLS between 1.5 and 2 NM from the intended landing point. Verbalize deviations in course and/or glide path to the crew and correct early to avoid excessive maneuvering close to the ground. Verbalizing “VISUAL” indicates that the crew will no longer provide callouts based on the GLS (one dot high/low) and has instead transitioned to landing short or long of the GLS intercept point using the FPM and visual reference. Go-Around criteria still apply.

4.8.7 Base to Final Turn. Table 4.2, Pattern Altitude References, shows common distances and altitudes the crew can use to assess turn spacing from the perch to final.

Table 4.2 Pattern Altitude References.

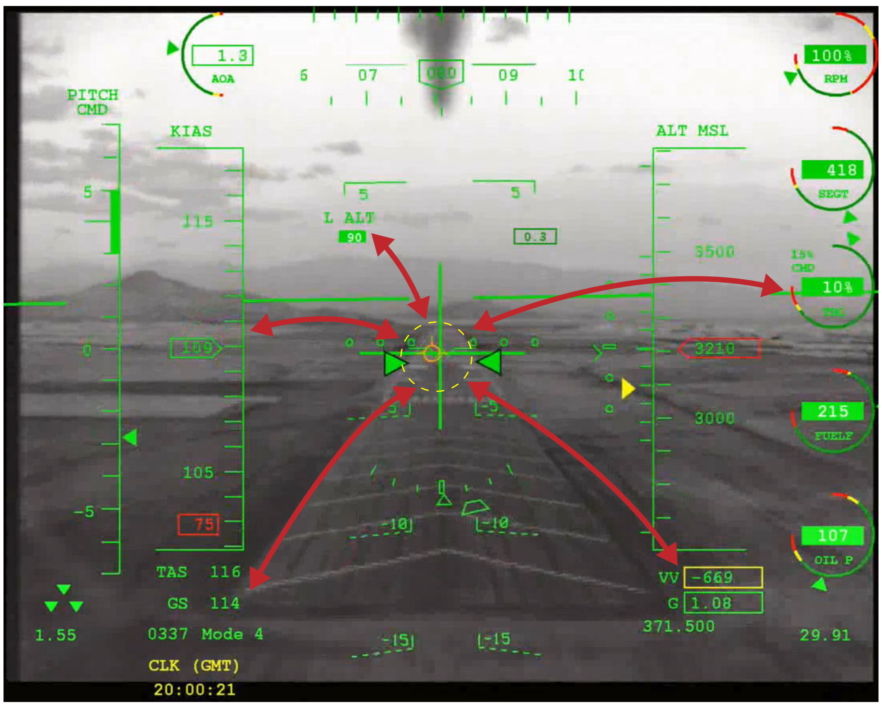
Altitude (Feet)	Reference Location
1,500	At the perch
900	Halfway through the turn
300	1 mile final
150	Approximately 1/2 mile final

4.8.8 Final Approach. Stabilize on glide slope and localizer at approach speed by 1 NM. Use the FPM or visual references to assess the desired aimpoint. In instrument meteorological conditions (IMC), plan to fly a precision approach radar (PAR) or approach surveillance radar (ASR) with vectors to final. The TGP often far exceeds traditional visibility minimums, particularly in dusty situations, and can enable a visual approach in conjunction with the aircraft's GLS.

4.9 Landing. The following procedures assume no flap, calm wind approaches.

4.9.1 Cross-Check. An effective landing cross-check is similar to the pattern cross-check, but with additional instruments included. See Figure 4.11, Landing Hub and Spoke Cross-Check. The "hub" is the flightpath marker, and each "spoke" of the cross-check encompasses, at a minimum: airspeed, laser altimeter, torque, VVI, and ground speed.

Figure 4.11 Landing Hub-and-Spoke Cross-Check.



4.9.2 Roundout and Flare. The Roundout is the transition from a normal glide path to Whiskey marker on the horizon (10 feet AGL). The flare is the end of the roundout through touch down, when the Whiskey marker is at or above the horizon. Visual references change with camera selection. The aircraft will appear lower in the TGP when compared to either of the nose cameras, which may cause a high flare. Conversely, going from the TGP to the nose camera may result in a late or incomplete flare.

4.9.3 Command Pitch Carets. The command pitch carets provide instantaneous indication of what pitch attitude the pilot is commanding to the aircraft. The pitch carets are the control instrument and the whiskey marker is the performance instrument.

4.9.4 Cutting Pitch Picture in Half. This phrase describes reducing the descent rate prior to the flare. To cut the pitch picture in half, smoothly apply back-stick pressure on the control stick until the command pitch carrots halve current value and the whiskey marker follows the command. Reducing the descent rate shifts the aimpoint down the runway. Oscillating command pitch carets can be an indication of or precursor to a PIO when the pilot is over-correcting pitch inputs and chasing the FPM.

4.9.5 Laser Altimeter Usage. The laser altimeter enhances situational awareness by providing accurate height above touchdown. Monitor the laser altimeter through peripheral vision while SOs will make call outs in accordance with unit standards. Do not channelize attention on the laser altimeter. Blowing snow, dust, fog, and moisture collecting on the body of the aircraft can all adversely affect the laser altimeter. (SO) Laser altimeter countdown callous should be as follows: "Laser Alive," "90," "70," "50," "30," "20," "10," "5, 4, 3, 2, 1," "Touch." The cadence should correspond to the rate of descent.

4.9.5.1 Technique 1. When the laser altimeter displays 50 feet, cut the pitch picture in half and continue to descend with power. At 30 feet, simultaneously begin raising the nose to the horizon while reducing throttle. The airspeed at 30 feet will dictate the rate of throttle reduction to idle (greater than 5 knots above approach, reduce rapidly; on speed reduce gradually or slow reduce as needed). Continue to increase pitch to place whiskey marker on the horizon at 10 feet.

4.9.5.2 Technique 2. When the laser altimeter displays 50 feet, cut the pitch picture in half and continue to descend with power. At 30 feet, simultaneously begin raising the nose to the horizon while reducing throttle. The airspeed at 30 feet will dictate the rate of throttle reduction to idle (greater than 5 knots above approach, reduce rapidly; on speed reduce gradually or slow reduce as needed). Continue to increase pitch to place Whiskey marker on the horizon at 10 feet.

4.9.6 Flare. In the flare, shift visual focus to the end of the runway and watch for the ground to rise and meet the artificial horizon line in the HUD. As the aircraft begins to settle on to the runway, maintain 1 to 3 degrees pitch above the horizon. The FPM should settle just below the horizon. Excess energy in the flare may cause the aircraft to float or balloon.

4.9.6.1 Porpoising. Maintain positive pitch command during roll out. If releasing the control stick while trimmed to a nose-low attitude during the roll out, porpoising may be the result. Porpoising is distinct from a nose-first landing, and occurs due to a combination of negative pitch trim, the RCM actively attempting to achieve this nose-low attitude, and the compression/rebound of the nose strut. Porpoising may be unrecoverable when recognized solely by visual cues.

4.9.7 Touch and Go. At touch down (laser altimeter reads 0), smoothly command a 3- to 5-degree nose-high attitude (solid green bar on pitch ladder), and simultaneously, advance the throttle to full forward position. Maintain centerline and crosswind controls. (SO) Confirm the throttle and pitch command by visually checking the pilot's control inputs are set for a positive rate of climb. Verify that the laser altimeter and VVI are both increasing.

4.9.8 Full Stop. Upon landing (laser altimeter reads 0), all throttle position changes should be verbalized ("GROUND IDLE," "FULL REVERSE"). (SO) Call out "TOUCH, GROUND IDLE" and "85, GROUND IDLE" when aircraft reaches 85 KIAS and confirm that the throttle is full reverse and the corresponding torque increase. Call out when the aircraft transitions from high-speed to ground lost link logic and cross-check ground speed for aircraft velocity call outs. At 20 KGS, make a call out and visually confirm that the pilot moves the throttle from reverse to ground idle.

4.10 Adjusting for Weather.

4.10.1 Thermal Activity. Updrafts/downdrafts are the result of differences in air temperature caused by uneven heating of the ground. Thermal activity increases after midmorning and continues until sunset. Thermal activity is notable when terrain is near the end of the runway. Understanding the terminal environment can help aircrew predict thermal activity in the pattern.

4.10.1.1 Altitude Considerations. Fluctuations of over 500 fpm and over 10 KIAS can occur on patterns and approaches during increased thermal activity. Prevent channelized attention with an effective cross-check and make corrections as soon as a deviation from parameters occurs. FPM deviation from the whiskey marker and fluctuations in VVI are two indications of thermal activity, but VVI indications significantly lag behind FPM movement.

4.10.1.2 Correct thermal activity deviations through positive aircraft control while cross-referencing the FPM. Normally, thermals create a short-duration effect, leave the trim set for level flight and adjust the control stick as required. Continue an effective cross-check while adjusting controls as required to achieve the desired performance.

4.10.1.2.1 In and updraft, the FPM will rise above the whiskey marker. Maintain level flight by pushing the control stick forward and fly the FPM back to the horizon (or slightly below to correct for any climb). If the power is set for level flight, anticipate that the aircraft will accelerate.

4.10.1.2.2 In and downdraft, the FPM will drop below the whiskey marker. Simultaneously add power and raise the nose to fly the FPM back to the horizon.

4.10.2 Pattern Wind Considerations.

4.10.2.1 Winds Aloft. Discuss winds and their effects before entering and while in the pattern. Cross-check tracker display winds with those relayed by tower. Based on local airfield wind instrumentation; winds may be from a source not collocated with the intended touchdown zone.

4.10.2.2 Crab to maintain desired groundtrack. Flying a wind-corrected groundtrack aids ATC in traffic sequencing.

4.10.2.3 Overshooting/Undershooting Winds Turning to Final. With overshooting winds, the aircraft will have a tailwind through much of the turn, resulting in less time to make the normal descent to final. Using the FPM and maintaining an increased descent angle will help mitigate the effects of overshooting winds. Conversely, an undershooting wind will result in a lower ground speed and longer time spent in the final turn. Using the FPM will aid in maintaining the desired descent angle, and will minimize the impact of undershooting winds.

4.10.2.4 Crosswinds. Correct for crosswinds on final by crabbing into the wind. Winds can change significantly in magnitude and/or direction as the aircraft approaches the touchdown point. If the crosswind component puts the runway out of the FOV, consider using a wing-low approach sooner to allow adequate runway visibility. Bank into the wind and use opposite rudder to keep the aircraft tracking on centerline. Complete the transition from a crab to crosswind control inputs (wing-low/opposite rudder) at any altitude. Prebriefing expected control inputs would enhance CRM and make for a safer approach. The two common techniques to help visualize and execute proper crosswind corrections are the "Whiskey Marker Method" and the "FPM Method." Both techniques achieve the same result.

4.10.2.4.1 Whiskey Marker Method. Apply rudder in the direction the whiskey marker needs to go to align with the FPM. Control the Whiskey Marker with the rudder pedals, and Once aligned, control the FPM laterally with the control stick (ailerons) and align with RWY centerline.

4.10.2.4.2 FPM Method. "Step on the FPM" means to apply rudder in the same direction the FPM is trending. For example, if the FPM is to the right of the Whiskey Marker (left to right crosswind) apply right rudder to align the two. Once aligned, use roll input (ailerons) to steer the FPM to RWY centerline.

4.10.2.5 Centerline Corrections. If the pilot drifts off extended centerline, lessen or stop the drift and correct back. Use the FPM to aid in determining the proper correction. If the aircraft is right of course, the FPM must be left of the touchdown zone in order to correct back to final.

4.10.2.6 An early transition to crosswind corrections allows better runway visibility in strong crosswinds and allows the pilot to get a feel for the crosswind controls and stabilize the throttle with the extra drag. The disadvantage is that winds often change from the initial setting, and pilots often struggle with determining the correct amount of bank and rudder inputs as conditions change.

4.10.2.7 A late transition allows the pilot to crab all the way to the flare and minimizes struggle with changing winds. The disadvantage is that pilot workload increases as rudder and bank must be included with pitch and power changes simultaneously in the flare. An early power pull combined with extra drag from the rudder and wing low can result in unacceptable speed deviations during landing.

4.10.2.8 Maximum Headwind Landing. Give considerations towards power pull, roundout and flare when landing in a maximum headwind situation. It may be necessary to delay power pull or lessen the roundout/flare phase to prevent ballooning.

4.10.3 Wind Shear. Wind shear in the pattern is very dangerous, and can cause an MQ-9 with a lower power setting to develop an excessively high sink rate. If there is a possibility of wind shear in the pattern, be prepared to go around at the first sign of airspeed decay. The reaction must be immediate with appropriate throttle and pitch adjustments. Maintain a disciplined cross-check and frequently reference the airspeed indicator, especially in gusty winds.

4.11 Forced Landing. There are two basic ways to accomplish a forced landing: the overhead and the straight-in approach. An overhead approach allows the crew to manage energy but limits runway visibility. A straight-in approach allows for increased runway visibility, but limits energy correction opportunities.

4.11.1 Energy Assessment. Correctly assessing the aircraft's energy state is critical to a successful forced landing. Atmospherics (e.g., wind and air density) change with altitude, thus changing energy state. Multiple energy assessments are required throughout forced landing maneuvers. If excess energy exists, make every effort to reach high key for an overhead approach. If unable to make an overhead key position or transition to a straight-in approach, make every effort to avoid personnel injury or damage to equipment on the ground. Use the following methods to evaluate energy state:

4.11.1.1 Flightpath Marker. Using the FPM to assess energy accounts for atmospherics and aircraft performance is the simplest way to assess energy, but requires the crew to acquire the landing environment visually in the HUD. Turn towards and align the FPM with the desired landing site. If FPM is within the first third of the runway or beyond, landing is assured. If the FPM is short of the runway at glide speed, the aircraft will likely not reach the field; consider ditching the aircraft in an unpopulated area.

4.11.1.2 Control Point (CP) Method. Using the control point to assess energy also accounts for atmospherics and aircraft performance. See **Figure 4.12**, Energy Management. First, place the CP over the desired landing point. Navigate direct to the CP by matching "Heading to CP" and "Course" on the tracker display. Note the "Time to CP" on tracker display and the VVI on HUD. Round "Time to CP" down to the nearest quarter minute (15 seconds) increment. Round VVI up to nearest 500 fpm. Multiply "Time to CP" by VVI. The product of "Time to CP" and VVI increments equals how much altitude will be lost prior to reaching the CP in thousands of feet. Subtract this value from current altitude to determine the altitude at which the aircraft will reach the CP.

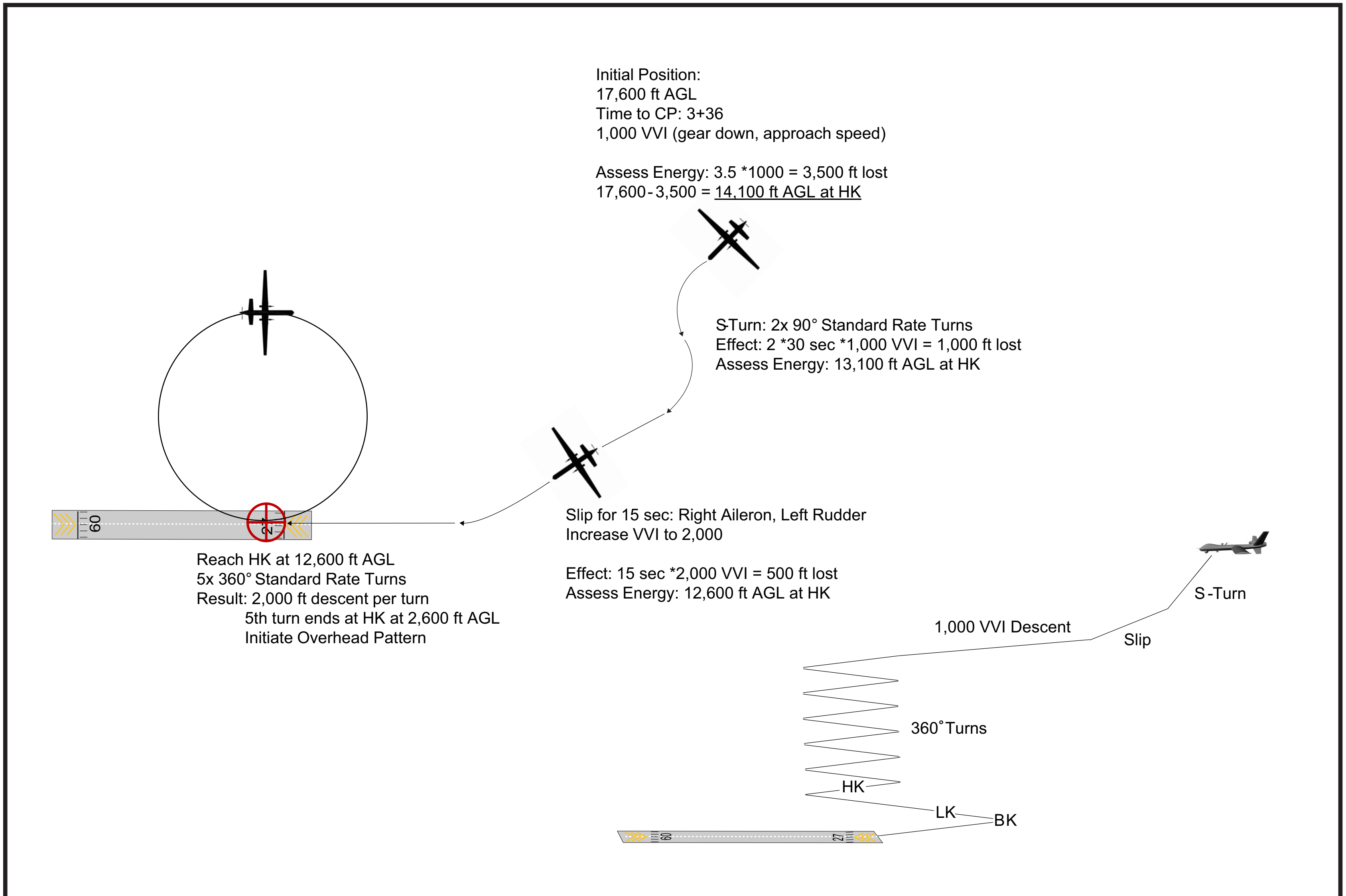
EXAMPLE: An aircraft with 17,600 feet AGL, with time to CP of 3:36, and 850 VVI, rounded to 3:30 and 1,000 VVI, results in 3,500 feet lost. Subtract this from 17,600 feet AGL to conclude aircraft will arrive at high key at 14,100 feet AGL.

4.11.1.3 2:1 Rule. This method does not account for aircraft performance or atmospherics, but only for a quick initial energy assessment. Reference aircraft altitude AGL on VIT 2, 97, or HUD, as applicable, in thousands of feet, and multiply the altitude by two. The resulting number is roughly the remaining glide range in nautical miles. If this distance is greater than the distance to GDT in the lower left corner of the HUD, glide-back is likely assured. This method assumes the landing gear up with prop unfeathered or the landing gear down with prop feathered. With the gear up and prop feathered, glide performance is approximately 2.4:1.

EXAMPLE: If the altitude observed is 8,045 feet, round to 8, multiply 8 by 2 = 16 NM glide back range.

4.11.2 Low Energy. If the aircraft energy state necessitates flying at glide speed until intercepting high key or the flare on a straight-in approach, do not dissipate energy or delay lowering landing gear after reaching low key (overhead) or 1,000 feet AGL (straight-in).

Figure 4.12 Energy Management.



4.11.3 Excess Energy. There are four principal means to dissipate energy: increased speed, lowering the gear, slips, and turns. Lowering the landing gear (if possible) prior to initiating a forced landing approach significantly decreases workload during the approach and allows crew to focus on aircraft maneuvering and energy.

4.11.3.1 Speed. Increasing speed from glide speed to approach speed (or faster) increases descent rate. If high key intercept is possible from current position at 1,000 VVI descent rate, consider increasing speed from glide speed to approach speed. Exceeding flap auto-scheduling speed will cause flaps to decamber, resulting in decreased lift and increased descent rate. If flying faster than approach speed while en route, crews should make every effort to slow to approach speed prior to initiating approach. Landing above approach speed can result in float, longer landing roll, and increased likelihood of departing the runway.

4.11.3.2 Gear. Lowering the gear increases drag, therefore increasing the descent rate while maintaining forward speed. If high key intercept is possible from current position at 1,000 VVI descent rate, consider lowering landing gear.

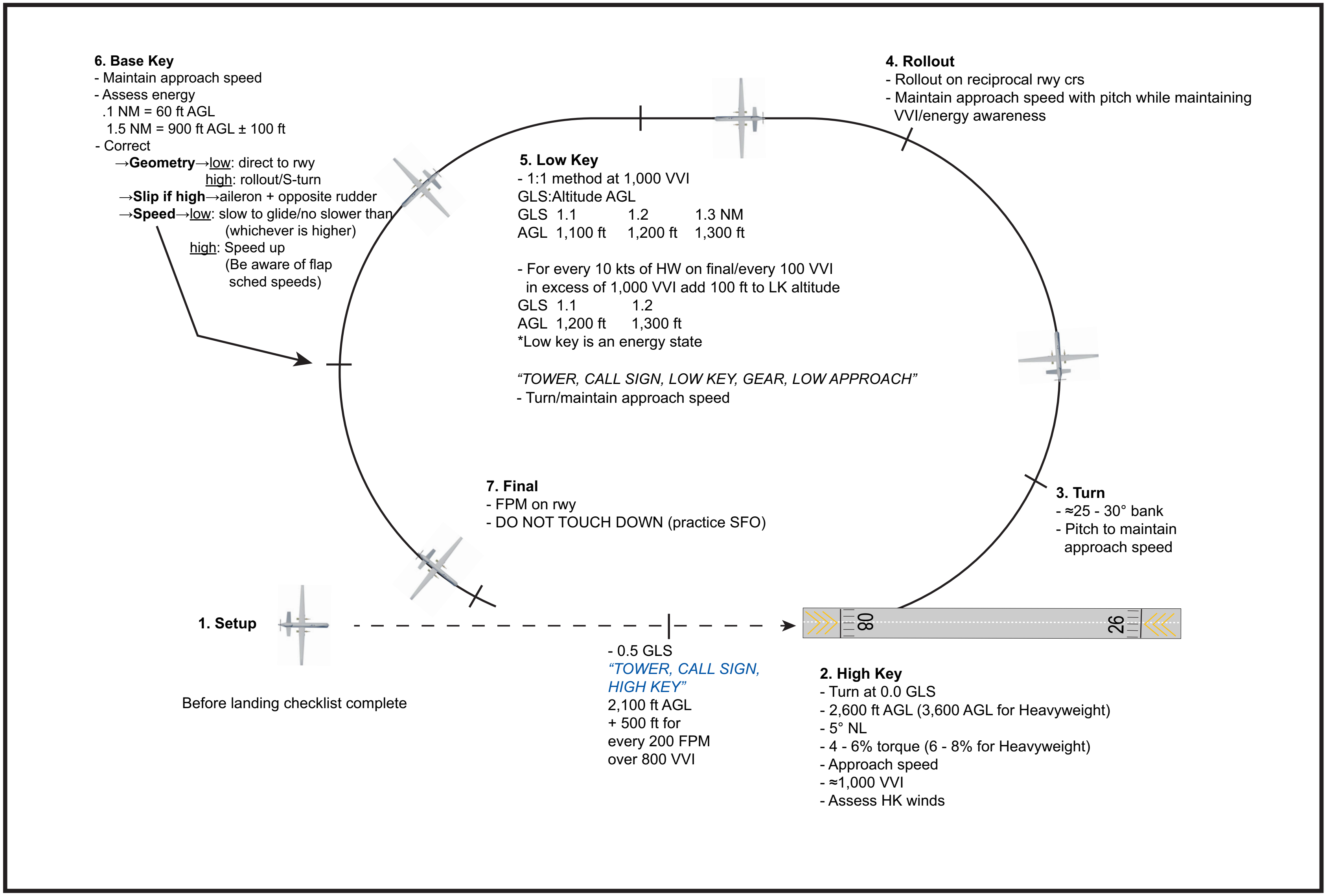
4.11.3.3 Slipping increases drag, therefore increase the descent rate while maintaining forward speed. Execute a slip by banking into the direction of wind, using 15 to 20 degrees of roll, while simultaneously applying full opposite rudder. Adjust roll to maintain a desired course, and pitch to maintain airspeed. Use caution while slipping at low altitude. Remove slip inputs smoothly to transition from uncoordinated to coordinated flight.

4.11.3.4 Turns. Turns increase the ground distance covered, providing time to dissipate excess altitude. S-Turns dissipate 1,000 to 2,000 feet of altitude within a short distance (assuming 1,000 VVI). Perform standard rate, 90- to 180-degree turns in alternating directions. Every 90 degrees of heading change will dissipate approximately 500 feet. Therefore, two 90-degree turns will dissipate 1,000 feet. S-Turns are more effective when performed farther from the landing site. 360-degree turns dissipate approximately 2,000 feet of altitude while returning the aircraft to the starting position upon completing the maneuver (assuming 1,000 VVI). Use standard rate turns to spend approximately 2 minutes in the 360-degree turn. Adjust bank angle as required to dissipate slightly more or less than 2,000 feet, as well as to adjust for winds. 360-degree turns are effective in dissipating altitude when established overhead the landing site.

4.11.4 Overhead Force Landing Pattern. Make every effort to arrive in the landing area at high key at approach speed, shown in **Figure 4.13**, Overhead Forced Landing Pattern. If the aircraft's energy state cannot meet high key, adjust the planned entry point to either low key or base key.

4.11.4.1 High Key. Report high key at approximately 0.5 NM on GLS distance to allow for communication prior to initiating turn. Initiate the forced landing pattern at 0.0 on the GLS. Reduce power to 4 to 6 percent torque if performing simulated flameout (SFO). Trim 3 or 5 degrees nose low, and use small pitch changes to fly approach speed. Begin a 25- to 30-degree bank turn toward low key. A delay in turning at high key could result in longer landing distances and the potential of departing the prepared surface. Turning early at high key could result in insufficient energy, and failure to reach the runway. Airspeed will typically increase during turns; therefore apply back-stick pressure to maintain approach speed. Key to success is an effective cross-check.

Figure 4.13 Overhead Forced Landing.



4.11.4.2 Low Key. Low key is an energy state on a reciprocal runway course, at the altitude and position specified in the -1. Analyze energy in order to adjust low key turnpoint for wind or VVI. Initiate the turn from low key to base key when altitude AGL = VVI + 200 at approach speed. Lead the turn by 100 feet of altitude for every 10 knots of headwind on final (e.g., turn at VVI + 300 with 10 knots of headwind).

4.11.4.2.1 1:1 Method. The 1:1 ("One-to-One") method of determining low key position bolsters -1 procedure. Cross-check altitude AGL on VIT 2/97 in thousands of feet and GLS distance on the HUD. For example, if the aircraft rolls out 0.8 NM from the runway centerline at 1,500 feet AGL, the initial ratio values are 0.8 and 1.5, vocalized as "POINT EIGHT, FIFTEEN HUNDRED." As the aircraft continues downwind, GLS distance will increase and altitude will decrease. When the ratio of distance to altitude aligns (e.g., 1.2 on GLS and 1,200 feet AGL), initiate the turn from low key to base key. Lead the turn by 100 feet of altitude for every 10 knots of headwind on final and for every 100 VVI above 1,000 VVI (turn at 1.2 on GLS: 1,400 feet AGL for 1,200 VVI). Assumptions:

- GLS configured for the landing runway.
- Positive GLS value.
- Approach speed and gear down.
- 1,000 VVI.

4.11.4.3 Low Key to Base Key. Use 25 to 30-degrees angle of bank (AOB) from Low Key to Base Key. Maintain approach speed using small pitch adjustments throughout the turn. Monitor the ground track and adjust bank to roll out on the runway extended centerline. From Base Key through final at 1,000 VVI, descent rate should be approximately 600 feet per nautical mile. See **Table 4.3**, Energy Assessment. Cross-check GLS distance against altitude AGL to determine energy state (1.5 NM on GLS, 900 feet AGL). Continue this cross-check until visual with the runway, and then use FPM to assess energy state. If low on energy, slow to glide speed or minimum approach airspeed (as applicable) and consider turning direct to the runway. If high on energy, increase speed, slip, and/or consider squaring the remainder of the turn.

4.11.4.4 Final Approach. As the airfield becomes visible in the HUD, align the aircraft with extended centerline, using FPM to assess energy. There is no power to counteract increased drag caused by crosswind controls. If it appears that the aircraft will fall short of the runway, adjust pitch to capture glide speed on a flame out () or stall + 15 KIAS for a SFO per the V3.

4.11.4.5 Touchdown. At 100 feet AGL, when laser altimeter becomes active, start a transition to 3 degrees nose low to shift the aimpoint further down the runway and arrest the descent rate. Roundout and flare similar to normal approach. If at glide speed (low on energy), delay the roundout and flare as long as possible to avoid stalling. When terminating an SFO approach, failure to compensate for increased descent rates from slower speeds and engine spool-up time can result aircraft touchdown. A technique is to smoothly execute a Go-Around at 100 feet AGL.

Table 4.3 Energy Assessment.

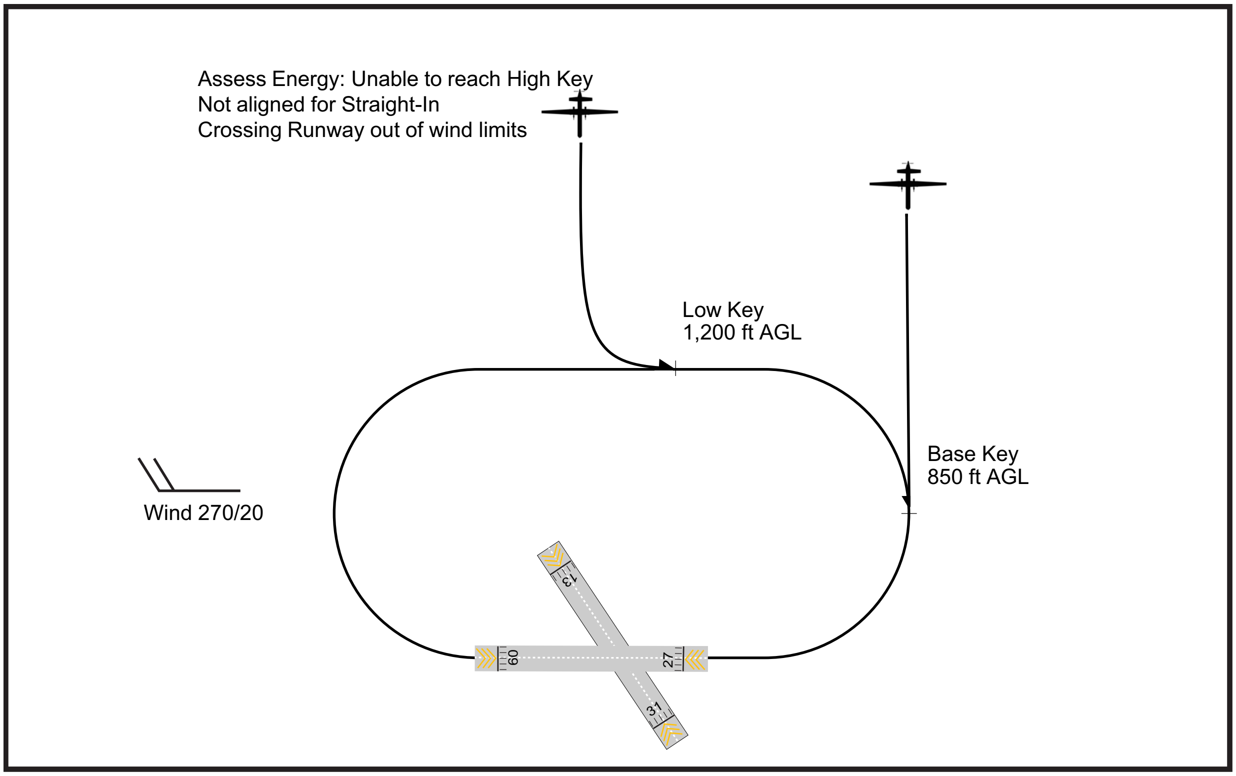
DASH-1 SFO Numbers				Base-to-Final Crosscheck Numbers	
VSI	High Key	Low Key	Base Key	GLS (NM)	AGL (feet)
800 VSI	2,100	1,000	700	1.0	600
1,000 VSI	2,600	1,200	850	1.1	660
1,200 VSI	3,100	1,400	1,000	1.2	720
1,400 VSI	3,600	1,600	1,150	1.3	780
1,600 VSI	4,100	1,800	1,300	1.4	840
1,800 VSI	4,600	2,000	1,450	1.5	900
2,000 VSI	5,100	2,200	1,600	1.6	960
EASY MATH: VVI + 200 = LOW KEY ALT.				1.7	1,020

4.11.5 Random Entry. The overhead pattern can be entered from any key position. If there is insufficient energy to reach high key make every effort to reach a low key or base key position, see **Figure 4.14**, Random Entry Force Landing. Consider what maneuvering will be required to intercept these points when assessing energy.

4.11.5.1 Low Key Entry. Reference Dash 1 guidance and **Figure 4.13**, Overhead Forced Landing, for low key position and altitude. A typical low key position is located abeam high key, 0.8 to 1.3 NM offset from runway centerline, on a reciprocal runway heading at 1,200 feet AGL for an aircraft at 1,000 VVI. Aim for low key position, using energy depleting maneuvers to intercept low key altitude. Upon reaching low key position, set 5 degrees nose low, report low key, and initiate a turn to base key.

4.11.5.2 Base Key Entry. Refer to -1 guidance and **Figure 4.13**, Overhead Forced Landing, for base key position and altitude. A typical base key position is located approximately 1.5 NM GLS distance from initial aimpoint, offset approximately 0.4 to 0.7 NM from runway centerline perpendicular to runway heading at 850 feet AGL for an aircraft descending at 1,000 VVI. Aim for the base key position, using energy depleting maneuvers to intercept base key altitude. Upon reaching base key position, set 5 degrees nose low, report base key, and initiate turn to final approach.

Figure 4.14 Random Entry Forced Landing.



4.11.6 Straight-in Approach. A straight-in forced landing approach offers better visibility of the airfield during, but affords fewer opportunities for energy management. The landing aimpoint is still located one-third down the runway and the landing zone is near the approach end, just beyond the captain's bars (1,000-foot marker). Less energy is often required in order to land on first third of runway. Assess energy state, when able, with the FPM prior to dissipating energy. Maintaining glide speed until the aimpoint reaches halfway down the runway provides some room to accelerate the aircraft to approach speed prior to the flare. Place the flightpath marker on the intended landing zone (500-foot marker, beyond cables, etc.) and let the aircraft accelerate towards that point. Avoid speeds in excess of the flap auto-scheduling speed. Once landing is assured, lower the landing gear, no later than 1,000 feet AGL ensuring time for the gear to fully extend.

4.11.6.1 Descent Control. Establish glide path control by placing the FPM on the captain's bars once visually acquired. Expected VVI should be a little more than 1,000 fpm to maintain a glide slope of 600 feet per NM (800 feet per NM if the propeller is windmilling). Using airspeed hold set to glide speed can load shed hand flying tasks, and will ensure the aircraft is maximizing its glide capability.

4.11.6.2 Glide Ratio. Use a glide ratio in NM/altitude (in thousands of feet) above touchdown zone of 2.4:1 (gear up, propeller feathered), 2:1 (gear down, propeller feathered), and 1.5:1 (gear down, propeller unfeathered). For example, an aircraft with gear down and propeller feathered at 10,000 feet AGL will glide approximately 20 miles. If time and conditions permit, consult the 1-1 charts to calculate a more accurate glide distance.

4.11.7 Emergency Mission Management. Continue managing the emergency mission through all forced landing approaches. If the aircraft loses link while engine out, it will still attempt to perform the emergency mission and lost link profile. If the aircrew does regain control, continue to evaluate the status and ability to reach the runway or desired impact site. Update the emergency mission accordingly.

4.11.8 Flame Out Brief. Supplement the standard approach brief with turn direction to low key, approach speed, glide speed, minimum approach speed (if applicable), and go-around point (if performing an SFO). Reference high key winds on tracker display when wings level to anticipate early/late turn from low key (if using 1:1 rule).

4.11.8.1 LAGS Check. The LAGS check covers essential items in time-critical situations. Consider running LAGS check prior to initiating landing approach.

- L—Links: Ensure that C-band is the active data link and select the appropriate GDT antenna (e.g., wide or narrow).
- A—Autopilot/Altimeter: Command landing configuration and ensure updated altimeter is set.
- G—Gear: Ensure gear is down no later than low key or 1,000 feet AGL.
- S—Speed/Start Point: Use glide speed until energy is adequate to accelerate to approach speed. Ensure the emergency mission start point will turn the aircraft away from other aircraft, personnel, buildings, and equipment on the ground.

4.11.8.2 Extended Range (ER). ER heavyweight aircraft configurations present significant differences in flight profile, bringing a variety of considerations to forced landing patterns. Due to heavy weights and four-bladed propellers, ER aircraft will experience higher VVIs when gliding; adjust energy evaluations and cruise considerations accordingly. When performing SFO patterns, set 6 to 8 percent torque to compensate for drag caused by additional propeller blade. Adjust high key to compensate for 1,400 to 2,000 VVI, typically correcting to 3,600 to 5,100 feet AGL. Limit bank angle to 30 degrees to prevent high angle of attack (AOA) decambering ailerons, causing increased drag and sink rate.

4.12 Boresight Procedures. The MQ-9 AN/DAS-1 TGP is boresighted while airborne by the aircrew, and is essential to guide precision munitions accurately, or other laser usage. Setting the range entry value to 10 allows for coarse boresight adjustment. When firing the LRD at a slant range of 10 km, a range entry value of 10 will adjust the boresight at 1-foot increments per unit of correction. Setting the range entry value to 20 while at a 10 km slant range will adjust the boresight at 6-inch increments per unit of correction thus allowing for finer boresight adjustments, if required.

- Climb to desired altitude for boresight.
- Boresight between 6 km to 9 km slant range.

4.12.1 Boresight Problems. If the ground party reports “NO SPOT,” adjust the laser slowly until it appears on the board, (e.g., rolling box). Depending on atmospheric conditions, a closer range may also bring the spot into view. If the spot still does not come into the ground party’s view, widen this rolling box around the board until it does.

4.12.2 Laser Corrections. Once the spot is in view, begin making corrections as required. A rule of thumb is that the edge of the board is approximately five units from the center horizontally, and four units vertically.

4.12.2.1 Correction Communication may be "UP" or "DOWN," then "RIGHT" or "LEFT" (however, each location call outs may vary). This does not correlate to actual laser correction values. To convert positive and negative values. "UP" always means positive and "DOWN" always means negative, while "RIGHT" means positive and "LEFT" means negative in the lateral correction. When the boresighting ground party calls corrections, they are telling which direction the spot needs to move. Therefore, if the spot is at the lower left of the board (as shown above) the ground party would call, "UP 2, RIGHT 2," and the SO would enter "+2" on the vertical correction, and "+2" on the horizontal (lateral) correction.

4.12.2.2 Boresighting with AN/DAS-4. Laser-to-sensor auto boresight (LSAB) should be performed immediately after a successful sensor-to-sensor auto alignment (SSAA) in order to ensure a precise boresight across all cameras. LSAB should be performed in the FOV and operational altitude desired for employment. The video processing settings for LSAB will be automatically controlled depending on the conditions prior to entering LSAB.

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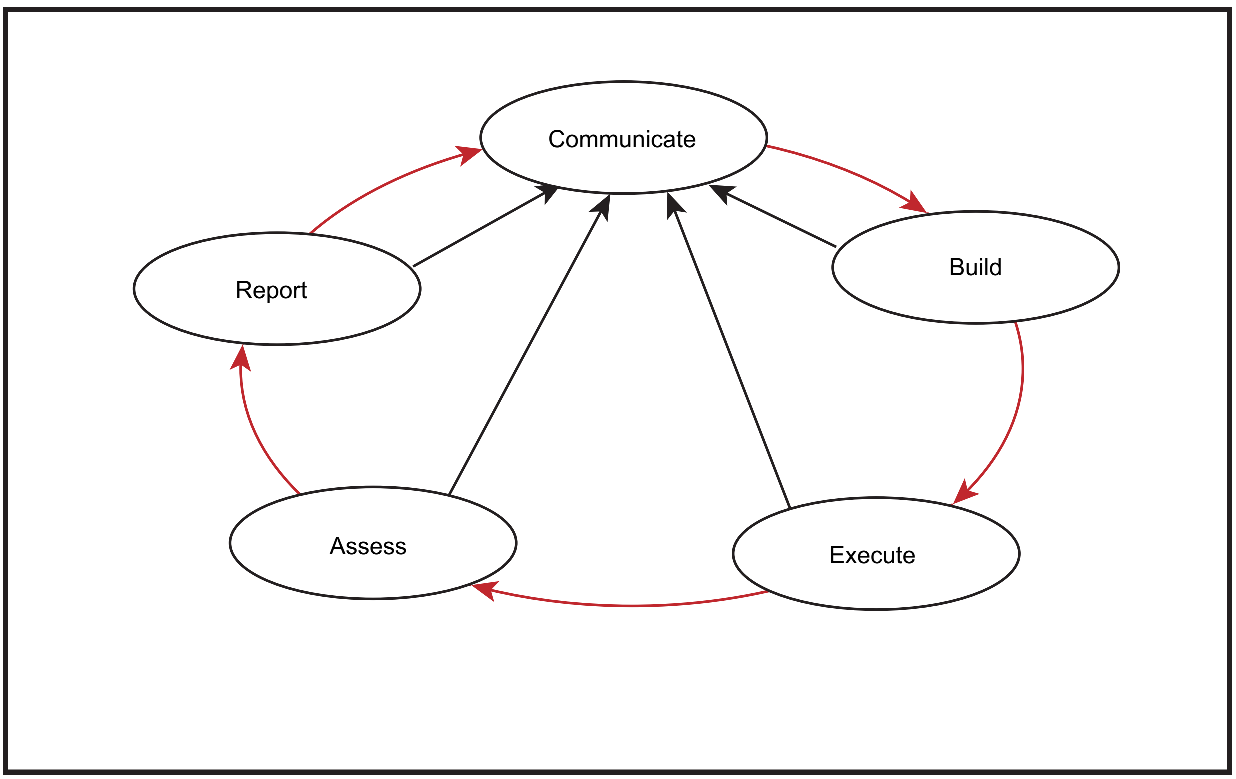
CHAPTER 5

BASIC MISSION EXECUTION

5.1 Introduction. Regardless of mission set, MQ-9 crews execute the targeting process consisting of six steps: find, fix, track, target, engage, and assess; commonly known as F2T2EA (reference JP 3-60, *Joint Targeting*). The MQ-9 can execute many different mission sets but the F2T2EA process remains universal. MQ-9 crews may be called upon to carry out the entire targeting process from Find through Assess, or they may be tasked to complete only portions in conjunction with other assets. It is therefore imperative that crews have a thorough understanding of the kill chain and the information required to transition between phases. The basic tasking flow begins whenever a new task is generated and is used during all phases of the kill chain.

5.2 Basic Tasking Flow. The basic tasking flow begins once the MQ-9 receives a new task for the crew to accomplish. Tasks may come via the air tasking order (ATO), directed from another asset, or self-generated by the crew based on off-board cuing or intelligence information received. Regardless, the crew must first understand the intent, priorities, resources available, and restrictions in order to build an effective and efficient game plan to then execute, assess, and report. If the intent was not met, the crew must adjust the game plan or report the results to the appropriate agency/asset. The mnemonic CBEAR (communicate, build, execute, assess, and report) provides the crew a simple, repeatable tasking flow that effectively delineates and accomplishes the F2T2EA process. See **Figure 5.1**, CBEAR Process Flow.

Figure 5.1 CBEAR Process.



5.3 Communicate. The goal of communication is to determine intent, priority, available resources, and limiting factors. Focus on salient information that aids in developing an effective execution plan which will vary from mission to mission. Information passed during major combat operations will differ in scope and level of detail from information passed during counter-insurgency operations. Aircrew must accurately capture incoming information, identify and plot salient tactical information, and assess the information for tasking intent or desired effect. This can be remembered with the mnemonic RPA (record, plot, and assess). Some of the information needed to develop an effective game plan includes the following.

- Tasking type.
- Target name, location, description.
  - Radar Cross Section.
  - Target Features.
- Intent.
- Essential elements of information (EEI).
- Restrictions.
  - Time available.
  - Standoff distance/detection concern.
  - Threat picture.
  - Airspace.
- Friendly positions and dispositions.

5.3.1 Record. At a minimum, the pilot must record key information by written or electronic means. When able, sensor operators should also record this information. In many mission sets, the relevance and value of information is heavily dependent on how current that data is, therefore crews must strive to also record at what time information was received and, if possible, generated. Relying on memory or "word of mouth" leads to mission degradation or failure when information is passed incorrectly or forgotten.

5.3.1.1 Search Objectives. The search objective is the desired entity the tasking requires to be found and fixed. The initial tasking might contain a vague search objective (e.g., search for threats) or an unachievable search objective (e.g., search for personnel within 300 meters of a 2 mile stretch of road within 5 minutes). The crew must gather specific details to eliminate ambiguities and make the search objectives specific and measurable (e.g., search a 2 NM by 1 NM ellipse for a reported SA-8 battery). A realistic and attainable search objective is one that can be found/fixed under the current conditions and restrictions (e.g., sensor capability, time allotted, search area). If the objective is unrealistic and/or unattainable, the crew should communicate this fact to the tasking source and provide realistic and attainable capabilities under the given circumstances.

5.3.1.2 Identification Criteria. Identification (ID) criteria are the key identification features that will aid in achieving identification sufficient to correlate a found target to the intended search objective. ID criteria can range from the descriptors of a high-valued individual (HVI) in the CAS/counter insurgency (COIN) environment (e.g., travels in a dark SUV with four fighting age males and wears a salmon-colored traditional garb), or the doctrinal employment of a surface-to-air missile (SAM) system battery in a conventional environment. Targets assessed to be in the area of operations (AO) should be studied during mission planning to become familiar with the ID criteria and appearance of the targets in the TGP and/or SAR, if TGP and/or SAR imagery is available.

5.3.2 Plot. Aircrew should plot applicable information on the tactical situation awareness tool (TacSit) to aid in tactical decision-making, and ensure mission continuity. Aircrew must ensure the information is translated to the TacSit at the earliest opportunity.

5.3.3 Assess. The pilot and sensor operator must both ensure they have a shared understanding of the intent of the tasking. Aircrew may need to query for additional information to gain the clarity required to develop an effective plan. Once the crew and tasking authority are operating with a shared mental model of the intent, MQ-9 crews must integrate this information into the game plan or premission planning. If the crew identifies a gap in information or a significant inefficiency in a game plan, the crew should communicate the shortfall and provide options to mitigate the problem.

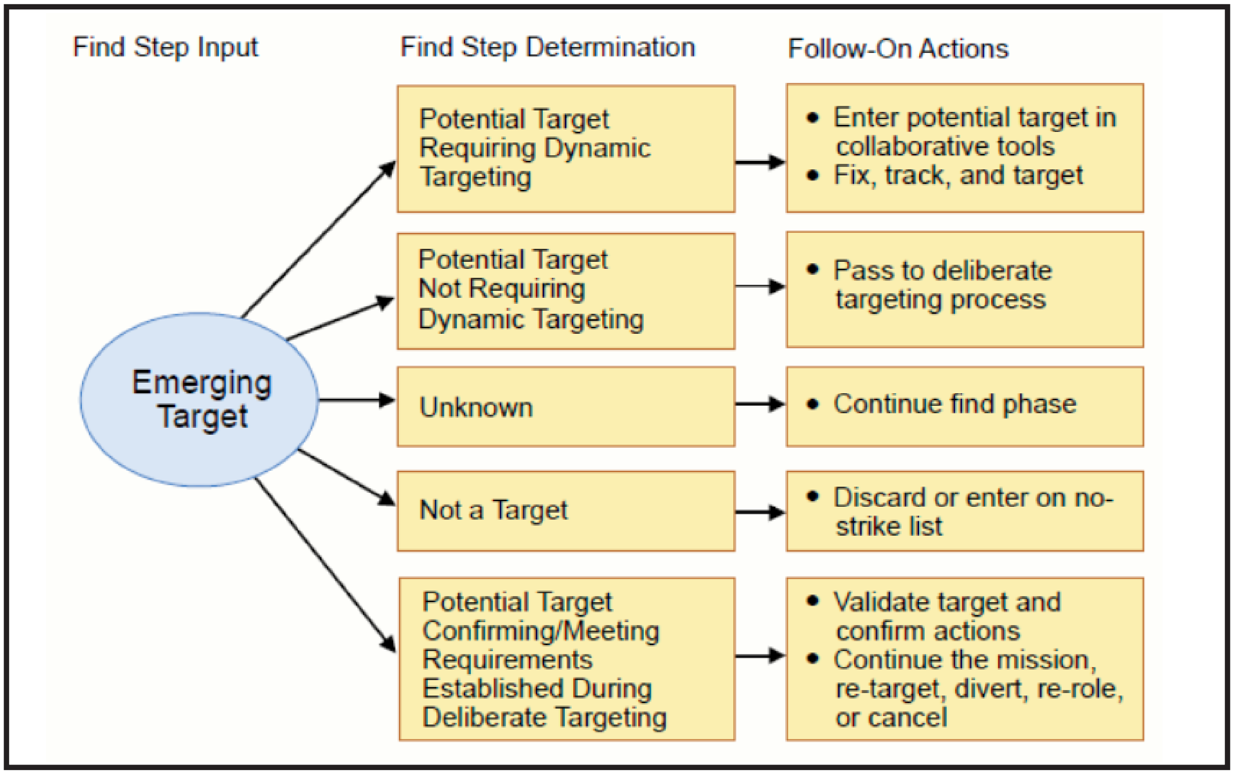
5.3.3.1 Task Analysis. Task analysis is the process that determines the requirements for task completion during the communicate step of the basic tasking flow. Task analysis occurs during the mission planning phase for preplanned targets and in real-time for ad hoc targets (i.e., new targets during mission execution not included in mission planning). To analyze a task, the specific search objectives, identification, restrictions, reporting criteria, and task completion criteria must be understood at a minimum. If this information is not provided, the crew should query the tasking agency/unit for additional information. See **Figure 5.2**, Find Step Determinations and Actions.

5.3.3.2 Task Completion Criteria. To prevent the mission tempo from stagnating and eliminate redundant searching, the crew must understand when the search and tasks are complete (i.e., the search must be bounded by the crew). Depending on the tasking, the search can be bounded by time, search area, number of targets to be found/fixed, or as soon as a specific objective is found/fixed. Once the crew reaches the defined search boundary, the task should be considered complete and the results reported.

5.3.3.3 Reporting Criteria. The crew must know when, where, and how to report findings. Some targets might require an immediate report; whereas, others might require the search to be completed and all findings reported back upon task completion.

5.4 Build. The build step begins once all members have a shared mental model of the tasking intent. The crew now develops an executable plan of action. Work from the target/intent backwards using the mantra "Aircraft, Sensors, Weapons, Comm" to develop requirements for aircraft placement and maneuvering, sensor management/prioritization, weaponeering, and communication tasks/flow. Each step could be as simple as only referring to the individual MQ-9 or it could be as complex as accounting for multiple aircraft and/or sensors depending upon the situation.

Figure 5.2 Find Step Determinations and Actions.



5.4.1 Aircraft. Assess aircraft positioning against the task location and required transit and/or holding to meet the intent and restrictions of the task. The priority should be to move the aircraft in the direction of the tasking as quickly as possible and then build the rest of the game plan; this will place the aircraft in position, or en route to the desired position, and ready for the execution step once the game plan is complete. This principle is equally true for a first target after a gaining handover with a two hour transit as it is when responding to a TIC, and immediately moving the aircraft to the appropriate side of the target for friendly force deconfliction and immediate weapons effects. A proactive transit and effective hold plan enables effective and efficient tasking execution.

5.4.1.1 Transit. Transit to the target and/or desired hold location should be as direct as possible, within applicable restrictions. The emergency mission should be updated to reflect the desired routing and the Start Point kept up-to-date inside approved airspace while in transit.

5.4.1.2 Holding. Enter holding at the desired range and look angle to meet the task's intent and restrictions. The holding plan will likely not be fully developed until after the crew formulates a sensor plan that meets the task's intent and adheres to all applicable restrictions. Proceed direct from the transit route into the initial holding pattern as outlined in **Chapter 4**, "Aircraft Fundamentals." The holding plan should also be deconflicted from other assets in close proximity and clear of threats, restrictions, and hazardous weather. If the look angle is flexible, the aircraft hold should be placed to minimize atmospheric effects, usually closer to the target with the aircraft positioned between the target and the sun. Balance the hold plan to account for the synthetic aperture radar (SAR) imaging and ground moving-target indicator (GMTI) employment to integrate the targeting pod (TGP) and SAR search plans. Once established in the hold, continuously evaluate the hold to ensure that the initial plan continues to meet the intent and update the aircraft's position as required.

5.4.2 Sensors. The sensor plan drives the holding plan during the first half of the kill chain (i.e., find, fix, and track). Evaluate all available sensors and how they enable target acquisition and prosecution. This includes all on-board and off-board sensors available.

5.4.2.1 Sensor Versus Weapons Driven Game Plans. The crew must identify the stage of the mission in which they are currently operating. Using the task analysis phase from above, the crew must either put the aircraft in a position that allows for optimal sensor use based on the task or intent, or place the aircraft in a position to employ weapons and meet the intent. If the intent is to initially find, fix, and track a specific target, then the crew will position themselves for a sensor driven game plan. If the intent is to strike a target at a specific TOT, set of parameters, or target, engage, assess phases of the kill chain, then the crew can posture for a weapons driven game plan.

5.4.2.1.1 Sensor Driven Game Plan. The sensor driven game plan must account for the objectives of the search, the triggers in which the objectives are met, and what factors will drive a transition to weapons employment. To develop this game plan, the crew must assess which organic and inorganic sensors are available, both organic and inorganic. The crew will then define areas in the AO which are best suited for each available sensor. For example, ISR and some fighter/bomber assets can accomplish wide area searches in order to expedite the target acquisition process which will further increase efficiency and effectiveness while accomplishing the intent of searching for the objective.

5.4.2.1.2 Weapons Driven Game Plan. The weapons driven game plan still involves a search objective, but the overall intent is to employ munitions to produce an effect. The F2T portion of the game plan is accomplished in the same manner as mentioned in **paragraph 5.4.2.1.1**, Sensor Driven Game Plan. Once the search objective is met, the crew must place the aircraft in a position that will produce the desired hold range and direction based on the weapon selected, winds, and the layout of target(s)/friendlies.

5.4.2.2 Search Plan Development. Search plan development begins once task analysis is complete and ends when the plan has been made for aircraft positioning, available sensors, and communication (i.e., aircraft-sensors-comm). The search needs to be conducted with sufficient fidelity to be effective. The development process is applied for preplanned and ad hoc taskings for both known and unknown targets. The specifics to an ad hoc tasking search plan might require the crew to acquire the target area first, analyze the target area, and then determine the best search plan.

5.4.2.3 Sensor Integration. Sensor integration is the timely use of available sensors to leverage capabilities to increase effectiveness and efficiency to find and fix search objectives. The SAR provides a capability to effectively and efficiently map an area, or search for moving targets within an area. The TGP provides the ability to search for targets with a high resolution electro optical (EO)/IR sensor. Lastly, off-board sensors that conduct effective and efficient wide area searches (WAS) to find objects can decrease the

MQ-9 crew's search time. Cross-cuing the TGP and/or SAR to the off-board sensor's refined area and then executing a search pattern significantly decreases the amount of time to fix the off-board detected objects. Additionally, cross-cuing on board sensors (i.e., SAR to find and cross-cuing TGP to fix targets) provides an efficient use of on-board resources. **Figure 5.3** Sensor Integration, provides an example of how to fix targets using off-board cuing to initially find.

5.4.2.4 Required Sensor Fidelity. Required sensor fidelity is the minimum sensor quality that enables search objectives to be found and fixed. Fixing a search objective will require a higher fidelity than finding it. The ID criteria generated during task analysis dictate the optimal TGP setup and SAR image resolution to find/fix targets. The widest practical TGP FVWs should be determined to effectively find objects that match the anticipated target size, and to achieve ID criteria during the fix step. While smaller FVWs provide increased fidelity, using the widest practical FVW provides the ability to find/fix search objectives with increased timeliness. Use the following rules of thumb to find objects in rural and urban areas. Rural areas will typically require the target to be approximately 1 to 2 percent of the FVW for detection. For example, an armor piece 6 meters in length would require a FVW of 600 to 300 meters in a rural environment. Due to greater target area density, urban environments require a FVW based on the search objective being approximately 5 percent of the total FOV for detection. An example is a vehicle that is 3 meters in length that requires a FVW of 60 meters. Use the lowest SAR image resolutions that will detect the anticipated target's radar cross section (RCS) to find objects while maximizing the image coverage on the ground. If searching for a vehicle with the shortest side between two and three meters, a 2-meter Brickmap should be selected. When using the SAR, crew members should understand the RCS of anticipated targets. Refer to *SAR Handbook,* V3.1, 20 June 2020.

5.4.2.5 Target Area Analysis. Target area analysis is the process of applying the environmental effects, terrain features, and points of interest within a target area to determine the best target acquisition technique to find and fix the target. It occurs during mission planning for preplanned targets and anticipated target areas with satellite imagery, as well as during mission execution for preplanned and ad hoc targets using the satellite, TGP, and/or SAR imagery. The outcome of target area analysis identifies terrain features, points of interest, and mitigates environmental effects to focus the search and provide target area familiarity.

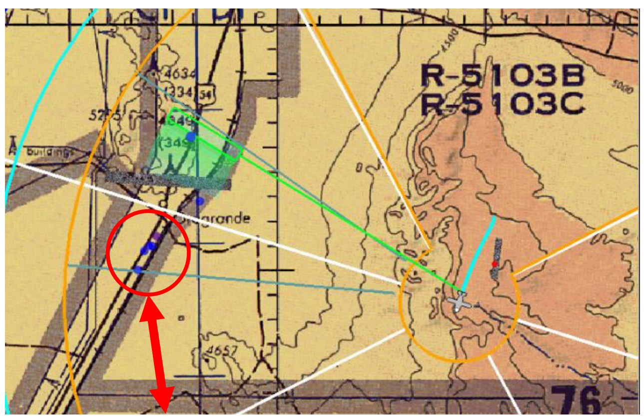
5.4.2.6 Environmental Effects. Environmental effects will dictate camera selection, TGP optimization and ideal aircraft positioning to effectively accomplish the search plan. Pilots should position the aircraft to mitigate environmental effects and facilitate optimal sensor fidelity (i.e., aircraft positioning to avoid clouds). One way to do this is to identify the location of clouds over a target area and position the aircraft where the least amount of obstruction occurs. Decreasing slant range, MWIR/SWIR/LWIR and TGP filter wheels (i.e., Vis Cut), can help look through significant atmospheric attenuation, dust, or fog.

Figure 5.3 Sensor Integration.

JSTARS MTI Hit

1) "Sabre reports 5+ MTI BULLSEYE 170/30"
2) Plot on TACSIT / CLAW Display

3) Search MTI hit with SAR GMTI Spot Mode



4) Cross-cue MTS on GMTI hits to CID.

SIGINT Hit w/ Ellipse

1) Voice : "Agent reports ROLAND ACTIVE BULLSEYE 145/35"
2) mIRC: "ROLAND ACTIVE, BULLSEYE 145/35, 1.0NM x 0.5NM, 069° Incl, centered at N 32° 19.979' W 105° 48.130' "
3) Plot on TACSIT / CLAW Display

4) Search the Ellipse with SAR Brickmap Mode

5) Identify significant radar returns
6) Cross-cue MTS to significant radar returns to *find/fix* the Roland.

5.4.2.7 Terrain Analysis. Terrain analysis is the task of familiarization with the physical features of an AO to aid in determining where the emerging target is most likely to be located. It determines the areas that should and should not be searched within the target area, and the required level of sensor fidelity to find/fix the target. Terrain analysis helps crew members plan where to focus attention, how to position the aircraft, which sensor and scan plan to use (see **paragraph 5.5.1.3**, Target Approach Analysis), and determine the level of sensor fidelity needed (see **paragraph 5.4.2.4**, Required Sensor Fidelity).

5.4.3 Weapons. Weapons and their employment drive the holding plan for the second half of the kill chain (i.e., target, engage, and assess). After determining the aircraft hold location, select the best weapon aligned with the desired weapons effects and weapons resource management. Hold in a position to achieve the required attack parameters and desired effects efficiently.

5.4.4 Communication. The communication plan between the pilot and SO, as well as with outside assets, requires deliberate development. The focus of the communication plan is to determine the reporting criteria so each crew member knows when and how to communicate the desired information at the applicable time and in an efficient manner. Communication contracts and priorities should be established during mission planning and the brief; however, it might be necessary to establish new contracts in an ad hoc tasking. Internal to the cockpit, the SO must know the items they find during a search that require an immediate report back to the pilot, and those that can be noted but reported back when the search is complete. Communication external to the cockpit is very similar. Time-critical items (e.g., pop-up S/A threat, ground-force threat, isolated personnel located) must be prioritized so the pilot knows, which items require an immediate report and how to report them in the required format over the correct communication medium (e.g., data link, radio, mIRC).

5.5 Execute. The execute step begins once the search plan development is complete. The plans for aircraft positioning, sensor employment, communication, and weapons employment should be adhered to during this step. A deviation from any aspect of the plan should be communicated to all impacted crew members and to outside assets (if required).

5.5.1 Find. The find phase is the first step in the killchain. Find refers to the detection of a probable target through an ISR collection process and/or sensors (e.g., targeting pod, visually observed, or via moving target indicator [MTI]). During this step, emerging targets are detected and characterized for further prosecution. Targets output from the find step lack identification and an accurate location (e.g., MTI with a Bullseye cut, SIGINT hit with a large ellipse, etc.).

5.5.1.1 Target Acquisition Techniques. When acquiring known targets or searching an area likely to contain a desired target, the initial find/fix actions accomplished should follow a predictable flow. The flow consists of using an initial sensor cuing TTP, followed by funnel nav with the TGP while developing 'big picture' situational awareness of the AO, and fixing of the TGT while refining TGT area SA.

5.5.1.1.1 Sensor Cuing. The sensor cuing process is the act of making the coarse movement of the TGP FOV from one geographic location to another. This process will involve aligning the TGP with a set of provided grids, and will provide an anchor point to begin the funnel navigation process outlined below. When performing the sensor cuing phase, the SO will select either the use of targeting mode, or will perform a geo walk-on to the target. Regardless of the TTP selected, the SO will use the smallest FOV that encompasses the target area to move seamlessly into the funnel navigation phase upon confirmation of coordinates. Once location information is confirmed, the SO should notify the crew with a “CONTACT” call. If the SO has been given adequate information to continue (i.e., high confidence location information, or a detailed and accurate TGT description), they should immediately begin the funnel navigation process (see **paragraph 5.5.1.2**, Funnel Navigation). If the information provided was not sufficient to move forward, the SO should request a talk-on.

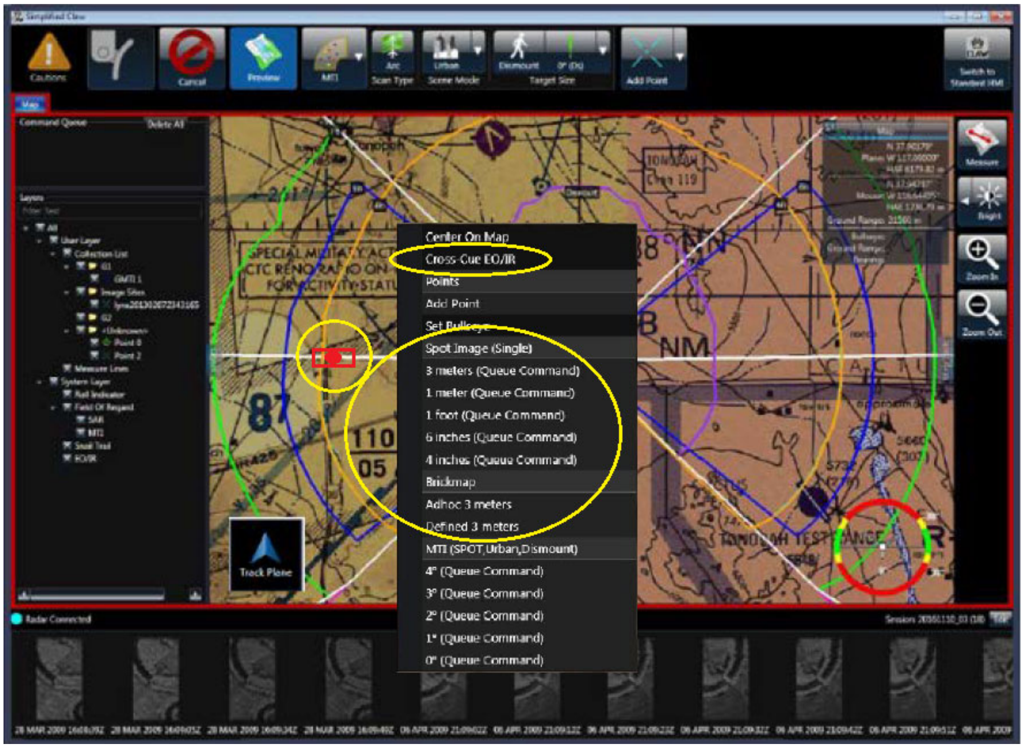
5.5.1.1.2 Cross-Cue. A cross-cue occurs when one sensor’s target information is relayed and used to cue a different sensor onto the same area or geographic point. The following techniques allow cross-cues to occur using targeting mode or by transferring sensor focus between the TGP, SAR, and Minotaur.

5.5.1.1.2.1 Targeting Mode. Targeting mode is a function of the SO MTS control, allowing automatic direct slew of the TGP to a set of grids or a geographic area on the tracker display. Once TGP has arrived at new location, SO can switch to rate mode and proceed with tasking.

5.5.1.1.2.2 SAR Cross-Cue for the TGP. A SAR cross-cue is commanded by the operator from CLAW and upon acceptance of the cross-cue via the payload station tracker, the TGP is automatically slewed to the CLAW-designated coordinates. A SAR cross-cue is best suited to situations when targets are detected by the SAR and/or the SO has minimal SA on the new target area/target. The crew member should right-click on the CLAW map on the target or target area and select “Export Location to PPO” when using the legacy HMI, or “Cross-Cue EO/IR” when using the simplified HMI. Then the SO must select the “Generic Target” function on the Lynx SAR control panel, verify the “Cross-Cue” button has black font and then select it. If the font is still gray, the crew member operating the SAR must redesignate the cross-cue location in CLAW. Once actuated, the TGP will enter targeting mode, slew to the CLAW designated coordinates, and then place the TGP into Rate mode. Prior to cross-cuing, it is recommended that the SO zoom out to a FVW that facilitates funnel navigation (see **paragraph 5.5.1.2**, Funnel Navigation) and imagery correlation of the target area.

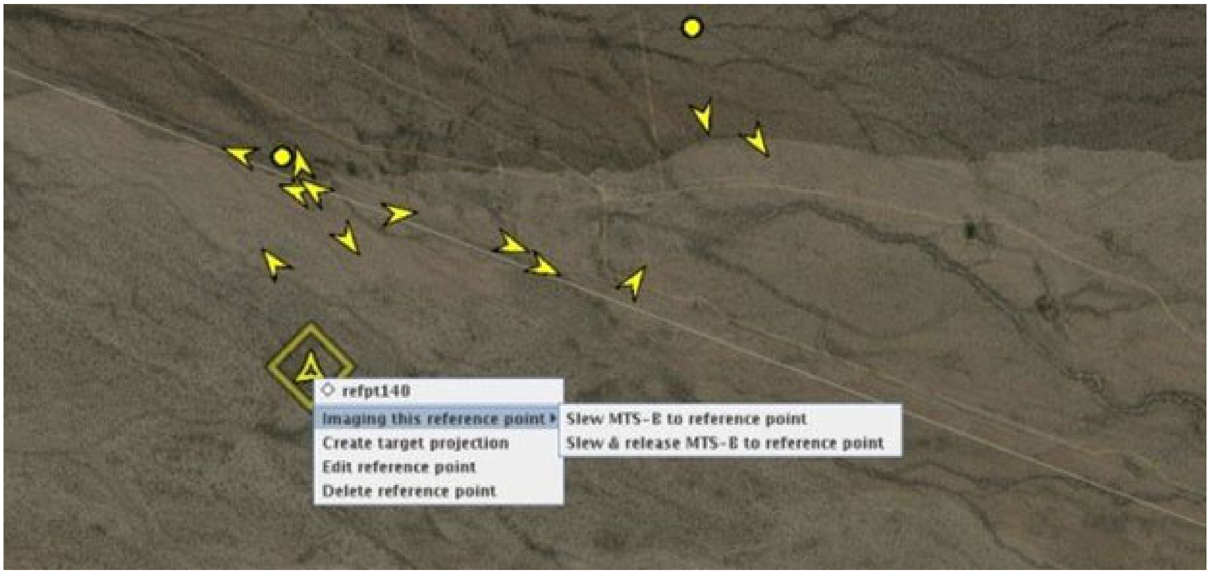
5.5.1.1.2.3 TGP Cross-Cue for the SAR. A TGP cross-cue is executed by using the TGP location on the CLAW Map for a reference point to employ a SAR mode. In CLAW’s main region map tab, “ASI” must be enabled under the FOV button to display the TGP FOV and sensor point of interest (SPI). If the SO already has the TGP in the target area, the pilot or SO should use the SPI as a reference point to command an imaging or GMTI mode for the applicable target type. The TGP SPI can be used for a reference to command a single spot image, but digital terrain elevation data (DTED) accuracy, SAR alignment, and desired resolution will limit the effectiveness. If commanding an imaging mode, command a brickmap that encompasses the TGP SPI prior to a high-resolution spot image. See **Figure 5.4**, SAR Cross-Cue.

Figure 5.4 SAR Cross-Cue.



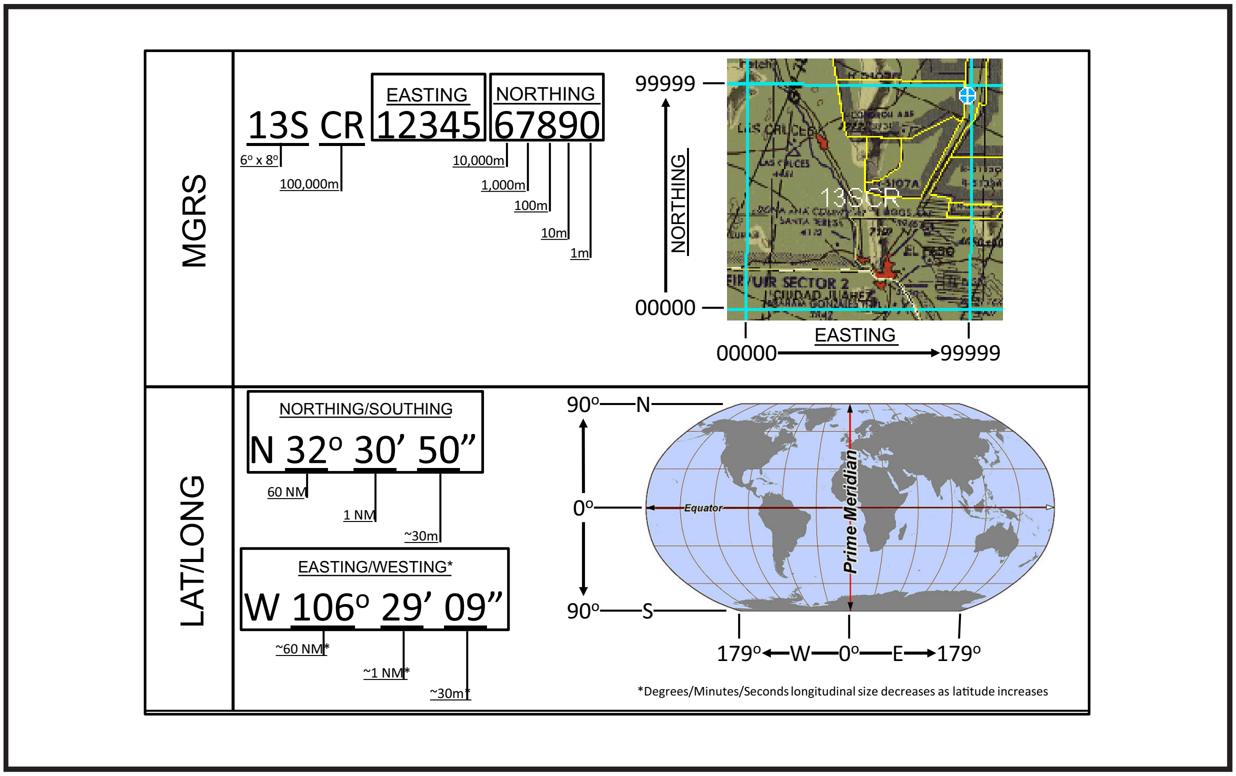
5.5.1.1.2.4 Cross-Cue for Minotaur. A TGP cross-cue is executed by using the cross-cue in the toolbar on the HUD. The pilot or sensor will right click on desired track or location on Minotaur map then select "Imaging this reference point," then select either "Slew TGP-B to reference point" or "Slew and release MTS-B to reference point." With the X-C TL selected, the TGP will slew to selected location for a maximum of 15 seconds or until the operator aborts command by selecting "stop" or making an input on the SO control stick. If the "Slew and release TGP-B to reference point" option is selected, the TGP will return to Rate mode, while the "Slew TGP-B to reference point" option will continuously command the TGP to the selected point. See **Figure 5.5**, Minotaur Cross-Cue.

Figure 5.5 Minotaur Cross-Cue.



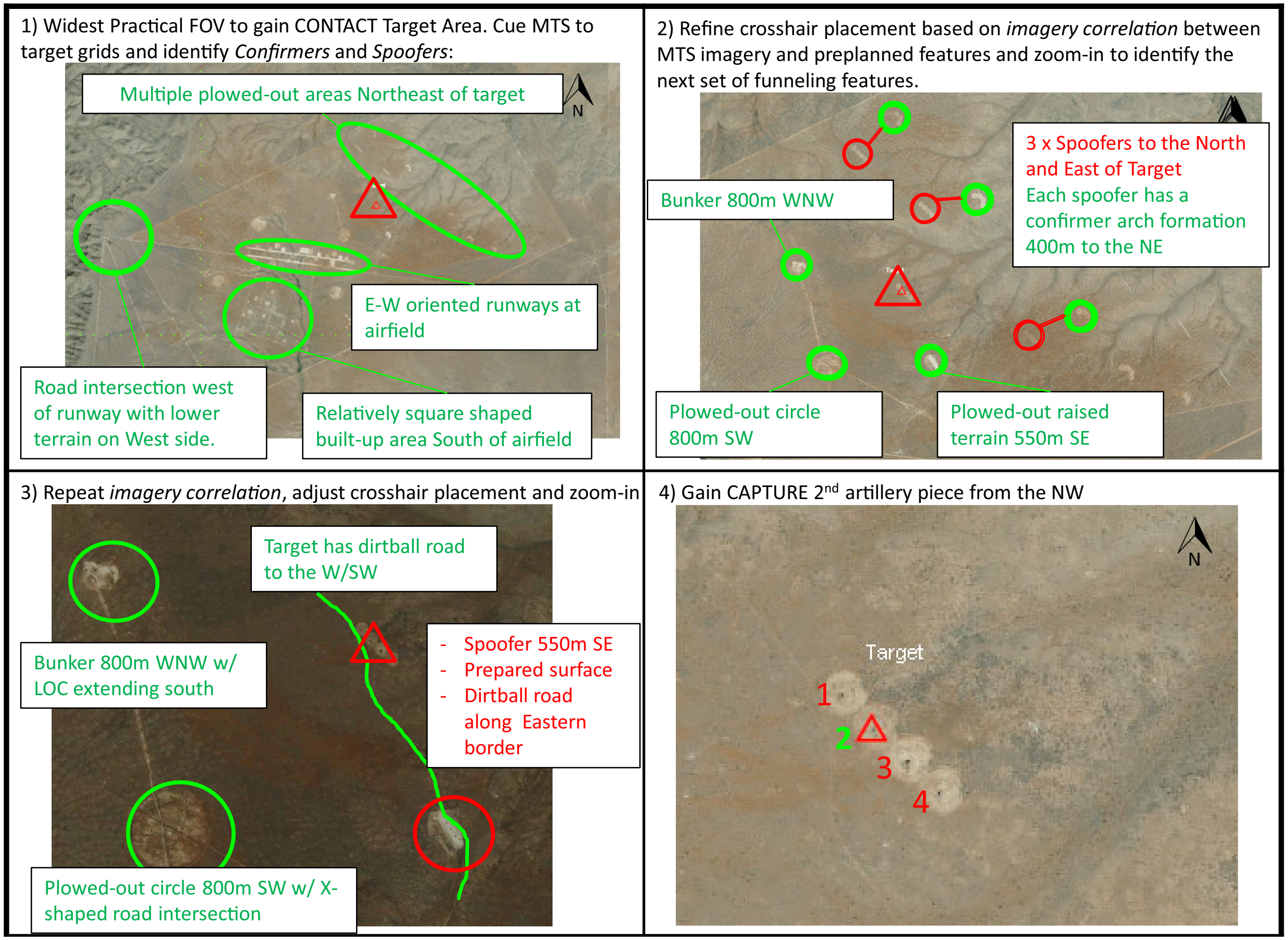
5.5.1.1.3 Walking Onto Coordinates. Walking onto coordinates is manually slewing the TGP to the target area in Rate mode by correlating the actual target coordinates to the current TGP coordinates. This sensor cuing technique should be used when there is a lack of imagery, target area SA, and/or minimal distinguishing features to perform funnel navigation when given a target within 2 km (military grid reference system [MGRS]) or 1 minute (Lat/Long) of the current TGP SPI location. To walk the TGP onto coordinates, match the coordinate format passed for the target to the TGP coordinate format. Compare the current crosshair coordinates to the target coordinates and assess the required slew direction. Each digit in any coordinate format equates to a specific unit of measurement. See **Figure 5.6**, MGRS and Lat/Long Coordinate Units of Measure, for MGRS and lat/long coordinate unit of measure. Using these coordinate format relationships, the SO should continually compare the current TGP crosshair coordinates to the target coordinates and slew the TGP in the appropriate direction until the coordinates match. It is recommended the SO slews to match Easting coordinates first, followed by the Northing. Once the TGP coordinates match, the crew is in the target area and should transition into the search plan execution phase.

Figure 5.6 MGRS and Lat/Long Coordinate Units of Measure.



5.5.1.2 Funnel Navigation. Funnel navigation is the process of using an external source of information, then comparing it using unique terrain features and objects in the target area to funnel the TGP onto a known target or target area. Once the TGP is CONTACT (see **paragraph 5.5.1.1.2**, Cross-Cue) on the correct location, SOs should begin using a FVW greater than 1,000 meters. SOs should use detailed imagery from available maps and TACSIT displays and match them with those features on the HUD. Begin with large features that are not likely to change over time (e.g., mountains, rivers). Once the large features are identified, continue to zoom in to more detailed imagery to correlate the targets relationship to its surrounding environment. The funnel navigation process should end once the TGP has established the correct FVW (**paragraph 5.4.2.4**, Required Sensor Fidelity). See **Figure 5.7**, Funnel Navigation.

Figure 5.7 Funnel Navigation.

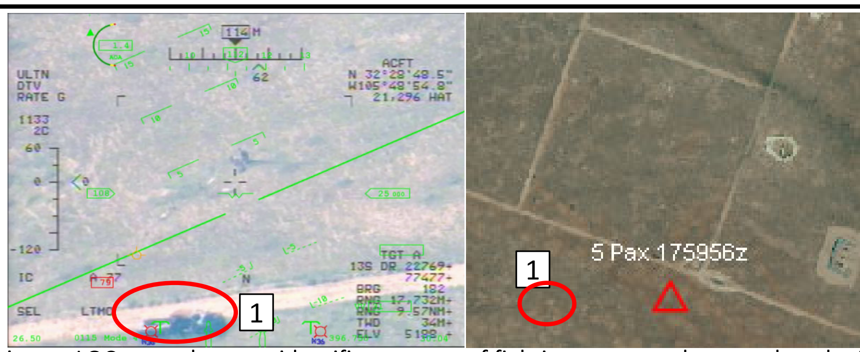


5.5.1.2.1 Building Target Area SA. Once the crew is CAPTURED on an intended target the process of developing additional target area, SA should be conducted prior to moving into the track phase or before continuing the scan based on the reporting criteria (see **paragraph 5.3.3.3**, Reporting Criteria). Increased target area awareness identifies features near the target and in the target area that enables expeditious target reacquisition, effective target talk-ons, mitigates soda straw effect, and facilitates efficient slewing between targets or points of interest (POI) within a target area. Big-to-small is the recommended TGP sensor technique to build target area awareness. Big-to-small is the manipulation of wider FOV's to initially gain awareness of the surrounding environment, followed by additional zoom levels to refine target area awareness, as necessary. While similar to funnel navigation, big-to small is conducted in real time with TGP imagery after a target is fixed to identify additional confirmers and spoofers within the target area, as well as other potential targets and POI. To perform the initial big-to-small, the SO should use a FVW that will give SA on the entire working area, as opposed to only near features. Once the entire target area has been visually correlated, the SO will be able to use the necessary method to maintain custody of the target while transitioning to the track phase (**paragraph 5.5.3**, Track). **Figure 5.8**, Big-to-Small.

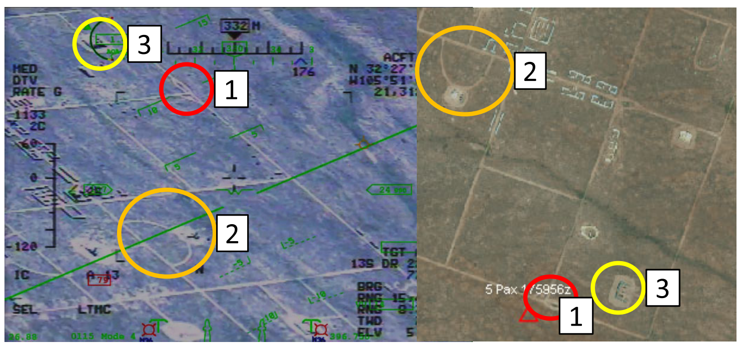
5.5.1.3 Target Approach Analysis. Once crew understands the intent of the tasking (see **paragraph 5.3**, Communicate), and are CONTACT the target area (see **paragraph 5.5.1.1.2**, Cross-Cue) they should analyze how the area should be searched based on the intent of the tasking while in the "find" phase. Based on the information obtained and the target objective (see **paragraph 5.3.1.1**, Search Objectives) crews will decide on using a high fidelity search or a wide area search. Crews should begin this decision based on a center reference point provided. If a center point is provided for the target location, crews should then assess if the target(s) can be within the location accuracy. If the answer is yes, then crews should assess if the target(s) can be present on the terrain within the target location (see **paragraph 5.4.2.7**, Terrain Analysis). If the crew answers yes to all of the previous decisions, then proceed with a high fidelity (HIFI) search approach. If the crew answers no to any of the decisions, then continue with a WAS approach. See **Figure 5.9**, Target Approach Analysis Decision Matrix.

5.5.1.3.1 High Fidelity Search. A HIFI search begins with the center point of a location. Crews should be aware of the fidelity of the location center point passed (see **Figure 5.6**, MGRS and Lat/Long Coordinate Units of Measure) as the boundary of the search. SOs should use search patterns (see **paragraph 5.5.1.5**, Search Patterns) for the TGP and/or SAR (Refer to *MQ-9 Lynx Synthetic Aperture Radar (SAR) Handbook V3.0*) while prioritizing the center point of the location and working outward. Crew members will bound the search to the accuracy of the center point passed.

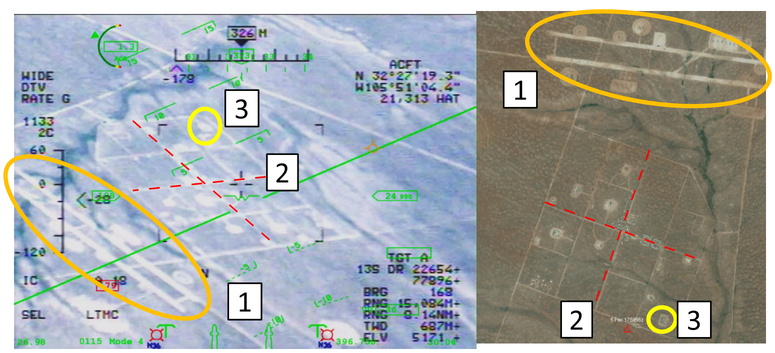
Figure 5.8 Big-to-Small.



While conducting an LOC scan, the crew identifies a group of fighting age guys that matches the ID criteria passed by the supported unit. The crew immediately plots the location in their TACSIT and begins building a *big-to-small* to facilitate rapid reacquisition if required. For the *small picture*, the crew takes note of the disabled vehicle (1) immediately north of the target which does not appear in their TACSIT.

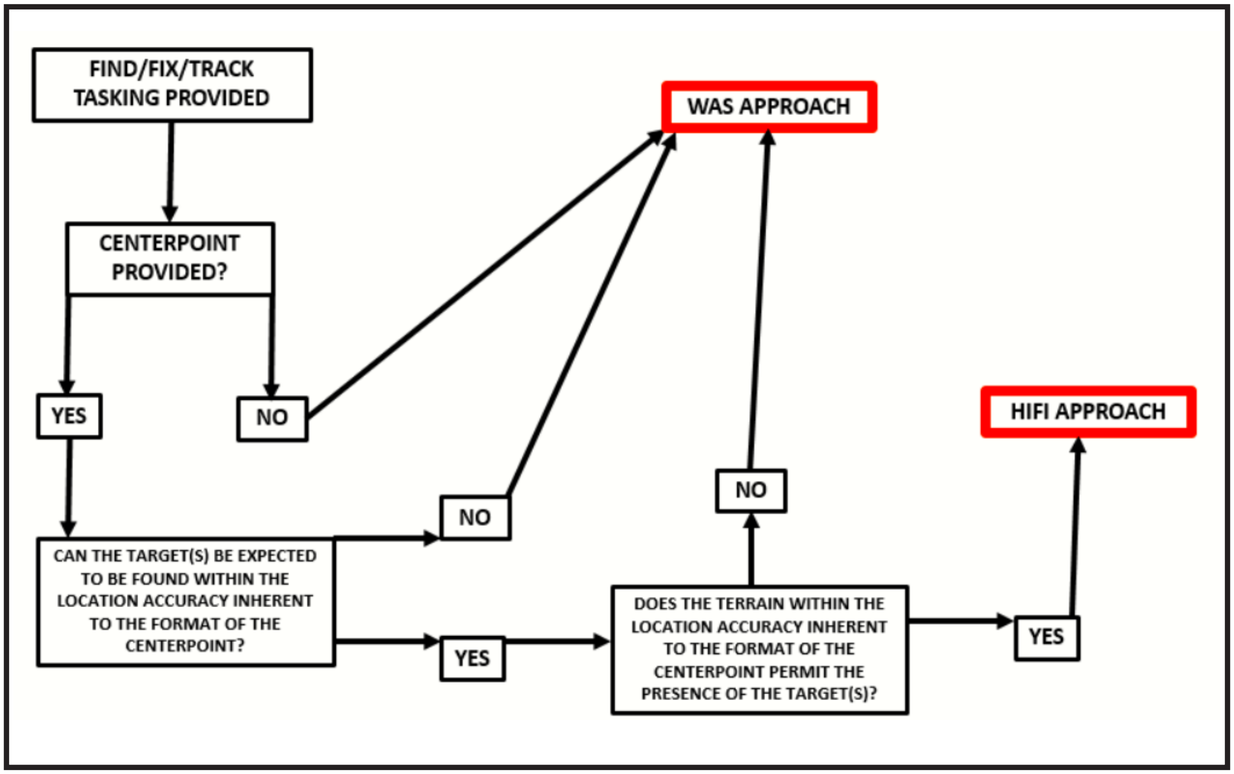


Zooming out to build several *medium picture* features, the crew identifies a unique T-intersection (1) east of the disabled vehicle which is also noted in the TACSIT. The crew identifies the intersection is bracketed to the north west by a U-shaped road (2) that opens to the north, and to the east by a C-shaped building (3) that opens to the east.



Zooming out further, the crew is able to see in the *big picture* that the village is south of an airfield (1), and that it can be broken up into four quadrants. The target is in the south-eastern most quadrant (2), easily identified by the C-shaped building (3) which the crew determines is the best STAKE. Once complete with the *big-to-small* the crew reacquires the LOC and continues the LOC scan.

Figure 5.9 Target Approach Decision Matrix.

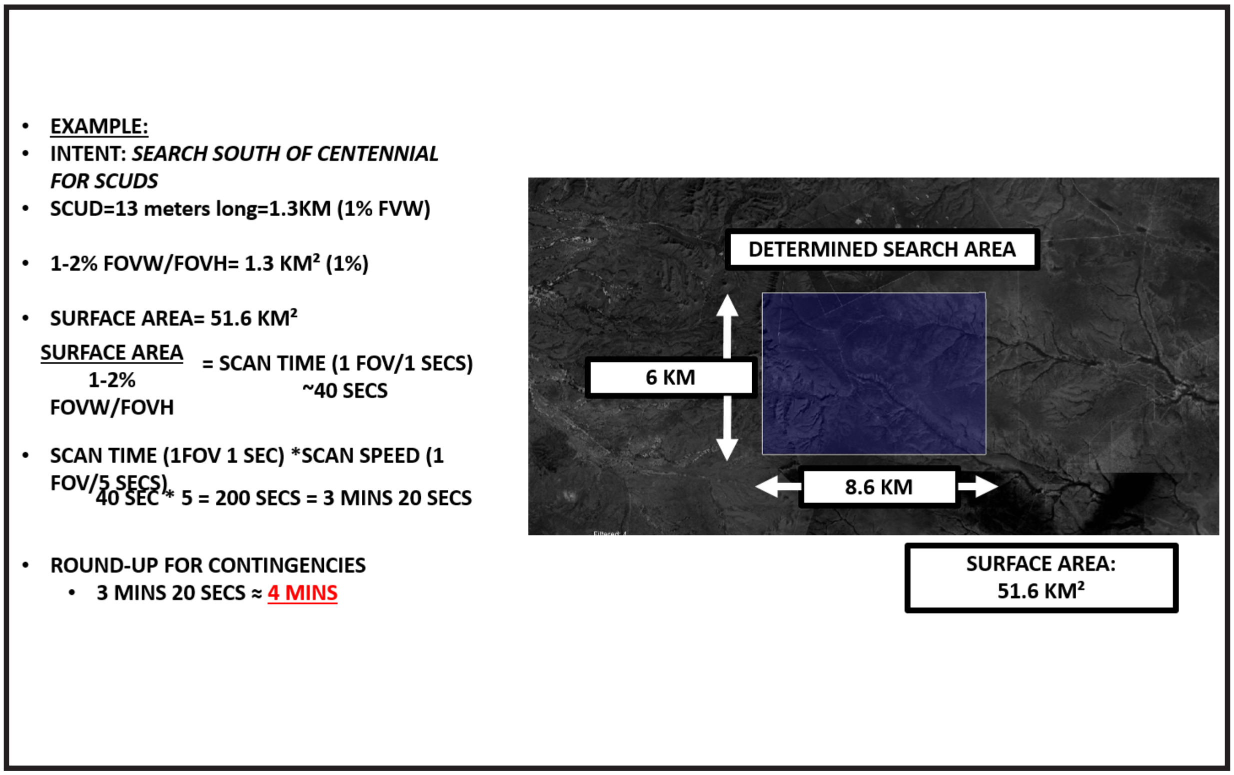


5.5.1.3.2 Wide Area Search. A WAS begins by assessing the target (see **paragraph 5.4.4**, Communication) and terrain (see **paragraph 5.4.2.7**, Terrain Analysis). Crews should assess the most likely areas the target could be and prioritize the scan in those areas initially with the SAR and TGP. An example is identifying mountainous terrain, an urban area, lines of communication (LOC), and rural areas during terrain analysis while tasked to search for a moving convoy. In this example, the crew should prioritize the LOC as the most likely location of the target, followed by urban then/or rural area, and lastly the mountainous terrain. SOs should use the TGP for different search patterns (see **paragraph 5.5.1.5**, Search Pattern) and the SAR (Refer to *MQ-9 Lynx Synthetic Aperture Radar (SAR) Handbook V3.0*) while scanning these prioritized locations.

5.5.1.3.3 Contingencies to Target Approach Analysis. Some circumstances may require a hybrid/opposite approach (HIFI versus WAS). In these situations, crews should understand the intent of the task (see **paragraph 5.3**, Communicate) and leverage sensors and search patterns to complete the scan in the most effective and efficient method. For example, if searching in a valley for tanks that has been deemed a WAS (i.e., no center point provided) and the search area is 1 km x 1 km, it may be more timely to conduct a HIFI approach by starting with the center point and conducting a rolling box search pattern (see **paragraph 5.5.1.5.1**, Rolling Box). An additional example is searching an ellipse generated by electronic intelligence (ELINT) for a Straight Flush radar. If the ellipse (i.e., 5 NM x 2 NM) is passed as a Bullseye cut and the terrain is assessed as feasible for the radar to exist, then a HIFI approach should be used. Based on the size of the target location, it would be more efficient to prioritize where the target would be from terrain analysis dictating a WAS approach instead.

5.5.1.4 Search Plan Time Line. Search plan time lines are to be primarily used for planning and debriefing purposes to measure efficiency. In order to maintain efficiency during a search tasking, crews should calculate the length of time for a scan. Crews should consider the size of the target location (see **paragraph 5.4.2.5**, Target Area Analysis) and the FVW to use during the search (see **paragraph 5.4.2.4**, Required Sensor Fidelity) Dividing the target area size by the 1 percent FVW will conclude the length of time scanning at 1FOV/1s. Multiplying the determined length of time by the assessed scan speed (see **paragraph 5.5.1.4.2**, Rate of Scan and TGP Slew Methodology) will provide the length of time for the TGP at the realistic scan speed. See **Figure 5.10**, Search Plan Time Line.

Figure 5.10 Search Plan Time Line.



5.5.1.4.1 Rate of Scan and TGP Slew Methodology. TGP slew methodology is a process the SO uses to slew the TGP and execute the search pattern. The two most common types of slew methodology are continuous and frame-by-frame. In continuous slew methodology, the SO slews the TGP at a constant rate commensurate with required fidelity and direction in accordance with the search plan. The continuous slew methodology lends itself to an efficient search, but the crew must exercise due diligence to ensure excessive slew rates do not prevent the ability to assess the TGP image and find/fix search objectives. In the frame-by-frame methodology, the SO slews the TGP approximately one screen at a time in the direction of the search pattern with the required fidelity, and allows the TGP to dwell on a scene long enough to assess the presence of objectives. The frame-by-frame methodology lends itself to an effective search, but the crew must exercise due diligence to ensure dwell times are not excessive, which limits the efficiency of the search. SOs should measure the time it takes to slew one frame in order to quantify the slew rate for planning purposes by referencing a point on the HUD in the direction of the scan and measure the time it takes to cross the screen.

5.5.1.4.2 Rate of Scan and TGP Slew Methodology Considerations. SOs should asses the slew rate based on multiple factors. In ideal situations, an experienced SO should have a faster slew rate than a lesser experienced SO. Additionally, less than ideal atmospherics may require a slower scan as well as holding distances and target area congestion.

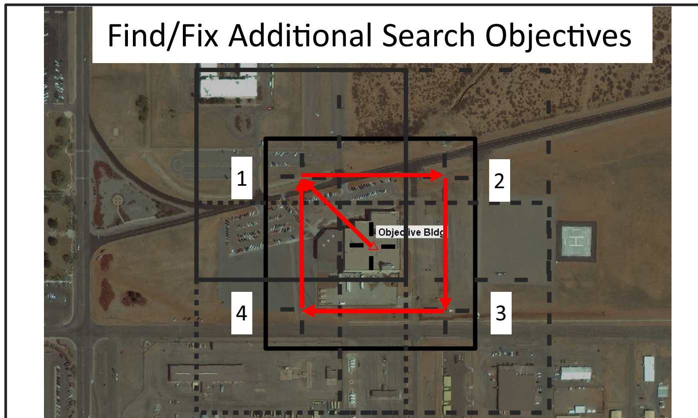
5.5.1.4.3 FVW. The 1 percent FVW is intended as a conservative factor for calculating a search time line during planning and debriefing. The assumption is that FVW and FVH will be equal at all times. Generally, FVH is larger than FVW, dependent on aircraft holding parameters and depression angle. Using a smaller, overall FOV for calculating, crews can compare the actual scan time line to the calculated in order to measure efficiency.

5.5.1.5 Search Patterns.

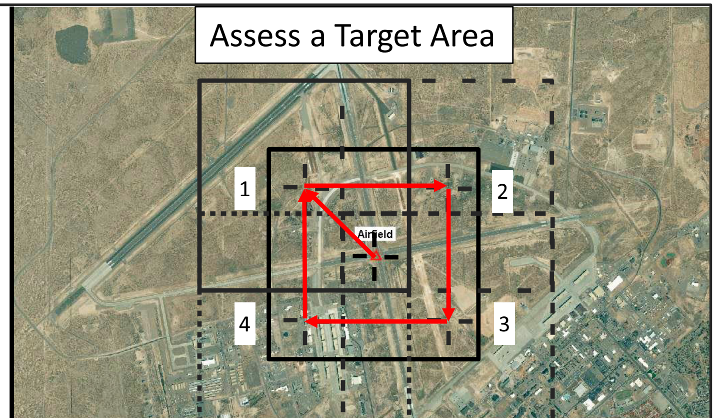
5.5.1.5.1 Rolling Box. A rolling box search pattern is a quadrilateral pattern conducted around a known target or target area to maintain custody of the target during its execution. It can be used to find/fix additional search objectives (e.g., threats, vehicles, people, and buildings) by searching the perimeter around a known target, or it can be used to find/fix an unknown target located in an area of high confidence that requires high sensor fidelity to detect it (e.g., isolated personnel). Additionally, the rolling box search pattern can be used to quickly assess a large target area to create, modify, and/or improve a search plan when updated imagery is unavailable and/or time and conditions do not permit excessive imagery study (e.g., ad hoc tasking). In this case, use the rolling box search pattern to conduct real-time target area analysis to determine which areas within the target area should be searched, which areas should not be searched, and how the search area should be divided. Once complete, the search plan should be updated with the applicable types of search patterns and required fidelity. See **Figure 5.11**, Rolling Box Search Pattern.

5.5.1.5.2 Raster Scan. A raster scan search pattern is a two-axis search pattern used to methodically search through a target area. The TGP is slewed between the defined boundaries of a target area one row at a time until the entire target area has been searched. Each row is the size of the corresponding FOV; therefore, increased required sensor fidelity increases overall search time. The raster scan search pattern can also be used to quickly assess a large target area to create, modify, and/or improve a search plan when updated imagery is unavailable, and/or time and conditions do not permit excessive imagery study (e.g., ad hoc tasking). Generate a TacSit overlay for preplanned target areas that can be used during mission execution to highlight and bound the search area. See **Figure 5.12**, Raster Scan Search Pattern.

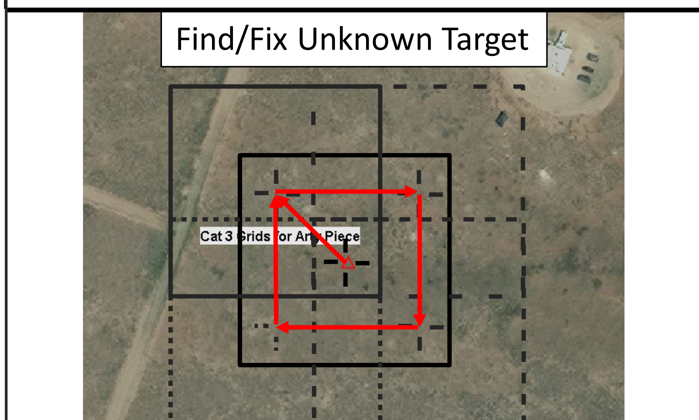
Figure 5.11 Rolling Box Search Pattern.



Slew Obj Bldg to lower right corner of screen and look for additional search objectives (1). Once complete, slew right until Obj Bldg is in lower left corner of screen (2) and look for additional search objectives. Continue this pattern until Obj Bldg is back in the lower right corner (1) and then center crosshairs on Obj Bldg.

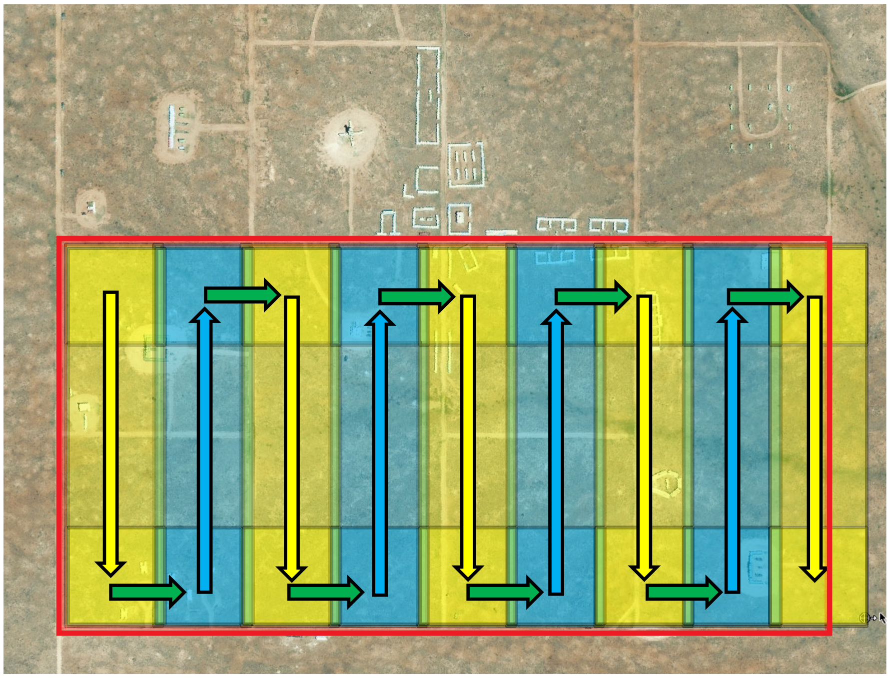


Use runway intersection for center reference point of target area. Slew intersection lower right corner of screen (1) and conduct target area analysis to determine areas and which search patterns to apply to search them for search objectives. (1). Once complete, repeat pattern in all quadrants around the runway intersection.



Slew sensor to passed Cat 3 target coordinates. Conduct *imagery correlation* between TACSIT imagery and MTS imagery to slew the MTS to the plotted location. Note the features of the center point and conduct the rolling box search pattern, while pausing in each quadrant and searching for the *unknown* target.

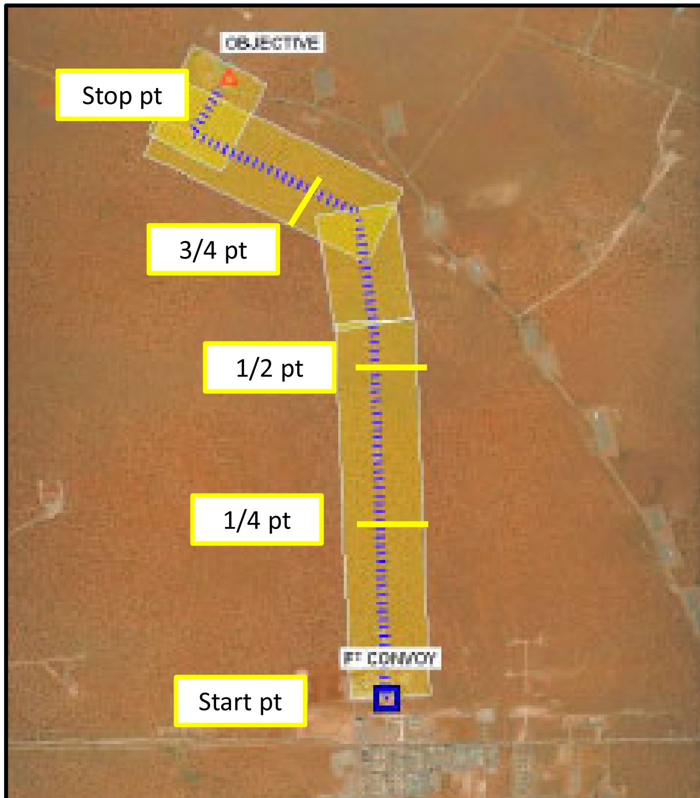
Figure 5.12 Raster Scan Search Pattern.



5.5.1.5.3 Line of Communication (LOC) Scan. The LOC scan pattern is a linear scan along a LOC to find/fix targets on the LOC or in the immediate vicinity. It is used to quickly search along a planned route of travel. To conduct an LOC scan, slew the TGP to the LOC and scan in the desired direction, maintaining the LOC in the FOV. SOs can offset the FOV in order to scan a specified distance (i.e., 400 meters off of an LOC for defensive fighting positions) while still maintaining the LOC in the FOV during the scan. See **Figure 5.13**, LOC Scan Pattern.

5.5.1.6 Maritime Wide Area Surveillance. The SAR and CLAW software provide a maritime wide area surveillance (MWAS) capability to detect the RCS of surface vessels using a Doppler-based mode in a maritime environment similar to MTI. When using MWAS, crews should determine the smallest and largest maritime targets anticipated to find and set the RCS minimum and maximum setting accordingly. For the RCS of vessels, see **Figure 5.14**, Maritime Vessel Detection Range. Additionally, MWAS has two submodes: Arc Scan and Spot Scan. Arc Scan provides the widest coverage area and stays at a fixed distance relative to the aircraft. To use an Arc Scan, pilots should establish the aircraft flightpath that covers the target area and set the scan far range to the distance between each leg of the path. Spot Scan references a designated point for as long as the desired imaging area remains in the MWAS field of regard or the crew commands Standby Mode. To use a Spot Scan, pilots should hold at a distance and direction that enables the MWAS to continuously be in range of the designated point. **Figure 5.15**, Arc Scan vs Spot Scan, shows a visual depiction of a proper flightpath for MWAS Submodes. Refer to *SAR Handbook V3.1,* 20 June 2020, for MWAS settings and set up.

Figure 5.13 LOC Scan Pattern.



LOC Scan Only (|||||| portion)

- Go from Start to Stop points with MTS centered on the LOC
- Backup search progress and allocated time with distance markers
- Clear the LOC from any obstructions, choose TWD for anticipated threats

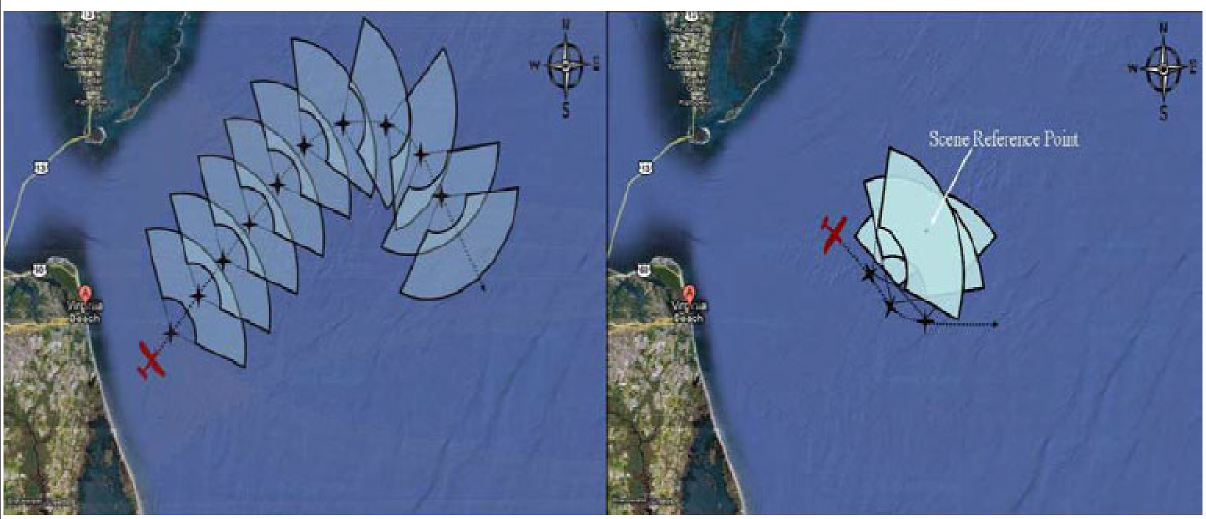
LOC Scan (||||| portion) & Raster Scan Search to 300m (portion)

- Conduct LOC scan on a section of the LOC with required sensor fidelity for anticipated threats
- Conduct Raster Scan from edge of the FOV during LOC scan, out to 300 meters from the LOC with required sensor fidelity for anticipated threats.
- Backup search progress and allocated time with distance markers

Figure 5.14 Maritime Vessel Detection Range.

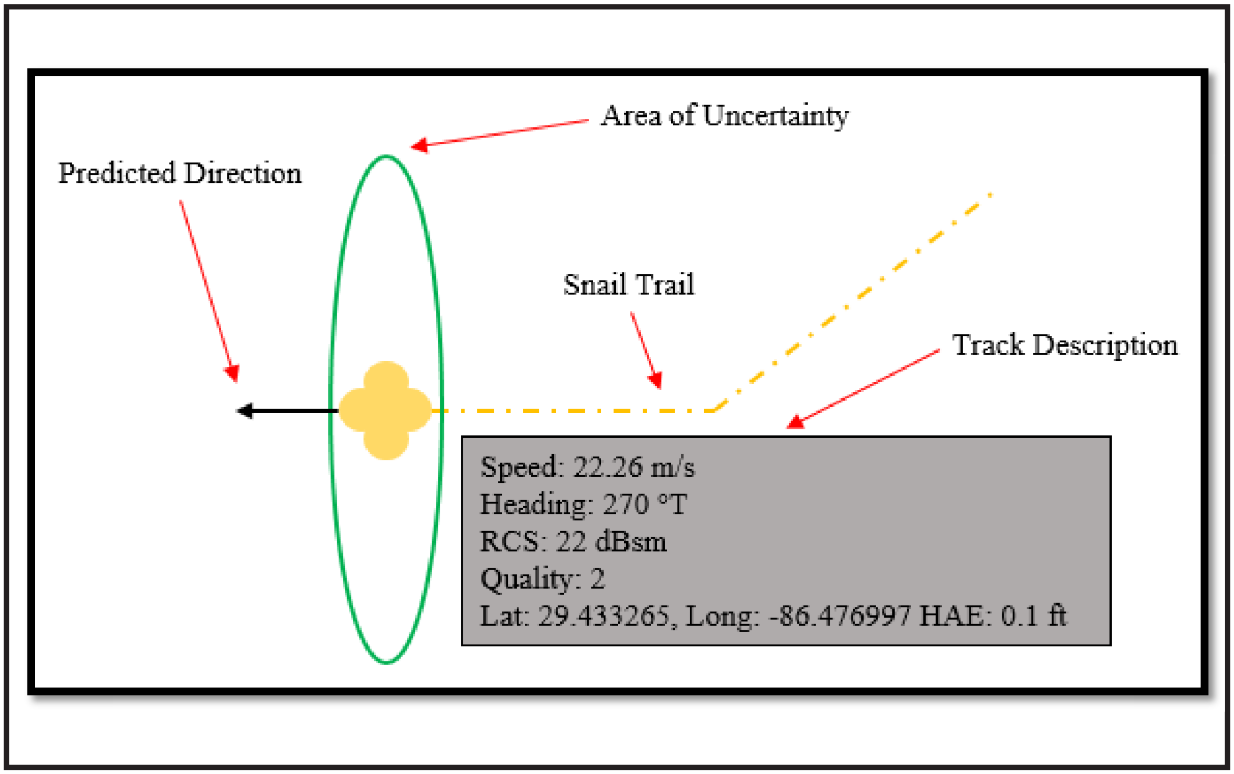
Vessel Type / Size	Representative Picture	~ Radar Cross Section (RCS)	Max Detection Range (Sea State 3)	
			km	NM
Small Rigid Inflatable Boat (<9 ft)		0.5 sq m	25	13
Shorter GOFAST Boat (<18 ft)		1 sq m	35	18
Longer GOFAST Boat (<45 ft)		2 sq m	45	24
Pleasure Boat (45-100 ft)		5 sq m	55	30
Fast Attack Boat (120 ft)		20 sq m	75	40
Patrol Craft & Larger (300+ ft)		50+ sq m	100	54

Figure 5.15 Arc Scan vs Spot Scan.



5.5.1.6.1 High Value Target (HVT). HVT is a function that allows CLAW to automatically assign a track number, and provide speed, RCS, predicted heading, location, and location history of a target discovered using MWAS and MTI. If crew members identify the expected RCS of a found target (see **paragraph 5.3**, Communicate) Fix (see **paragraph 5.5.2**, Fix). If an emerging target is identified with MWAS and displays the expected RCS, crews should proceed to further confirm the target identification using the TGP or other available sensors (see **paragraph 5.5.1.1.2.2**, SAR Cross-Cue for the TGP). The information displayed with the HVT function on CLAW is shown in **Figure 5.16**, HVT Track Information.

Figure 5.16 HVT Track Information.



5.5.2 Fix. The Fix phase begins when a potential target has been detected and nominated for further development. Fixing a target is determined from terrestrial, electronic, or astronomical data from the Find phase to determine the identification and precise location. Targets can be fixed with the TGP and/or SAR using the best resolution necessary to determine the characteristics and location.

5.5.3 Track. When it has been determined that the target meets priority and PID criteria per the tasking, track the target by using the best sensor to maintain target identification for further collection/exploitation and/or completion of the F2T2EA process (i.e., target, engage, and assess). The kill chain moves fluidly into the track step after the fix step and is continually executed through the remainder of the kill chain. The target area awareness developed during the find/fix steps should provide the crew the necessary awareness to update the game plan for the track step. Conduct task analysis (see **paragraph 5.3.3.1**, Task Analysis) in order to build/modify an effective game plan to track the target as discussed in the find/fix section. The three most common objectives of the track step are to collect/exploit a target, maintain target custody to prepare for the target/engage steps, or to maintain custody to handoff the target to another asset.

5.5.3.1 Static Targets. Static targets are targets that are stationary without the ability to autonomously move (e.g., buildings, bunkers). Position the aircraft at range and direction to maintain custody of target. If the SO is stuck between FOVs that do not provide coverage of the entire target when zoomed-in and do not provide sufficient fidelity to collect on the target when zoomed-out, the pilot should increase range from the target to increase the FVW in the narrower FOV in order to provide complete coverage of the target with sufficient fidelity. If higher fidelity imagery is required, or a top-down look angle of the target, then execute a zero-ground range pass.

5.5.3.2 Mobile Targets. Mobile targets are targets that can move. Examples of mobile targets include parked vehicles that are occupied or have potential occupants nearby. Considerations for tracking mobile targets are similar to static targets but with the anticipation that it may quickly become a moving target. Accomplish target area analysis to determine the likelihood that the target will move. Anticipate moving targets by selecting a track mode other than area track and holding in a manner that will allow moving target tracking (e.g., holding closer in cluttered environment to prevent terrain/object masking).

5.5.3.3 Moving Targets. Any target in motion during the track phase is a moving target. Examples include any vehicles on the surface or airborne that are in motion. Moving dismounts are generally not considered moving targets. Moving targets complicate target tracking by requiring additional target area analysis to prevent terrain masking and drive holding considerations to avoid aircraft masking. Hold at a range that balances steep look angle and room to maneuver. Make turns into the target to avoid aircraft masking. Use the TacSit to anticipate travel direction of vehicles on LOCs. TGP is the primary sensor for tracking moving targets. Use the largest FVW as possible to maintain custody. If a moving target exits the FOV, immediately zoom out to reacquire. Zoom back in and continue track once target is reacquired.

5.5.3.4 Collect/Exploit. Collection/exploitation of a target is persistent sensor collection on the tracked target to gain additional information that triggers the remaining steps in targeting process or gain additional information that updates intelligence assessments and nominates additional targets. Considerations should be made when collecting/exploiting targets to ensure the collection requirements are understood and continue to assess game plan effectiveness.

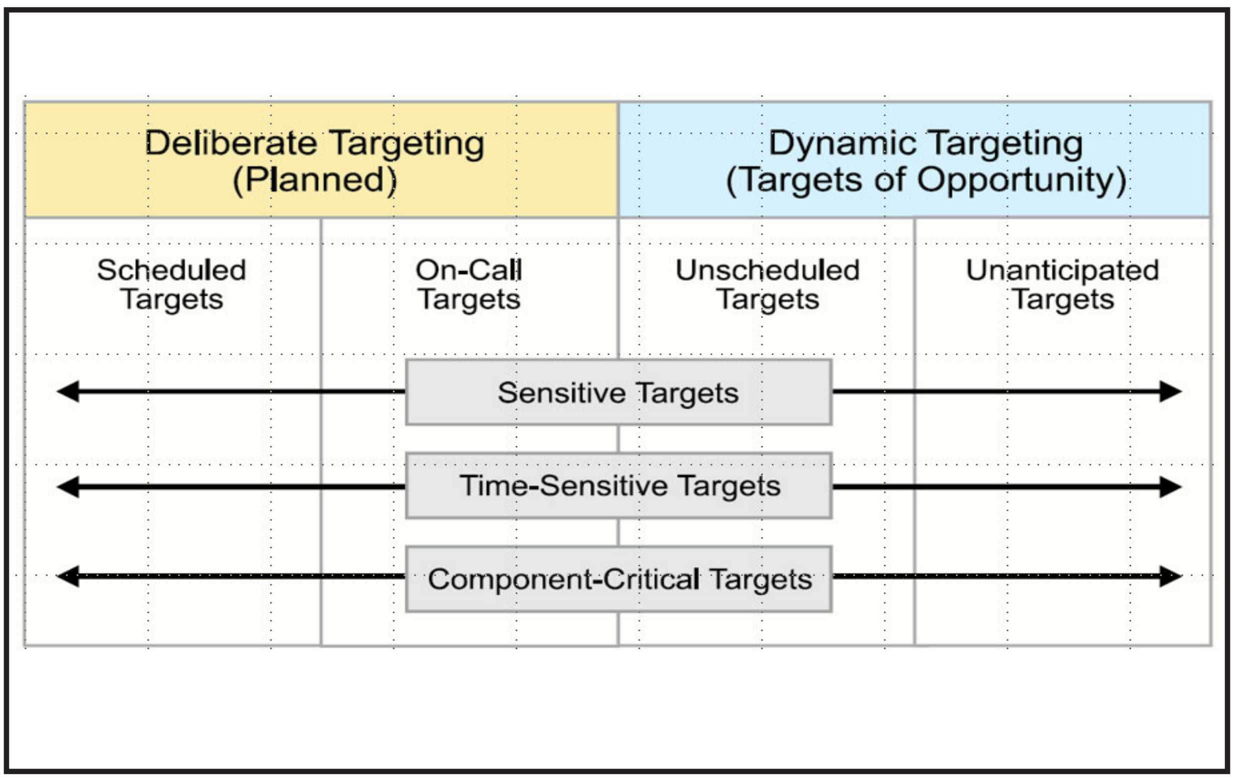
5.5.3.5 Prepare for the Target/Engage Steps. In order to prepare for the target and engage steps, the target must be tracked from the time it is found/fixed through the remainder of the kill chain. When the objective of the track step is to prepare for the target/engage steps, a proactive mindset minimizes delays for aircraft positioning once ready to target and engage. The crew's game plan will typically be weapons-driven for a known hostile target.

5.5.3.6 Handoff. The crew may be required to pass custody of the target to another asset. The crew will be required to maintain track of the target until the gaining asset calls CAPTURED or TALLY. A common method for handing off a target to another asset is a target talk-on.

5.5.3.6.1 Talk-On. A talk-on is a target acquisition technique between the MQ-9 crew and an outside source to get one or the other onto a known target or target area. Many resources can be used to help assist in a talk-on to include the LRD, LTM, video downlink (VDL), or target sorting message (TSM). When providing or receiving a talk-on, confirmatory communication methods should be used as a means to ensure the assets share a mental model of the information being passed. Describing distinguishing features on a target or geographical references are some methods to use, but anything that stands out in the respective level of fidelity can be used as a confirmatory communication method. Refer to JP 3-09.3, *Close Air Support*, Ch V, Section 7, Target Correlation.

5.5.4 Target. The target step begins with validation. Validation ensures the target's compliance with commander's intent, law of armed conflict (LOAC), ROE, collateral damage estimate (CDE), and any other restrictions. By the end of the Target phase the target engagement must be approved, weaponeering determined, deconfliction solved, and collateral damage estimated. Starting from the target backwards, determine the best available solution to meet intent. The plan for the target will vary depending if the target is deliberate or dynamic. See JP-3-60, *Joint Targeting*, and **Figure 5.17**, Targeting Categories and Targets.

Figure 5.17 Targeting Categories and Targets.



5.5.4.1 Deliberate Targets. Deliberate (preplanned) targets are properly validated and placed on the joint target list. Deliberate targets are further broken down into two categories: scheduled and on-call. Scheduled targets are prosecuted at a specific time, while on-call targets have actions planned but not a specific delivery time. Crews will receive taskings via the ATO for deliberate targets. Deliberate targets often allow for dedicated mission planning. In some circumstances, the target might be currently tracked by one crew while another crew plans the attack game plan. Refer to AFTTP 3-1.MQ-9, Chapter 7, "Air Interdiction," for detailed planning considerations through all phases of a deliberate target attack plan.

5.5.4.2 Dynamic Targets. Dynamic (ad hoc) targets are targets that are serviced within the current ATO cycle (24-hour execution period). Dynamic targets can be further broken down into unscheduled and unanticipated. Unscheduled targets are known targets that were not nominated on the current ATO cycle but changes in the target status or priority has resulted in a need to engage the target within the current ATO cycle. Unanticipated targets are targets that are unknown or unexpected in that operational environment. Dynamic targets provide a different challenge to crews than deliberate targets because all of the steps of the target phase must be accomplished ad hoc without the luxury of prior mission planning and often on an accelerated time line.

5.5.5 Engage. The engage step is when action is taken against the target. An engagement order is issued and passed and the target is engaged. At this point in the kill chain, the weapons-driven game plan has been built and the crew executes the attack plan. See **Chapter 7**, "Single-Ship Surface Attack Tactics," for surface attack TTP.

5.6 Assess. The CBEAR assess phase requires continuous evaluation of plan, progress, and effectiveness to prevent complacency and ensure efficiency. The crew must be ready to adjust the plan if new information affects the current plan or if the plan is identified as insufficient to meet the desired intent. The crew should assess whether the game plan has met the communicated intent or return to the beginning of the CBEAR process. In some cases, for example, when new information is provided or results are unexpected, the crew should clarify whether or not the intent remains the same.

5.6.1 Assess. Determine if the desired killchain effects were met from the initial engagement. If a reattack is required, report the results of the engagement back to the applicable source. The desired effects and need for a reattack are determined through a munitions effectiveness assessment (MEA) and battle damage assessment (BDA).

5.6.1.1 Assessing with the TGP. Assessing MEA and BDA with the TGP is as simple as looking at the target(s) struck and identifying if the intent of the strike was met. **paragraph 7.3.2.1.5.4** outlines the post-impact procedures for each strike. The addition of SWIR and LWIR to the DAS-4 TGP provides the best capability to penetrate through smoke, dust, fog, and haze, which could yield a faster assessment in a rapidly evolving environment. These features are an option to use—however, DTV and MWIR provides better capability for tracking potential Squirters. SWIR and LWIR should be used when the potential for Squirters does not exist or the likelihood is very low.

5.6.1.2 Assessing with the SAR. SAR use for MEA and BDA should be limited to situations that require the aircraft to be employing munitions above the weather or when the TGP is being used in a higher priority task. To properly employ this technique, the highest possible resolution spot image must be taken prior to the attack run. When the attack is complete, the crew must take the same resolution spot image of the same location and compare the two images for the fastest assessment. If time and conditions permit, the crew should repeat the image collection procedures (Refer to *SAR Handbook V3.1*) in order to give the most precise assessment. Crews should be looking for either an additional return in CLAW, indicating a miss of the bomb, or a change in the magnitude of the target, indicating a hit.

5.6.1.3 Reattack. The crew will make reattack recommendations based on initial assessment of MEA and BDA. If desired effects were not achieved and a reattack is required, obtain any required approvals and execute the reattack IAW **Chapter 7**, "Single-Ship Surface Attack Tactics."

5.7 Report. The report step begins at the completion of the assess step, or when something triggers an immediate report back to the crew and outside assets. The required tasking information should be reported back in a clear, concise and correct manner in accordance with the established communication contracts, or requested EEIs. As with any type of communication, crews should seek acknowledgment of reported information to ensure all parties are aware of the most recent data. Once the information is reported back, the crew members execute the CBEAR loop over again.

5.7.1 MEA/BDA. Report back the MEA, BDA and reattack recommendation (as required). If an inflight report is required, provide the required information in the correct format to the correct source. This step closes out the kill chain and the basic tasking flow. Upon its completion, the crew should request next tasking or RTB.

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CHAPTER 6

BASIC WEAPONS AND EMPLOYMENT TOOLS

6.1 (FOUO) Overview. This chapter provides guidance on MQ-9 weapons, Stores Management System (SMS), and basic employment of tactical execution tools. Topics include basic weapons overview, SMS setup, and weapons employment tools. Refer to unit-specific weapons and tactics guidance to further supplement this chapter.

6.1.1 (FOUO) Weapons. The MQ-9 carries forward-firing ordnance, laser-guided bombs (LGB) and joint direct attack munitions (JDAM). This chapter will cover AGM-114, GBU-12, GBU-49, GBU-38 and GBU-54 employment. An intimate understanding of each weapon's capabilities is required for the crew to select the best weapon to pair against each target to achieve the desired effect. Refer to TO 1-1M-34, *Aircrew Weapons Delivery Manual (Nonnuclear)*, for detailed information on weapons and components.

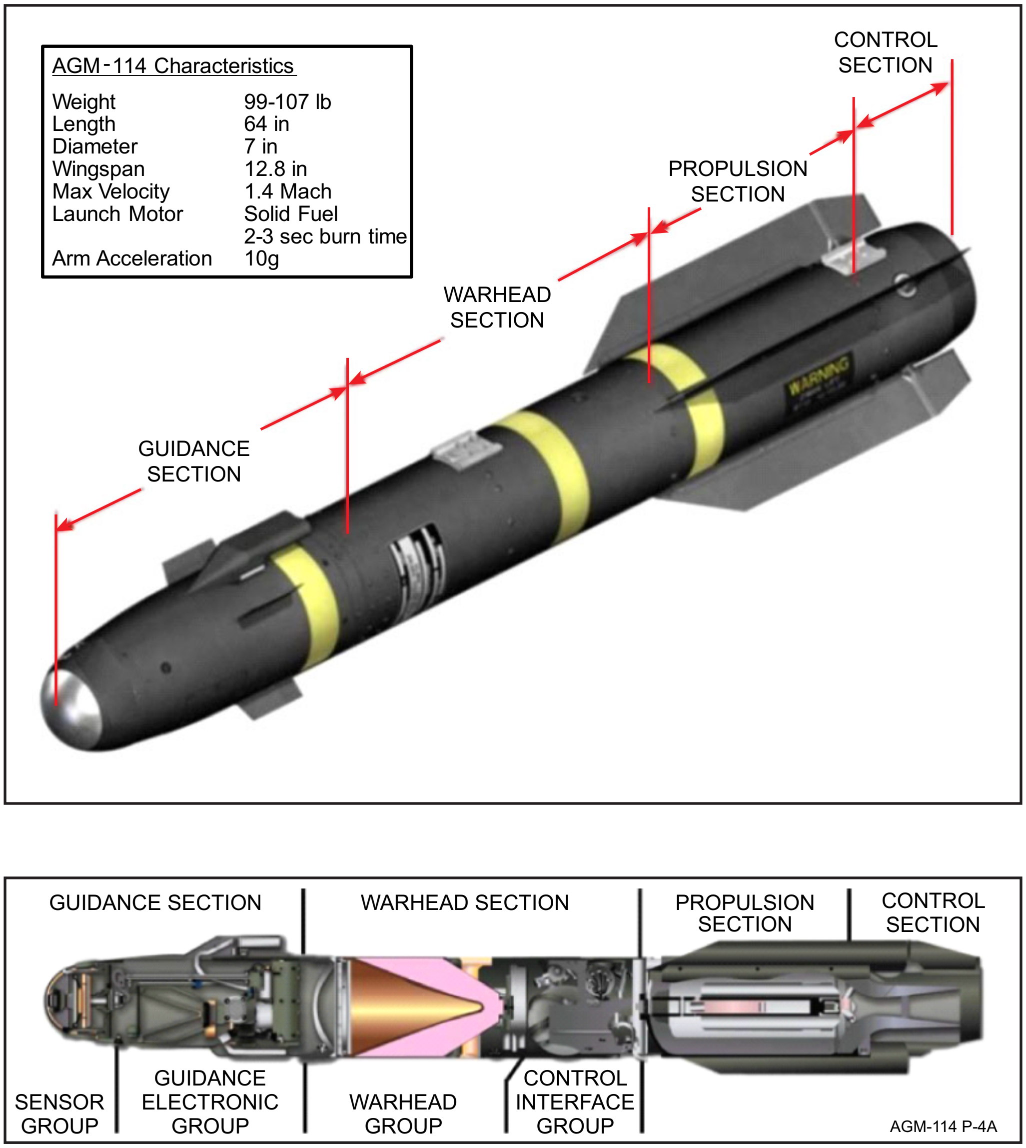
6.2 (FOUO) AGM-114 Hellfire. The AGM-114 Hellfire is a laser-guided, forward-firing missile. The missile contains four sections, Guidance, Warhead, Propulsion, and Control. See **Figure 6.1**, AGM-114 Overview, for a depiction of the missile and its sections. The MQ-9 can carry up to four AGM-114s; two on each M-310 Hellfire launcher, loaded on Stations 2 and 6. For detailed information on the AGM-114, refer to the current version of the *Hellfire Handbook* produced by the 26th Weapons Squadron. This publication will refer to the P-4A, N-4, R-2, and R9E variants. **Table 6.1**, MQ-9 Hellfire Variants, contains additional information. The Hellfire is effective against a variety of targets with varying kill mechanisms and flight characteristics to achieve its effectiveness. Refer to AFFTP 3-1.MQ-9 Chapter 3, "Mission Planning Considerations," for a more detailed target to weapon pairing for the AGM-114.

6.2.1 (FOUO) Guidance and Flight Characteristic. All variants of the Hellfire discussed earlier use Romeo guidance logic. At launch, the Hellfire receives a handover target through an R09 message. The handover target is independent of stores management system (SMS) settings and provides the guidance solution for the Hellfire using the TGP location when launch is commanded. The Hellfire flight trajectory consists of three phases (refer to the *Hellfire Handbook* for a more detailed discussion on the guidance characteristics).

- Initial Command Turn—Maneuvers missile towards handover target within 60 degrees of the handover target.
- Midcourse—Provides trajectory shaping and ends at laser acquisition.
- Terminal—Maneuvers using proportional navigation (Pro Nav) toward the laser spot, i.e., if laser spot is moving the missile will pull lead to intercept.

6.2.2 (FOUO) Flight Profiles. R-Guidance missiles are launched using Lock-on After Launch (LOAL) mode, with three cockpit selectable flight profiles. The flight profiles available include LOAL-H, LOAL-D, and LOAL-L. Flight profiles adjust the missile endgame impact angle. More important to impact angle is aircraft altitude, ground range, and azimuth at launch. **Figure 6.2**, Hellfire Flight Profiles, depicts each flight profile.

Figure 6.1 AGM-114 Overview.

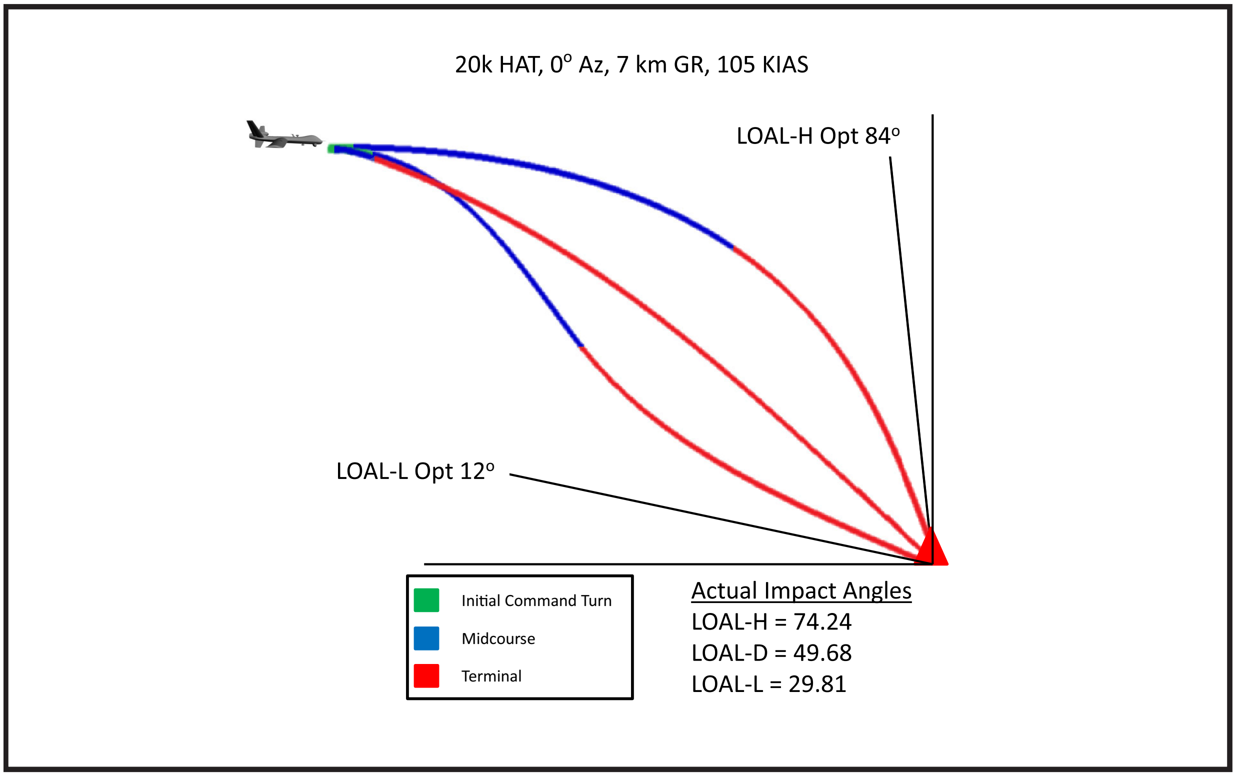


FOUO

Table 6.1 MQ-9 Hellfire Variants.

Type	Length Weight	Guidance	Warhead Types	Fuzing
P-4A	64 inches 104 pounds	Hellfire R	Tandem Shaped—Charges with Steel Sleeve	Contact.
N-4	64 inches 105 pounds	Hellfire R	MAC with flaked aluminum/viton	Time (9.8 ms)
R-2	64 inches 108 pounds	Hellfire R	Tandem Shaped—Charge and IBFS	Programmable: airburst, contact, or time delay
R-9E	64 inches 108 pounds	Hellfire R	N Warhead case with internal tungsten sleeve	Programmable: airburst, contact, or time delay
FOUO				

Figure 6.2 Hellfire Flight Profiles.



6.2.2.1 (FOUO) LOAL-High characteristics. Maximizes impact angle in an attempt to achieve a hard-coded optimal impact angle of 84 degrees. Trajectory shaping minimizes altitude loss.

6.2.2.2 (FOUO) LOAL-Direct characteristics. Does not use trajectory shaping biasing for most direct flightpath. Impact angle dependent on range, HAT, and azimuth at launch. Initial command turn places missile in laser acquisition basket.

6.2.2.3 LOAL-Low Characteristics. Minimizes impact angle in attempt to achieve a hard-coded optimal impact angle of 12 degrees. To minimize impact angle increase range and reduce HAT; trajectory shaping maximizes altitude loss.

6.2.3 (FOUO) Target Handover Boundary and Target Velocity Boundary. Target handover boundary (THB) is used for static targets and is the area on the ground within the limits of the Hellfire seeker's FOV at laser acquisition. Use the THB distance for split lase Hellfire engagements to ensure laser acquisition of all missiles being released. Target velocity boundary (TVB) is used for dynamic targets. The TVB assumes that the handover target is collocated with the moving target when the R09 message is delivered to the weapon. Use TVB for moving target engagements cross-checking the speed of the target to verify it is not exceeding TVB limitations. LOAL-H may provide a sufficient THB and TVB based on missile heading without sacrificing impact angle. **Figure 6.3** Target Velocity Boundary/Target Handover Boundary, contains a depiction of a THB and TVB. For more information on THB and TVB reference current version of *R-Missile Impact Tool User Guide*.

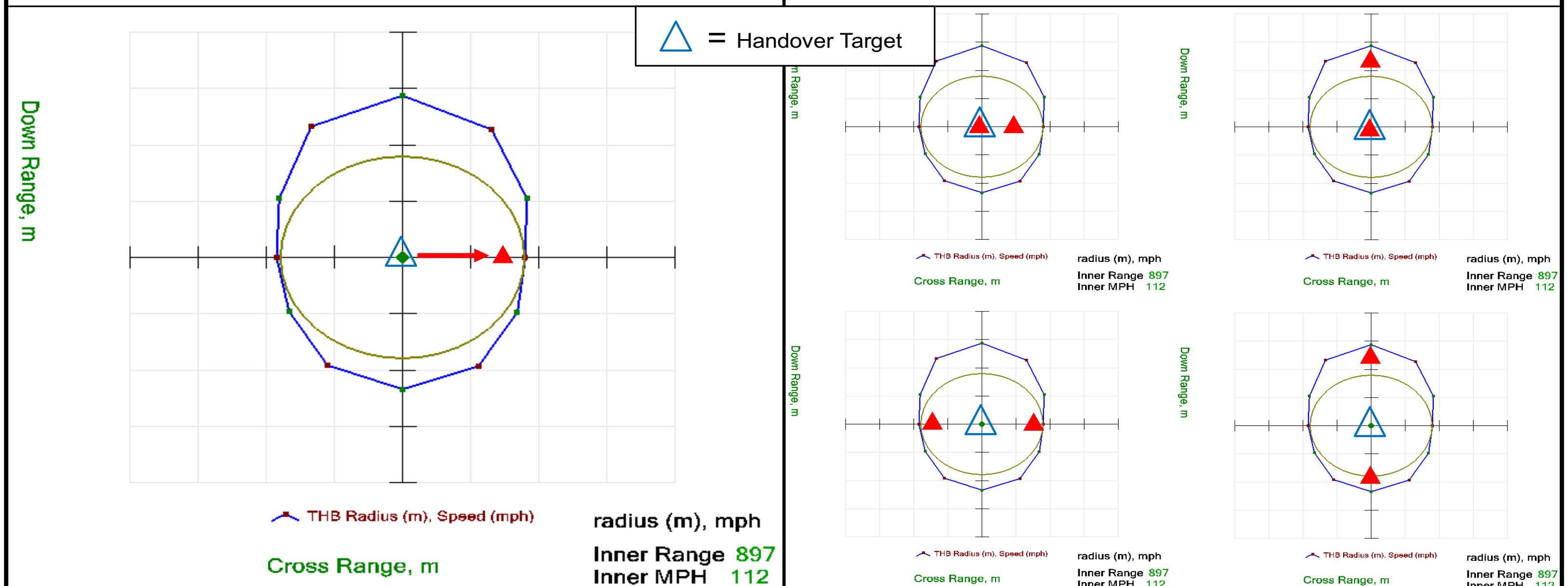
6.3 (FOUO) MQ-9 Bomb Variants. The MQ-9 is capable of carrying 500-pound class bombs; without any Hellfire missiles on board, it can carry up to four bombs at once. The typical bomb body is the MK 82; based on guidance kit an advanced multi-effects bomb live unit (BLU) can also be used. See **Table 6.2**, MQ-9 Bomb Variants, for a quick reference on the differences in bomb components and capabilities. TO 1-1M-34 contains more detail on the individual components and variants.

6.3.1 GBU-12 Paveway II. The GBU-12 Paveway II is a maneuverable, free-fall, 500-pound class, laser-guided bomb (LGB). **Figure 6.4**, GBU-12 Overview, depicts the GBU-12 and its components. GBU-12s are paired effectively against light-skinned vehicles, troops, aircraft, and non-hardened buildings. The MQ-9 typically employs GBU-12s with instantaneous fusing which limits its effectiveness for targets requiring penetration to achieve desired weapons effects.

6.3.2 (FOUO) GBU-49. The GBU-49 is a dual mode, 500-pound class LGB with GPS/inertial navigation system (INS), plus laser guidance. **Figure 6.5**, GBU-49 Overview, depicts the GBU-49 and its components. Currently, there are two seeker variants of GBU-49s that MQ-9 crews must be aware of, Lot 3A and Lot 5. Lot 3A GBU-49s pair effectively against light-skinned vehicles, troops, stationary aircraft, and non-hardened or hardened buildings. Lot 5 has improvements in flight profile, moving target engagement capabilities on movers up to 70 mph, low reflectivity targets, accuracy in high wind conditions, and enhanced laser accuracy.

Figure 6.3 Target Velocity Boundary/Target Handover Boundary.

Moving Target	2 x Static Targets, 2 x AGM-114 with split PRFs



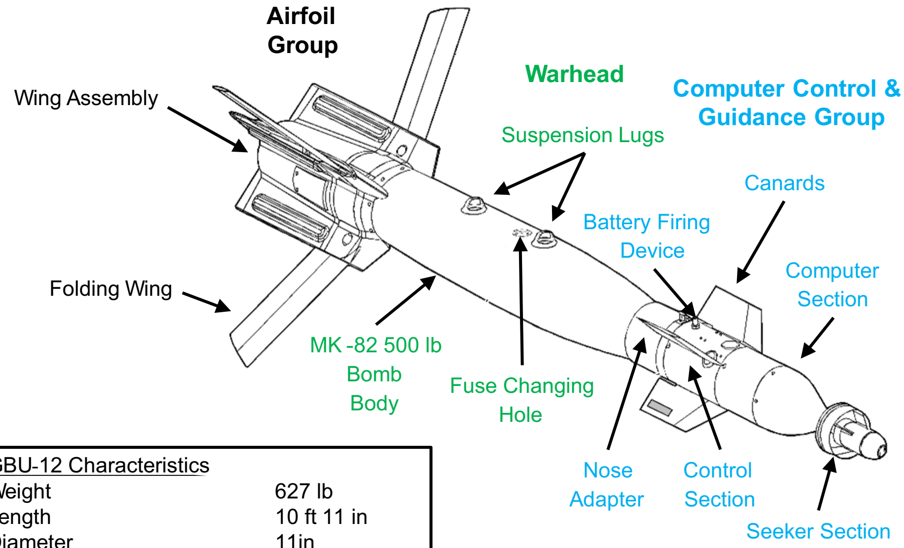
During MTEs, the AGM-114 will initially guide to the handover target sent via the R09 message (i.e., vehicle location at RIFLE). In order to acquire, lock and track the laser spot, the vehicle's speed must be slow enough to stay within the THB until laser acquisition. Worst-case speed is depicted in the lower right corner of the THB.	When engaging multiple DPIs, all missiles initially guide to the handover target. If all DPIs are within the THB at laser acquisition, each missile will acquire, lock and track to its respective DPI. If the distance between DPIs exceeds the THB, it may be necessary to offset the crosshairs between the targets to keep both targets within THB.

FOUO

Table 6.2 MQ-9 Bomb Variants.

Weapon	Fuze	Warhead	Kit Components	Guidance
GBU-12	FMU-152 FZU-63 initiator	MK 82	MAU-169 Computer Control Group (CCG) MXU-650 Airfoil Group (AFG) MAU-209 CCG (for inert bombs)	Laser (LGB) - Ground Set PRF
GBU-49	Programmable FMU-152 A/B FZU-63/B	MK 82, BLU-133, BLU-111, BLU-126, or BLU-129	MAU-210B/B enhanced computer control group MXU-650H/B AFG	Laser - Cockpit set PRF GPS/INS Laser with GPS/INS
GBU-38	Programmable FMU-152A/B *Opt. DSU-33	MK 82	KMU-572X/B guidance set	GPS aided/INS guided
GBU-54	FMU-152 FZU-63 *Opt. DSU-38A/B	MK 82 BLU-111 BLU-126, BLU-129	KMU-572/B guidance set DSU-38A/B	Laser - cockpit set PRF GPS/INS Laser with GPS/INS
NOTES: * DSU-33 provides airburst fuse options selectable in the SMS. * DSU-38 is laser sensor, an optional air proximity sensor (APS) can also be installed on DSU-38.				
FOUO				

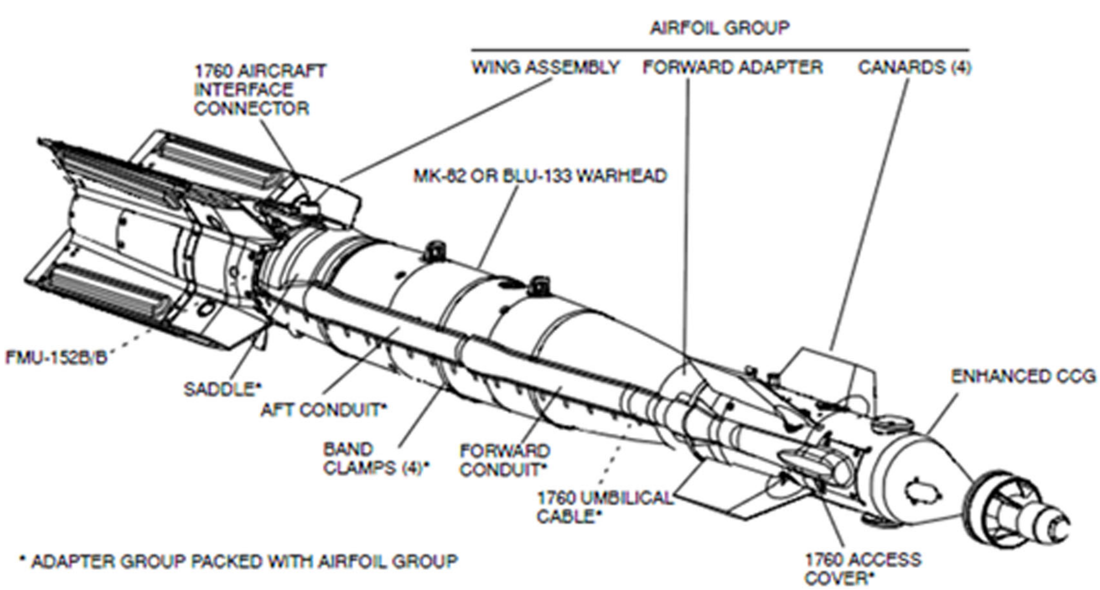
Figure 6.4 GBU-12 Overview.



GBU-12 Characteristics	
Weight	627 lb
Length	10 ft 11 in
Diameter	11in
Wingspan	18 in closed (52 in deployed)
Suspension Lug Spacing	14 in

FOUO

Figure 6.5 GBU-49 Overview.



FOUO

6.3.3 (FOUO) GBU-38 Joint Direct Attack Munition. The GBU-38 JDAM is a coordinate seeking, all-weather, GPS-aided, INS guided 500-pound class weapon. Target-weapon paring is similar to GBU-12s with the exception of improved penetration capability. **Figure 6.6** GBU-38 Overview, depicts the GBU-38 and its components.

6.3.4 (FOUO) GBU-54 Laser Joint Direct Attack Munition. The GBU-54 is a dual mode, 500-pound class JDAM with laser guidance. Target-weapon paring is similar to the GBU-49 including the moving target capability. Kill mechanisms and components are similar to the GBU-38 with the addition of the DSU-38.

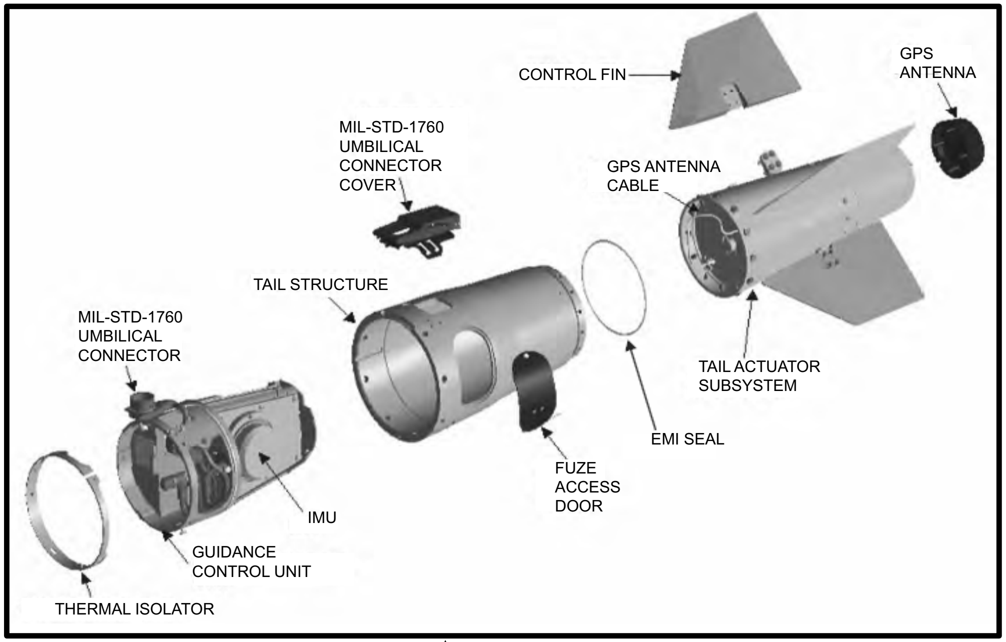
6.3.5 (FOUO) Kill Mechanism. Generally, bombs use blast and fragmentation for its kill mechanisms. The GBU-12/49/38/54 use the FMU-152. With the exception of the GBU-12, the FMU-152 provides cockpit selectable fusing options to pair with specific target types. The FZU-63B initiator accommodates the slower speeds of the MQ-9. If equipped, the DSU-33 on the GBU-38 proximity fuse increases fragmentation effects due to its airburst function. Different bomb bodies provide different kill mechanisms. The kill mechanism with a BLU-129 on a GBU-49 is blast and over pressurization. Additionally, the GBU-49 provides more penetration capability than the other bombs. For a more detailed discussion on weapon target paring reference AFTTP 3-1.MQ-9 Chapter 3, "Mission Planning Considerations."

6.4 (FOUO) Weapons FENCE Procedures. Proper weapons setup during the FENCE-in is required to determine each weapon's functionality and to be prepared for immediate weapons employment in time-critical situations. Weapons-specific FENCE items include: the SMS, Romeo-missile impact tool (RMIT), Guided Weapon Trajectory Software (GWTS), GBU Impact Tool (GBIT), Planning Tool, head-up display (HUD), tracker display, and the TGP.

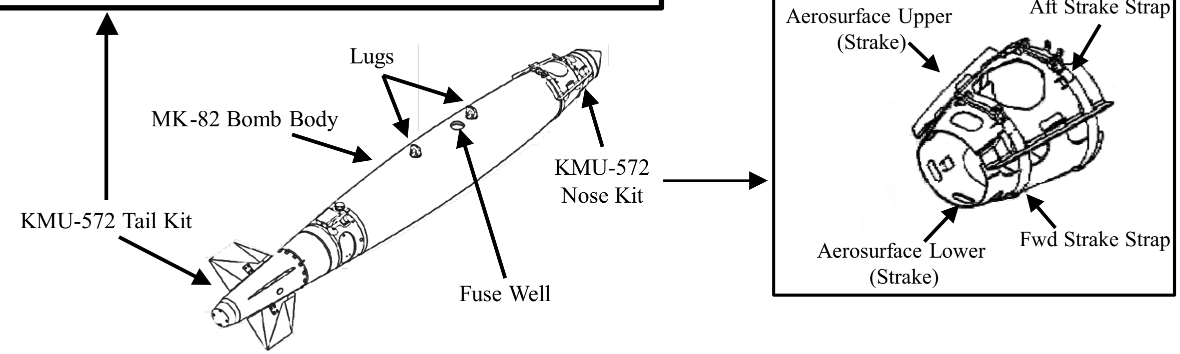
6.4.1 (FOUO) Stores Management System. The SMS is the conduit between the aircraft and the weapons. The SMS provides attack data to the pilot, aids the pilot in flying the aircraft to the appropriate point in space to employ the weapon, and carries out all the requisite communications between the aircrew and the weapons to include the fusing, and release commands. TO 1Q-9(M)A-34-1-1, *Nonnuclear Munition Delivery: MQ-9A Reaper Remotely Piloted Aircraft*, contains detailed information and figures for the SMS and its operation. The following techniques and procedures expedite the proper handling of the SMS. With the SMS displayed, the FENCE flow for SMS setup goes from right to left on the bottom four pages, and then top to bottom on the five pages within the Air-Ground page. **Figure 6.7**, SMS Setup, depicts this flow and the ensuing procedures for setup. The SMS provides the ability to inventory onboard weapons, check SMS/weapons warning, select weapons stores, adjust store settings, select or create a target, adjust release settings, and verify launch status.

6.4.1.1 (FOUO) Inventory. The Inventory page provides the ability to set the weapons loadout on the aircraft into the SMS. When the SMS first powers up, the weapons need to be manually loaded and verified by the SMS. Select each station and then the station's weapon. To load a Hellfire, select the M310 Launcher, then select the specific AGM-114. Once the inventory is set, select "Start Verify" to have the system poll each station and begin communicating with each weapon.

Figure 6.6 GBU-38 Overview.

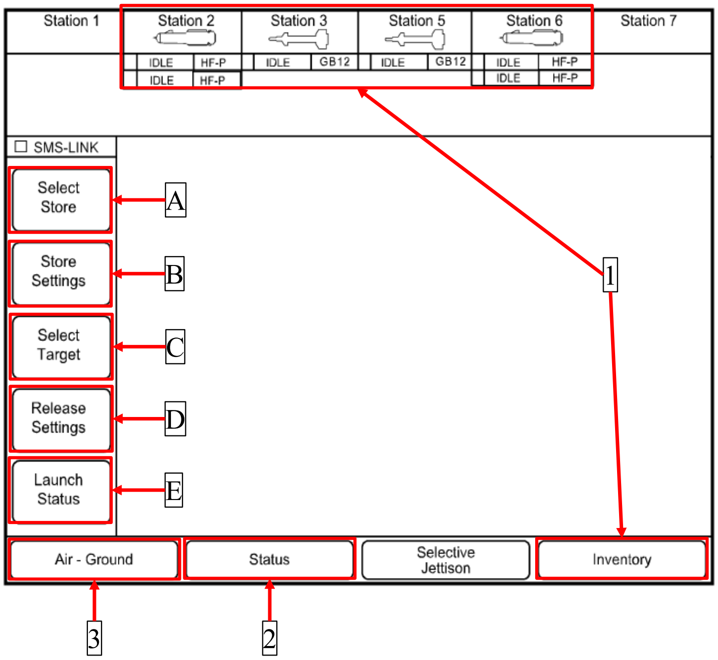


GBU-38 Characteristics	
Weight	568
Length	10 ft 5 in
Diameter	17 in
Suspension Lug Spacing	14 in



FOUO

Figure 6.7 SMS Setup.



1. Load and verify weapons, A/R.

2. Check "Status" page for warnings.
   -If no warnings present, continue to "Air–Ground"
   -If warnings present, check "detailed status"/ "maintenance" pages to trouble shoot.
   Contact GCS/MX.

3. Select "Air-Ground" and begin at the top of the stack:
   A. Select Store
      -Select AGM-114s to start power-up/BIT sequence. Adjust number of munitions to release, release order and release interval, as required for each type of ordnance.
   B. Store Settings
      -Program weapon settings for each individual weapon loaded (e.g., PRF code, launch mode fuzing, delay, etc.).
   C. Select Target -Select CCTP (auto/manual) or a manual target.
   D. Release Settings -Set WEZ, LAR, release modeand adjust run-in line as required for each type of ordnance.
   E. Launch Status -Confirm weapon status and PRF indicators are green with no unexpected red/yellow, correct PRF coded into the MTS and weapon, and verify target information/update mode A/R.

FOUO

6.4.1.2 (FOUO) Training Munitions. The AGM-114T virtual trainer can be used to simulate HUD and SMS indications for R-type missiles. When using the virtual trainer select M310-T and HF-T for stores 2 and 6 with current software. An M310-T cannot be used with live HF on the aircraft but can be used when an M36 is loaded or the M-310 is empty. Bomb virtual trainers are available to simulate HUD and SMS indications for GBU-12, GBU-49, and JDAM. To use these training weapons, select either GBU-12T, GBU-49T, or JDAMT. For a JDAMT to display as a GBU-54T select DSU-38; to display a GBU-38T select a DSU-33 during inventory. Set the airburst for the JDAM based on training requirements.

6.4.2 (FOUO) Status. The Status page at the bottom of the SMS provides detailed warning messages about SMS items. During the initial SMS setup, check the Status page for any warnings. Use the Status page after a weapon malfunctions to conduct detailed analysis of weapon and its related systems.

6.4.3 (FOUO) Select Store. The Select Store page provides the ability to select a type of store. First select the number of weapons within the store's type for release, then adjust the release order and interval of the stores, and power-ON the weapons. The Select Store page is visible with the Air-Ground page selected and begins the top-to-bottom flow in the SMS setup. If AGM-114s, JDAMs, or GBU-49s are loaded, initially select them to start the built-in test (BIT) process to increase SMS setup efficiency.

6.4.3.1 (FOUO) The SMS will default to a single release for each weapon type in its inventory. Push the Single button to open the next menu that enables specific stations to be selected, release order to be set, and release interval to be set. Set the release interval to unit standards, or 0.32 seconds for AGM-114, and 0.3 seconds for bombs. Weapons should be powered-on for the duration of a sortie. Once the release settings are correct for each weapon, select one of the weapons and continue the SMS setup flow down to the next page.

6.4.4 (FOUO) Store Settings. The Store Settings page allows the pilot to adjust settings specific to a type of weapon, independent of the currently selected store in the SMS. To navigate between stations, select the left or right arrows on the upper-right of the SMS display. To navigate between multiple stores on a single station press the up or down arrow to select the desired weapon. If the store settings are the same for all weapons of the same type in the SMS inventory, select the Type button underneath "Apply to Type" to set the currently displayed store's settings to all weapons of the same type. If a store with a ripple release is selected in the Select Store page, then the "Ripple Train" button will appear underneath the Type button and provide the ability to set the currently displayed store's settings to just the weapons in the ripple train. Each weapon type has a unique display when it is the currently selected store on the Store Settings page to allow it to be properly set up. Refer to TO 1Q-9(M)A-34-1-1, *Nonnuclear Munitions Delivery*, for more detailed information on store settings. The following settings for the individual weapons can be used as a default SMS setup. SMS setup can be different based on squadron standards for the mission being flown.

6.4.4.1 (FOUO) AGM-114. AGM-114 store settings. Set launch mode to LOAL-H, PRF code 1111, and fuse Settings INST for R2 and R9E.

6.4.4.2 (FOUO) GBU-12. GBU-12 store settings set fuse Arm to Nose Center and Tail, set PRF code per CCG setting on the ground, found in aircraft forms or passed from the LRE.

6.4.4.3 (FOUO) GBU-49 and GBU-54 store settings. Set PRF per unit standards or CCG settings, Last Pulse—Long, Guidance—GPS Laser, Store Target Coordinate—Off (On for ripple release on separate target), Hardness—Soft (GBU-49 only), Impact Angle—90, Fuse arm—Nose, Center, and Tail, Airburst and Function—as required, and Arm—6.0 s.

6.4.4.4 (FOUO) GBU-38 store settings. Store Target Coordinate—Off, (On for ripple release on separate target), Impact Angle—90, Impact Azimuth—Off, Fuse arm—Nose, Center, and Tail, Airburst and Function—as required, and Arm—6.0 s.

6.4.5 (FOUO) Select Target. The Select Target page provides the SMS the target location. SMS target location is used for weapon release solutions and aircraft holding. Default to the following settings. Primary setting for laser-guided weapons is cross-cued targeting pod (CCTGP) in AUTO mode. CCTGP pulls targeting location from the targeting pod. Manual entry is the primary for GPS-only guided weapons, select "Create Target" and input the target location and elevation. Coordinates can be input using MGRS, LAT/LONG UTM, elevation formats include MSL, and height above ellipsoid (HAE) in feet or meters.

6.4.5.1 (FOUO) Release Settings. The Release Settings page provides the pilot the ability to modify Tracker and HUD symbology for the currently selected store. To set desired release settings, the pilot must select each store type from the Select Store page, input the settings on the Release Settings page, and then go back to the Select Store page and select the next weapon type. Release Settings page has similar options for all weapons and allows the tracker display's run-in line to be adjusted. Run-In Mode can be set to Track or Manual. In Track mode, the selected weapon's run-in line on the tracker is slaved to the aircraft icon as it moves around the selected target in the SMS. Track Mode is useful for unrestricted run-ins. In Manual mode, the selected weapon's run-in line on the tracker can be manually changed by pushing the button next to Run-In Course and entering the desired run-in displayed in TRUE. Convert the restricted run-in heading if passed in magnetic to degrees True and enter it on the SMS Release Settings page to accurately display the run-in on the tracker. A useful technique to convert these two is using Mag, Add, True, Subtract (MATS). If a magnetic heading is passed, simply add the mag-variation. If a true heading is passed, subtract the mag-variation. This technique is only valid for positive magnetic declinations. For negative declinations, use True, Add, Mag, Subtract (TAMS). As an example, with a -10 degrees or 10 degrees east magnetic variation and a magnetic run-in restriction of 260 plus or minus 30 degrees. The center of the run-in restriction would be 270. Run-in setting time to release (TTR) should be set to DPI. The following setting for the individual weapons can be used as a default SMS setup. SMS setup can be different based on squadron standards for the mission being flown.

6.4.5.1.1 (FOUO) AGM-114 Release Settings. Tactical Settings set release settings to WEZ. Staple Settings set Desired Distance based on planned attack (RMIT calculated release point).

6.4.5.1.2 (FOUO) GBU-12 Release Settings. Tactical Settings set Release Cue Mode CCRP (Manual if requiring specific weapon impact parameters). Staples settings for a manually delivered GBU-12, update minimum, maximum, desired distance, and time of flight from GWTS calculated release point.

6.4.5.1.3 (FOUO) GBU-38, GBU-49 and GBU-54 Release Settings. Tactical Settings set Release Cue Mode—LAR, Target Type—Moving, and OWT—ON (GBU-38/54 Only). Staple Settings for manual LAR deliveries only update minimum, maximum, desired distance, and time of flight from GBIT calculated release point.

6.4.6 (FOUO) Launch Status. On the Launch Status page verify an overview of selected weapons, TGP PRF codes, Transfer alignment (TXA) quality, and target information. The right side of the page displays PRF codes for the TGP and the weapons selected for launch. The status indicator will display green if the TGP PRF code and the selected weapons PRF code match. If the codes do not match, the indicator will turn yellow and state "PRF code mismatch." A PRF code mismatch will not prevent release of the weapons. In the event of a mule or ripple release with split PRF codes, the yellow status indicator is expected. Below the TGP and weapons PRF, an additional "TXA Quality 1, 2, or 3" indicator is present (GBU-49, or JDAM). TXA 1 being the highest quality and TXA 3 being the lowest. The bottom of the Launch Status page displays the target information. If CCTGP is the currently selected target, the pilot has the ability to perform an Auto or Manual update from the Launch Status page.

6.4.7 (FOUO) Profiles. Weapons profiles provide crews the opportunity to save multiple weapon configuration setting in the SMS. Once the Air-Ground settings are completed, profiles are saved by selecting the profile button at the bottom of the SMS. The right side of the screen will show what setting is selected in the SMS. Select profiles at the top. Choose which profile number starting with 1 through 8. Verify which profile saving to by referencing the top of the page for the number. Click save if weapon settings are as desired.

6.5 (FOUO) R-Missile Impact Tool. RMIT provides real-time information on the AGM-114 launch parameters. RMIT has a GUI that is used to input desired employment data and receive missile endgame parameters for an attack with those values. RMIT also creates a display that contains eight tabs: Real Time Footprint, Planner Footprint, THB, WEZ Calculations, Staple, Advanced Calculations, and 3-Dimensional Trajectory. The Lethality tab is available in SECRET versions of RMIT only. RMIT and its associated displays should be set up in accordance with unit standards. Refer to the current version of the *R-Missile Impact Tool User Guide* for detailed information on RMIT (this section is based on RMIT v1.4). **Figure 6.8**, RMIT Setup and Displays, depicts the main RMIT GUI and RMIT Display. RMIT is used in debrief to validate AGM-114 employments near the WEZ boundary and verify impact parameters and attack restriction adherence.

6.5.1 (FOUO) Real Time Footprint Tab. The Real Time Footprint is a breathing WEZ and displays the WEZ and AGM-114 shot data based on aircraft parameters from the exploitation support data (ESD) (Ku delay is not included). It must be run from a cockpit MFW in order to receive the ESD. On the main RMIT GUI, click on the aircraft tail number in the lower left corner and then select "Watch Selection" to enable Real Time Footprint.

6.5.2 (FOUO) Planner Footprint Tab. The Planner Footprint displays similar information as the Real Time Footprint; however, it only displays the AGM-114 employment parameters specific to the data input into the RMIT GUI. The Planner Footprint should be used to display the portions of the WEZ that achieve the desired impact angles for weapons effects in order to determine the desired release range, azimuth and aircraft positioning for an attack.

6.5.3 (FOUO) THB Tab. The THB tab provides the user with enhanced awareness for situations requiring THB and TVB planning, such as moving target or multiple DPI ripple release. Information is displayed using a 4 km cross range x 4 km down range grid. Do not confuse the top of the chart with North; it depicts what the THB/TVB is with respect to cross range and down range as seen by the missile trajectory.

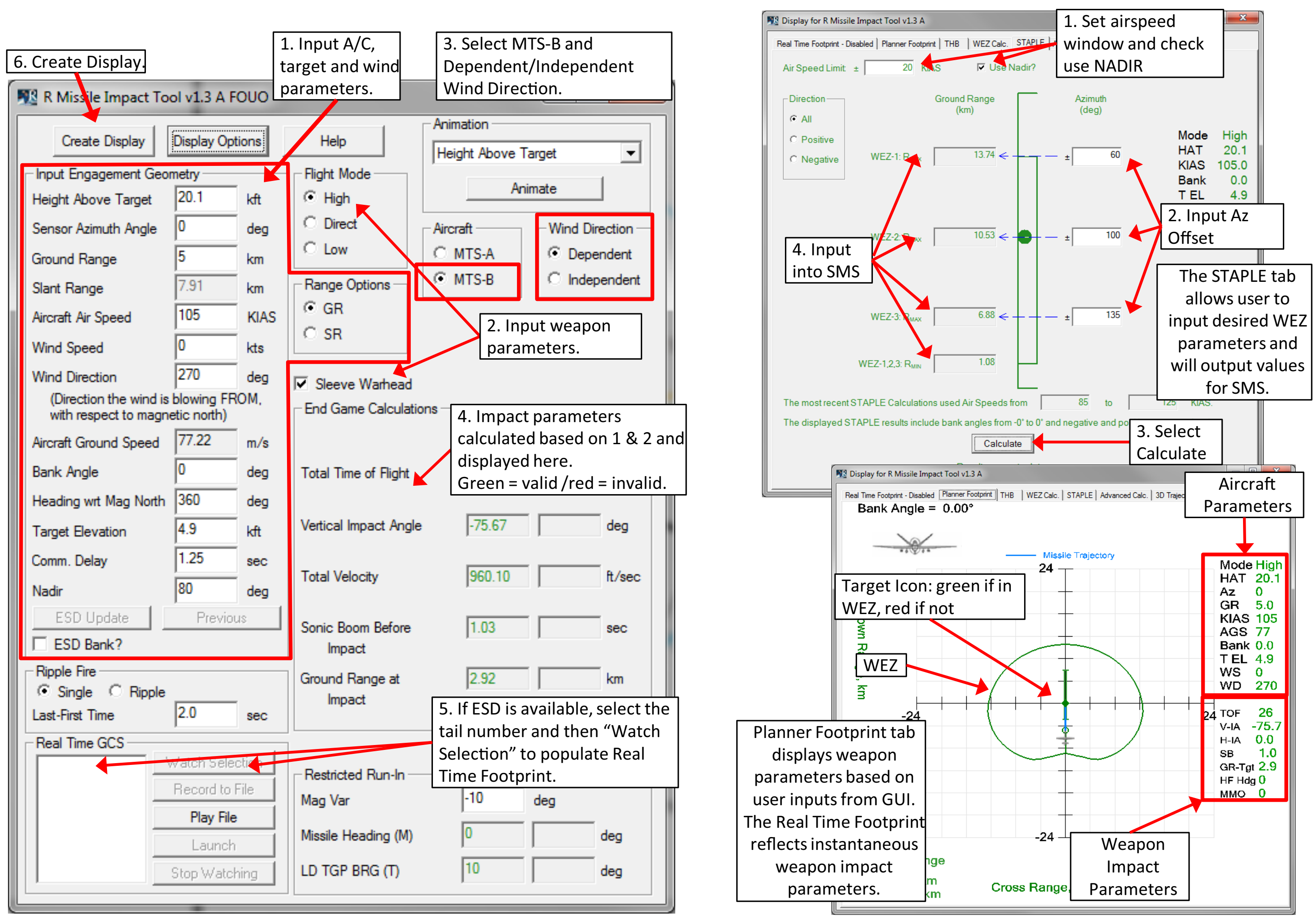
6.5.4 (FOUO) WEZ Calculations Tab. The WEZ Calculations Tab provides the ability to see the WEZ and specific impact condition at ranges other than those set up in the Staple Tab.

6.5.5 (FOUO) Staple Tab. The Staple Tab provides the minimum range and up to three maximum ranges at different azimuths in order to set up the HUD's WEZ through the SMS Release Settings page. Use anticipated or current target information to set up or update the AGM-114 WEZ in accordance with unit standards by using RMIT's Staple Tab.

6.5.6 (FOUO) Advanced Calculations Tab. The Advanced Calculations Tab provides details on the endgame parameters and engagement geometries based on the information input into the GUI.

6.5.7 (FOUO) 3D Trajectory Tab. The 3-Dimensional Trajectory tab provides rotating 3-dimensional views of the AGM-114's flightpath based on the input parameters on the main RMIT GUI.

Figure 6.8 RMIT 1.4 Setup and Displays.



FOUO

6.5.8 (FOUO) Lethality Tab. The Lethality Tab displays lethality charts from the table that is the closest match to missile parameters based on scenario input from the main GUI. The Lethality Tab shows data that is not interpolated. Data in the Lethality Tab is SECRET and is only seen in the SECRET version of the RMIT. Tab data is located in *RMIT 1.4 Users Guide* on SIPR.

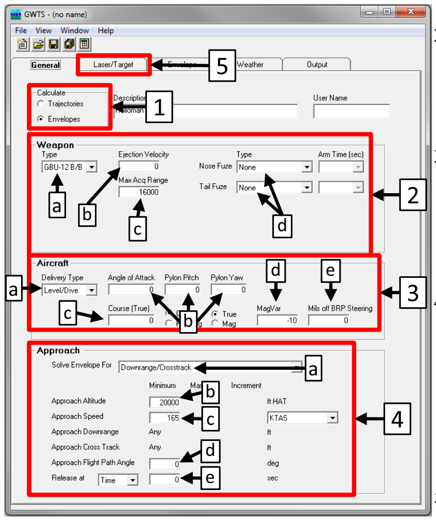
6.6 (FOUO) Guided Weapon Targeting Software. GWTS (specifically version 2.0) provides GBU-12 employment envelope data and impact parameters. It can generate user-defined tables to determine acceptable employment ranges to achieve desired effects (e.g., impact angle, impact velocity). GWTS can also provide a graphical display of the release envelope and the downrange and cross range capability at user-defined parameters. It is used to determine the release point for GBU-12 manual deliveries. GWTS can be run during mission planning or during execution from an MFW or peripheral computer with the most up-to-date target and environmental information. **Figure 6.9**, GWTS Setup and Displays, depicts the main GUI and an example table and envelope output.

6.7 (FOUO) GBU Impact Tool. GBIT (version 1.3) provides GBU-49, GBU-38, and GBU-54 employment data and impact parameters, similar to RMIT. GBIT also has a GUI that is used to input desired employment data and receive endgame parameters for an attack with those values. GBIT also creates a display that contains six operational tabs, Real Time Footprint, Planner Footprint, THB, LAR calculations, Advanced Calculations, and Staple. Real time footprint is not functional in current GBIT versions. **Figure 6.10**, GBIT Setup and Displays, depicts the main GUI and different values that can be set up.

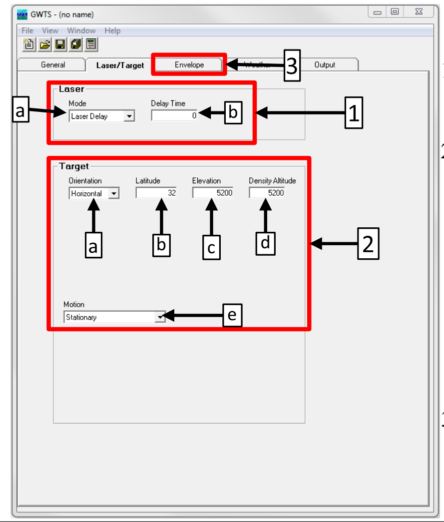
6.8 (FOUO) Planning Tool. The Planning Tool is used for developing and executing timed attack game plans, to determine untimed-attack hold distances, and may be used to determine a specific ground range to achieve a desired depression angle. This AFTTP volume will refer to Planning Tool v10. See **Figure 6.11**, Planning Tool Features, for a description of its features, and **Table 6.3**, Planning Tool v10 Assumptions and Mitigations, for the planning tool assumptions and mitigation. Refer to unit-specific weapons and tactics guidance for Planning Tool differences.

6.9 (FOUO) Head-Up Display. The HUD provides the data required for weapons employment and is the main reference during attacks. Information entered into the SMS directly affects the quality of the symbology generated on the HUD. Set up the HUD during the FENCE-in to display the air-to-ground (A/G) HUD, the steering line caret and weapons graphics via the head-down display (HDD) menus. The HUD displays the SMS inventory and weapons state on the bottom. Cross-check the icons to verify the anticipated stores are selected and the state is as expected (e.g., green versus yellow versus red). The weapons graphics and the steering line provide information based on the currently selected target and weapons in the SMS. The HUD displays weapon-specific employment data on the right side to include: “staple” for the GBU-12/49, WEZ information for the AGM-114, and LAR symbology for the GBU-38 and 54. Release Cue Mode is displayed on the left side of the HUD to include CCRP/Manual, WEZ or LAR.

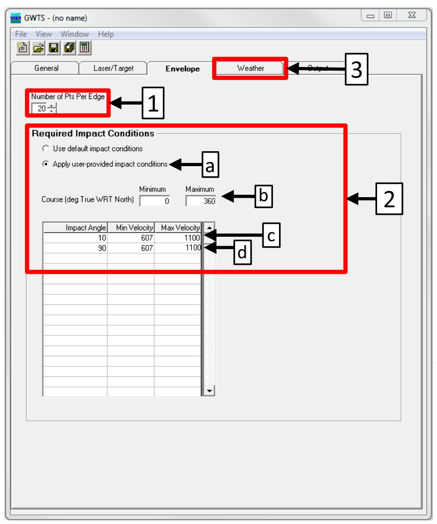
Figure 6.9 GWTS Setup and Displays (1 of 2).



1. Calculate for Envelope.
2. Weapon:
   a. Select GBU-12B/B.
   b. Eject Velocity = 0.
   c. Max Acq Range = 16000.
   d. No fuses needed.
3. Aircraft:
   a. Select Level/Dive.
   b. AOA/Pitch/Yaw = 0.
   c. Course (True) = A/R.
   d. MagVar A/R.
   e. Mil off BRP Steering = 0.
4. Approach:
   a. Solve Envelope for Downrange/crosstrack.
   b. Enter HAT.
   c. Enter Airspeed.
   d. Flight Path Angle = 0.
   e. Release at time = 0 (CCRP) / 1.25 (Manual).
5. Select Laser/Target Tab.

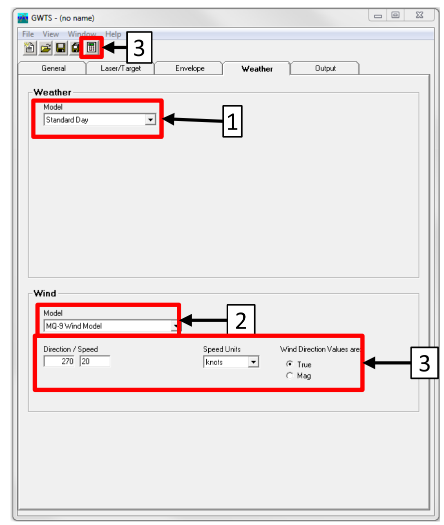


1. Laser:
   a. Mode = Laser Delay.
   b. Delay Time = 0.
2. Target:
   a. Orientation = Horizontal (DPI on top of target)/Vertical (DPI on side of target).
   b. Latitude = Per target
   c. Elevation = Per target
   d. Density Altitude = Enter if known, otherwise use Tgt Elevation.
   e. Motion = Stationary.
3. Select Envelope Tab.



1. Number of pts per edge = 20.
2. Required Impact Conditions:
   a. Apply user provided impact conditions.
   b. Set Course 0 to 360.
   c. First row = 10, 607, 1100.
   d. Second row = 90, 607, 1100.
3. Select Weather Tab.

NOTE: Adjust impact angle boundaries as needed.



1. Weather Standard Day unless another category is more applicable.
2. Select MQ-9 Wind Model.
3. Set winds A/R.
4. Select Calculator Button.

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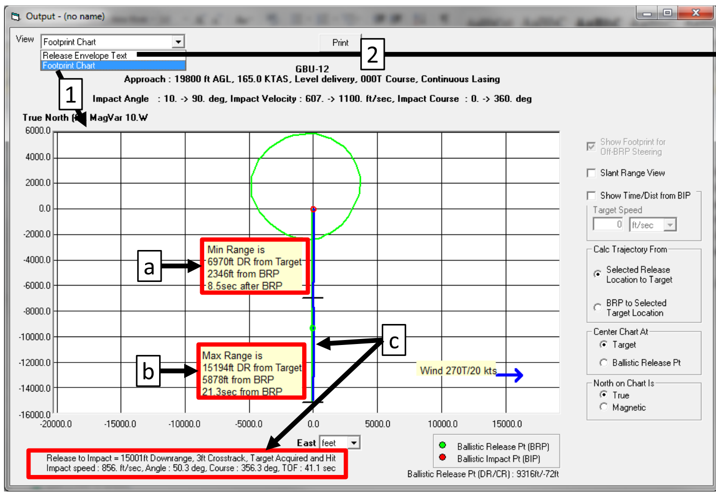
Figure 6.9 GWTS Setup and Displays (2 of 2).



UNCLASSIFIED

GWTS 6.4.1 16 Feb 2012

Mon Nov 17 11:22:24 2014

Input file: (no name)

Weapon Type : GBU-12
Weapon Weight : 614.8
Level/Dive Delivery

Laser Delay Time : 0.00 seconds

Standard Day (Table)
Target Elevation : 5200.0 ft.
Target Density Alt : 5200.0 ft.

Impact Condition Requirements :

Impact Angle (deg)	Min Impact Velocity (ft/sec)	Max Impact Velocity (ft/sec)
10.0	607.0	1100.0
90.0	607.0	1100.0

Impact Course : 0.0 -> 360.0

Limits on the Envelope Solution Independent Variables:
Approach Downrange : -40000 -> 140000 ft
Approach Crossrange : 0 -> 100000 ft

Approach Alt (ft)	Approach Speed (KTAS)	Approach Angle (deg)	Down Range (ft)	Cross Range (ft)	Laser Turn-On Time (sec)	Laser Acquis Time (sec)	Impact Velocity (ft/sec)	Impact Angle (deg)	Impact Course (deg)	Angle of Attack (deg)	Time of Fall (sec)	Ground Plane Down Range Miss (ft)	Ground Plane Cross Range Miss (ft)
19800	165	0.00	6968	0	0.0	20.4	924.1	84.58	336.17	5.34	36.9	1.9	3.9
19800	165	0.00	6923	346	0.0	20.8	940.6	84.12	302.70	6.07	36.9	1.5	2.4
19800	165	0.00	6997	701	0.0	19.6	935.5	81.55	302.53	7.42	37.0	2.5	3.5
19800	165	0.00	7012	1101	0.0	20.1	929.9	80.05	294.77	5.95	37.1	1.7	4.4
19800	165	0.00	7105	1547	0.0	20.2	939.3	77.83	288.72	5.49	37.1	-0.4	5.8
19800	165	0.00	7321	2042	0.0	19.3	931.3	75.28	292.96	3.66	37.3	0.9	4.2
19800	165	0.00	7651	2625	0.0	18.4	915.8	72.04	297.46	5.84	37.6	-2.1	6.3
19800	165	0.00	8190	3295	0.0	17.1	888.2	69.30	298.55	6.24	38.1	-0.1	1.3
19800	165	0.00	9012	4087	0.0	17.7	896.5	65.34	304.79	7.87	38.6	-2.9	0.6
19800	165	0.00	10292	4765	0.0	18.7	878.5	56.29	306.81	6.25	39.4	2.2	0.4
19800	165	0.00	11863	4714	0.0	19.6	857.2	51.41	314.04	2.91	40.2	1.3	-1.1
19800	165	0.00	13202	4186	0.0	20.3	868.6	48.58	322.41	3.27	40.8	1.0	2.3
19800	165	0.00	14056	3390	0.0	20.7	858.5	47.56	325.58	2.77	41.0	-1.9	-0.1
19800	165	0.00	14569	2668	0.0	20.9	876.7	48.08	332.61	3.61	41.0	-0.3	2.3
19800	165	0.00	14912	2080	0.0	21.1	857.1	47.40	340.46	5.46	41.3	-4.9	-0.4
19800	165	0.00	15058	1547	0.0	21.1	863.5	45.91	344.15	5.72	41.2	-0.6	2.7
19800	165	0.00	15151	1101	0.0	21.1	861.7	48.88	347.32	6.02	41.3	-3.7	8.8
19800	165	0.00	15166	701	0.0	21.1	856.4	48.33	349.68	6.88	41.2	-5.7	2.2
19800	165	0.00	15240	346	0.0	21.1	859.4	48.91	353.02	3.71	41.3	-1.8	-0.3
19800	165	0.00	15195	0	0.0	21.1	856.7	47.48	356.67	6.42	41.2	-1.0	-0.2
19800	165	0.00	15189	-342	0.0	21.1	860.1	48.07	1.37	6.32	41.2	0.7	-0.9
19800	165	0.00	15069	-684	0.0	21.0	883.7	48.56	4.03	3.44	41.0	-1.0	-0.3
19800	165	0.00	14970	-1052	0.0	20.9	854.8	49.25	3.51	6.24	41.1	1.4	1.3
19800	165	0.00	14814	-1452	0.0	20.9	882.0	50.44	10.69	5.08	40.9	-0.5	3.4
19800	165	0.00	14564	-1891	0.0	20.7	889.3	49.41	12.12	7.60	40.7	-1.2	4.6
19800	165	0.00	14231	-2410	0.0	20.5	885.9	51.45	15.34	3.49	40.5	-0.7	1.0
19800	165	0.00	13643	-2919	0.0	20.2	868.0	51.85	19.14	6.10	40.4	0.7	-3.1
19800	165	0.00	12798	-3389	0.0	19.7	910.1	56.24	24.24	0.79	39.6	-0.9	-0.0
19800	165	0.00	11701	-3740	0.0	19.0	906.6	60.33	28.61	3.56	39.3	1.5	3.8
19800	165	0.00	10479	-3638	0.0	18.3	905.0	65.95	31.65	2.49	38.7	-2.6	0.3
19800	165	0.00	9466	-3189	0.0	17.6	903.0	70.76	29.58	4.38	38.2	-3.6	0.4
19800	165	0.00	8686	-2730	0.0	18.7	932.3	73.50	38.63	0.45	37.6	0.7	0.0
19800	165	0.00	8101	-2281	0.0	19.8	909.7	77.20	44.16	5.85	37.5	-0.8	0.0
19800	165	0.00	7739	-1815	0.0	19.6	934.6	79.25	42.39	5.84	37.2	1.8	-0.5
19800	165	0.00	7430	-1421	0.0	20.4	922.8	81.22	37.75	2.27	37.1	1.2	2.0
19800	165	0.00	7283	-1027	0.0	19.8	930.1	82.56	16.78	5.87	37.0	0.0	-0.8
19800	165	0.00	7094	-684	0.0	20.7	930.9	85.64	15.50	5.94	36.9	-3.1	6.8
19800	165	0.00	6974	-342	0.0	21.7	947.9	87.97	344.61	4.39	36.8	1.5	2.5
19800	165	0.00	6968	0	0.0	20.4	924.1	84.58	336.17	5.34	36.9	1.9	3.9

a

b

Center of the Envelope:

Approach Alt (ft)	Approach Speed (KTAS)	Approach Angle (deg)	Down Range (ft)	Cross Range (ft)	Laser Turn-On Time (sec)	Laser Acquis Time (sec)	Impact Velocity (ft/sec)	Impact Angle (deg)	Impact Course (deg)	Angle of Attack (deg)	Time of Fall (sec)	Ground Plane Down Range Miss (ft)	Ground Plane Cross Range Miss (ft)
19800	165	0.00	11135	503	0.0	18.0	912.0	65.67	344.49	6.53	38.4	0.4	3.4

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Two options to view data:
1. Footprint Chart
   a. Min Range.
   b. Max Range.
   c. User Selected Release Point:
      -Using cursor, click on desired release point.
      -Data will appear at bottom of window.
      -Blue line indicates selected distance.
2. Release Envelope Text:
   a. Min Range Parameters.
   b. Max Range Parameters.

FOUO

Figure 6.10 GBIT Setup and Displays (1 of 2).

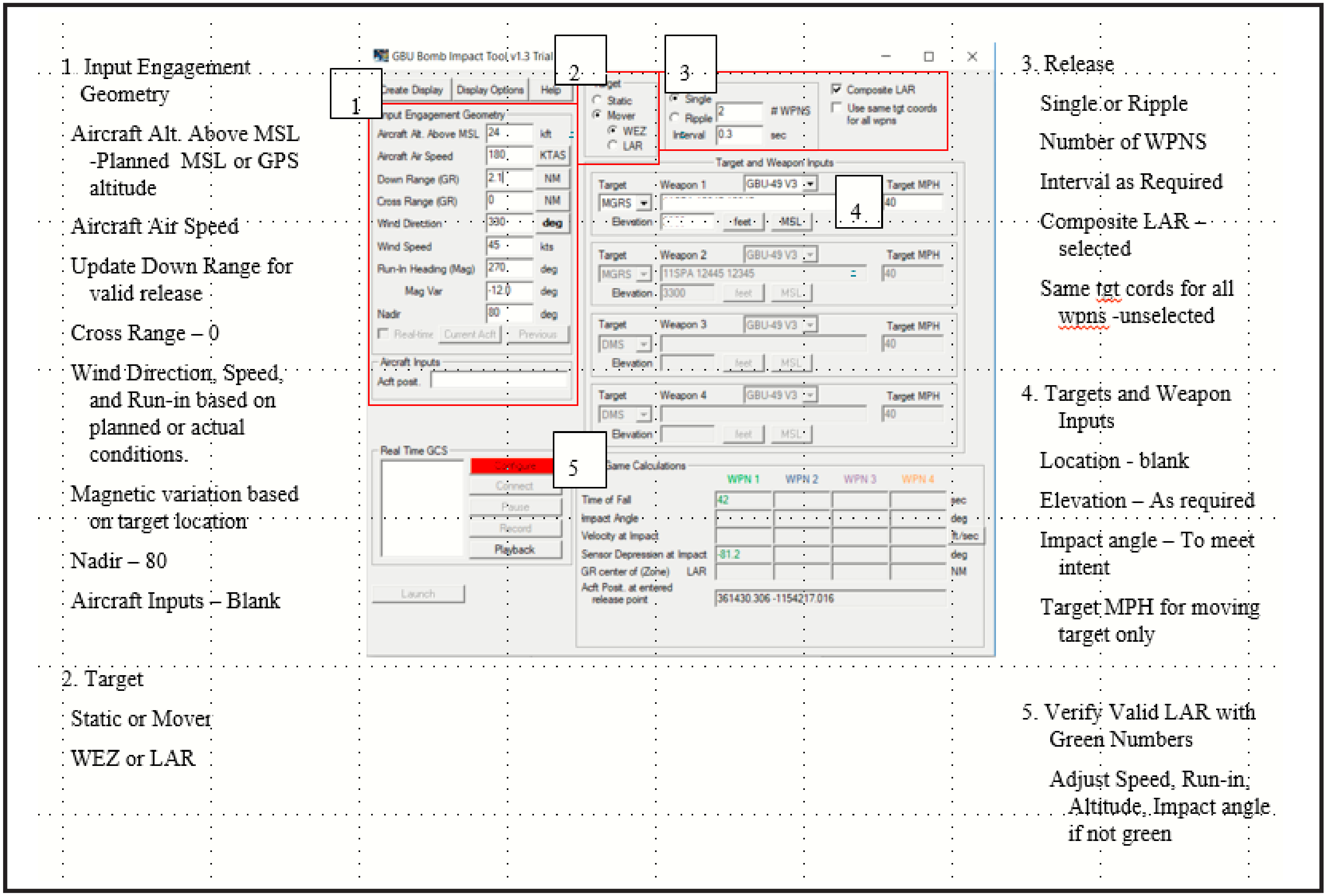


Figure 6.10 GBIT Setup and Displays (2 of 2).

Select Create Display from main GUI

1. User Inputs from main GUI
2. Reference this field for Range and Zone LAR max/min values

1

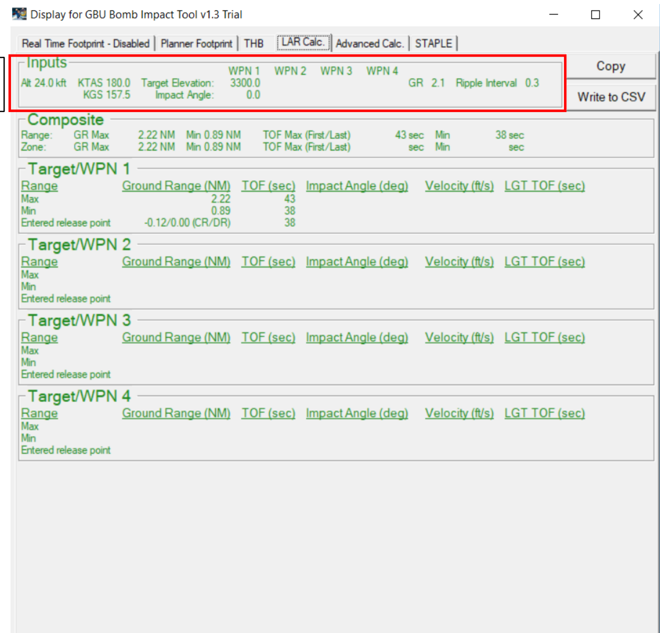


Figure 6.11 Planning Tool Features.

FOUO

Table 6.3 Planning Tool v10 Assumptions and Mitigations.

Planning Tool Assumption	Mitigation
Planning tool output is correct	Pilot should update the six-pack engagement parameters prior to each attack involving the Planning Tool.
Aircraft holding 90 degrees TGP azimuth	If the aircraft is not 90 degrees TGP azimuth, Turn-In should occur ± 3 seconds early/late for every 10 degrees off azimuth. If TGP azimuth is less 90 degrees, the pilot will delay their turn (e.g., 80 degrees TGP azimuth = turn 3 seconds later). If the TGP azimuth is greater than 90 degrees, the pilot should turn early (e.g., 110 degrees TGP azimuth = turn 6 early).
For timed attacks, aircraft final attack position is within ± 30 degrees of run-in entered	Hold and ensure aircraft is within 30 degrees.

6.10 (FOUO) Tracker Display. The Tracker display provides a moving map for holding and attack geometry. The Tracker display is particularly useful during restricted run-ins, first run attacks, timed attacks, battle tracking, and for a general overview of target location. Set the tracker display map to at least the JOG level to provide the increased fidelity. The run-in line on the Tracker display should be set to manual mode for attacks with a specific and/or restricted run-in. Use the run-in line to center the aircraft hold pattern and execute holding. The run-in line can also be used to help determine if target masking will take place, deconfliction with other assets will be a factor, or if weather in the vicinity will affect the attack. The Tracker display can also be used to track multiple targets through the control point and collection list. The circle tool should be used for battle tracking information such as threats, or ROZs, and not as a primary aircraft holding tool.

6.11 (FOUO) Targeting Pod. SOs should set up the TGP in accordance with FENCE procedures. Test the LRD and LTM in approved areas during the FENCE-in. Testing the LRD prior to delivering weapons also identifies laser deficiencies prior to entering a time critical situation.

CHAPTER 7

SINGLE-SHIP SURFACE ATTACK TACTICS

7.1 Introduction. This chapter provides the fundamental tools to build precise weapons delivery skills essential to executing single-ship surface attack TTP for the AGM-114, GBU-12, GBU-49, GBU-54, and GBU-38. Topics include first run attack procedures, reattack procedures, vertical attack procedures, low-height above target procedures, timed attack procedures, and weapons employment contingencies.

7.2 Preparation.

7.2.1 General. Weapons delivery in the MQ-9 requires a thorough understanding of training rules, administration procedures, aircraft systems knowledge, weapons delivery theory, and heads-up display (HUD) symbology. Preparation for weapons delivery encompasses the references listed in **Table 7.1**, SAT Employment References, and includes a thorough knowledge of the MQ-9 weapon fundamentals. See **Chapter 6**, "Basic Weapons and Employment Tools," for in-depth information for each MQ-9 weapon variant.

7.2.2 Mission Preparation. The importance of planning for every weapons delivery sortie, both in tactical and non-tactical environments, cannot be overemphasized. Flight members should contact the pilot in command (PIC) prior to the briefing in order to arrive prepared. In addition to mission preparation considerations discussed in **Chapter 2**, "Aircrew Fundamentals," all flight members should comply with the following information.

7.2.2.1 Be familiar and comply with squadron standards, local procedures, range procedures, and applicable NOTAMs.

7.2.2.2 Know the target type(s), dimensions, visual recognition (VISRECCE), and references.

7.2.2.3 Know the target environment. A thorough map and target area study is critical to success. If photographs are available, use them. Identify lead-in features during map study that will be visible and aid in target acquisition in accordance with search plans as discussed in **Chapter 5**, "Basic Mission Execution."

7.3 Basic Attack Procedures. Basic attack procedures are the weapons employment skills a crew must apply to successfully conduct every attack. Without a proficient foundation in basic attack procedures, it will be difficult or impossible to purposely achieve all desired effects with more advanced TTP. This section details the attack phases in generic terms and then applies them the AGM-114, GBU-12, GBU-49, GBU-54, and GBU-38.

7.3.1 (FOUO) Attack Phases. Every attack has five distinct attack phases: Intent, Game Plan, Hold, Execution, and Egress. **Table 7.2**, Attack Phases, summarizes the criteria of each attack phase.

Table 7.1 SAT Employment References.

Reference	Title	Notes
TO 1Q-9(M)A-1	Flight Manual	Technical manual of MQ-9 systems
TO 1-1M-34-1-1	MQ-9 Non-Nuclear Weapons Delivery Manual	Weapon data for planning and executing an air-to-ground surface attack; weapons delivery techniques or tactics are not included
TO 1Q-9(M)A-34-1-1	Non-Nuclear Weapons Delivery Checklist	Discusses all aspects of MQ-9 weapons delivery to include preflight and in-flight checks, and delivery considerations
TO 1Q-9(M)A-34-1-1CL-1	Non-Nuclear Weapons Delivery Checklist	Checklist version of -34-1-1
AFTTP 3-1.MQ-9	MQ-9 Tactical Employment	Discusses specific mission sets and tactical weapons delivery
AFTTP 3-1.Shot/Kill	Shot/Kill Criteria	Training and validation criteria for air-to-ground kills
AFI 11-2MQ-1_9V3	MQ-9 Flying Operations	MQ-9 weapons delivery procedures
AFI 11-2MQ-1_9V1	MQ-9 Aircrew Training	Discusses weapon delivery qualification, currencies, and training requirements
AFI 11-214	Air Operations Rules and Procedures	Discusses air-to-surface training procedures for all CAF aircraft, to include knock it off (KIO), terminate, range radio procedures, training rules, employment patterns, and live ordnance procedures
Hellfire Handbook	MQ-1B/9 Hellfire Handbook	In depth discussion on Hellfire variants, components, and technical information
USAF Weapons School Student Papers	Multiple topics	In-depth discussion of various topics at the graduate level
Tactics and Flash Bulletins	Multiple topics	Concise TTP discussion of various topics no included in AFTTP 3-1/3-3.MQ-9

Table 7.2 (FOUO) Attack Phases.

Phase	Summary
Intent	Communicate and build shared mental model with tasking authority, as required. • Determine attack restrictions • Understand desired end state/effects Direct aircraft to either 10 km (AGM-114) or 6 NM (GBU-12/49/54/38) as required, based on restrictions.
Game Plan	Turn to intercept and anchor the aircraft along the planned run-in at a range that accounts for the Turn-In and desired time on final prior to release. Determine weaponeering to meet desired end state/effects • RMIT/GWTS/GBIT DPI breakout and determine initial track plan (SO). Update holding game plan IAW **Table 7.3**, Basic Attack Holds Comparison. Determine timing solution (as required) • Update 9-pack • Place the CP in the LAR (GBU-38) • Set desired launch range
Hold	Track target with TGP while optimizing picture for weapons engagement. Preattack checks: • SLAPUM—Set the systems for the attack. See **Table 7.4**, SLAPUM. • WTARSEC—Brief the attack plan to the crew. See **Table 7.5**, WTARSEC. Timing assessments/cross-checks (as required).
Execution	Turn-in on desired run-in/parameters and obtain clearance, if required. Final: • Execute attack pacing specific to the weapons being released • Pilot conducts steering, timing, airspeed, track (STAT) cross-check • SO conducts hub and spoke cross-check Release to Splash: • SO executes Track plan • Pilot executes required post-release maneuvering • Pilot calls TOF remaining every 10 seconds • At Splash, SO accomplishes post-impact immediate action procedures
Egress	Maneuver aircraft into position for reattack. “CEASE LASER” (pilot)/“LASER OFF” (SO) Conduct BHA/BDA. Execute reattack procedures, if required. • Airspeed, SMS, Update, Laser/LAR, Track (ASULT) Safe systems once it is determined a reattack is not required.
FOUO	

7.3.1.1 (FOUO) Intent. The intent phase begins immediately following awareness that the crew is to conduct an attack on a specific target. In order to clarify the intent, the crew must communicate with the tasking authority to build a shared mental model regarding desired end state and/or effects for the target. The crew must also gather target priorities and clarify restrictions. Restrictions range from, but are not limited to, a TOT, a run-in, standoff prior to weapons effects, vertical impact requirements, or collateral concerns (all of which are necessary to develop the associated attack plan). If unable to meet/achieve intent due to restrictions, the crew should query the tasking authority to either amend or remove the restriction. The intent phase ends when the aircraft is directed to either the 10 km (AGM-114) or 6 NM (GBU-12/49/54/38) point in accordance with restrictions. The intent phase is unchanged for all weapon attack types.

7.3.1.2 (FOUO) Game Plan. Following a clearly defined end state, crews must attack the tactical problem with a "target backward" approach. This process requires crews to think through, in priority order, the necessary target and weaponeering considerations to achieve desired effects. The following are a basic overview of the necessary items to address when developing a Game Plan.

7.3.1.2.1 (FOUO) Target Area Restrictions. Prior to beginning weaponeering, a thorough understanding of the target and the surrounding area are necessary.

7.3.1.2.1.1 (FOUO) Look Angle Restrictions/Target Obstructions. Identify anything that could pose an issue the terminal look angle or weapon flightpath by actively scanning for any mountains, terrain, foliage, telephone poles, power lines, other buildings, etc., along the planned run-in.

7.3.1.2.1.2 (FOUO) Environmental. Take into consideration surface winds, smoke from previous/potential strikes, dust, and potential weather within the area.

7.3.1.2.1.2.1 (FOUO) Low Level Clouds. FEW to SCT clouds pose more issues due to their intermittent nature. Identifying these clouds unfortunately does not typically happen until already established on final, resulting in an ABORT situation. It is imperative that crews zoom out to see an overview of the area. When clouds are present in the target area, use the cloud's shadow on the ground combined with a known solar angle to determine where the cloud is located with respect to the target. Use known flight level winds to determine the direction of travel to aid run-in selection.

7.3.1.2.1.3 (FOUO) Target Orientation. Primarily for buildings, unless weaponeered to ensure the laser spot size, weapons CEP, and detonation point meet desired weapons effects, the longest axis of the building is the most forgiving for mistakes/errors in the above factors.

7.3.1.2.1.4 (FOUO) Collateral Concerns. When applicable, identify friendly forces, noncombatants, and/or neutral forces in the area and prioritize the run-in, in that order. The collateral area depends on weapons effects distance (using danger close, collateral effects radii, etc.). Offsetting collateral is dependent upon weapon type, fuzing, and flight profile. As such, crews must be aware of fragmentation patterns associated with specific attack(s). Reference AFTTP.3-1.MQ-9, Chapter 10, Weaponeering and/or the Hellfire Handbook for fragmentation considerations.

7.3.1.2.2 (FOUO) Aircraft Restrictions. In addition to the target area, analyze the airspace to identify restrictions that will affect aircraft and/or weapon flightpath.

7.3.1.2.2.1 (FOUO) Airspace. Identify borders to other ACMs, countries (or required buffers from said countries), and airspaces not currently in the crew's airspace clearance. Airspace not only includes the lateral boundary, but the vertical boundary as well. Identify how much altitude is available, as the current altitude may not allow for a successful engagement.

7.3.1.2.2.2 (FOUO) Winds Aloft. Winds may determine optimal ingress/egress. A headwind ingress has lower ground speeds that allow the crew to hold closer while having a tighter turn radius and allowing a slower pacing on final. A tailwind ingress causes crews to hold further from the target which can lead to target masking, depending on HAT and bank angle. Crosswind run-ins increase complexity of holding for the attack due to the lack of wind to help lower the turn radius. This also causes varying ground speeds in the hold, which increases the complexity, especially for TOTs. Winds aloft may also restrict available run-ins (specifically GBU-12).

7.3.1.2.2.2.1 (FOUO) Target Handover/Velocity Boundary (THB/TVB). Generally, winds aloft do not affect target handover boundary/target velocity boundaries.

7.3.1.2.2.3 (FOUO) Other Aircraft. Deconfliction from other aircraft is imperative to a successful strike. Deconflict both the aircraft and the weapon's flightpath from other airborne assets. A good rule of thumb is to keep a 10 degree buffer on either side of the weapon's flightpath for aircraft stacked lower and closer to the target. This rule may also be applied for LOWAT employments with a weapon apogee that elevates into a higher aircraft's block.

7.3.1.2.3 (FOUO) Release Conditions. Run applicable weaponeering programs (RMIT, GWTS, GBIT; as required) to determine the employment parameters and identify DPI placement. A range at desired launch (R_{DL}) should be one of the last things identified before executing an attack. The R_{DL} will change drastically depending on the impact conditions required (and also depending on the run-ins available). Other parameters to identify are azimuth, delivery type (e.g., CCRP versus manual deliveries for GBU-12), airspeed, THB, and TVB.

7.3.1.2.4 Holding Game Plan. After area analysis and solving for weaponeering, next determine the refined holding game plan. The intent to developing a holding game plan is to place the aircraft in the best position that enables timely and effective attack prosecution. The initial hold plan can start vaguely by determining the best run-in to achieve weapons effects and moving the aircraft towards the run-in and anticipated hold. Or the hold plan can begin specifically, such as in the case of a run-in restriction. Pilots must then determine which hold pattern to fly based on the previously above paragraphs considerations: Wheel, Figure Eight/Modified Figure Eight, or Racetrack. Additional considerations for holding game plan are potential reattack positioning, weapon deconfliction (if multiple aircraft are employing), and timing. If a TOT is required for the attack, the timing solution should be figured out after a hold plan is determined and before the preattack checks. **Figure 7.1**, Basic Attack Holds, depicts each hold for an attack; **Table 7.3**, Basic Attack Holds Comparison, compares advantages and disadvantages of each hold. The Game Plan phase ends when the aircraft turns to intercept the refined hold.

7.3.1.2.4.1 (FOUO) Wheel. Use this type of hold when the weapons effects can be met from any attack axis and nothing restricts the run-in (e.g., threat, friendly forces, deconfliction, and airspace).

7.3.1.2.4.2 (FOUO) Figure Eight/Modified Figure Eight. Use this type with a restricted run-in. Some factors that may restrict the run-in are when an attack requires a specific attack axis to meet intent, friendly force deconfliction, rural/urban masking limits line of sight azimuths to the target, or aircraft threats. Accomplish maximum performance turns into the wind when executing to minimize the turn radius.

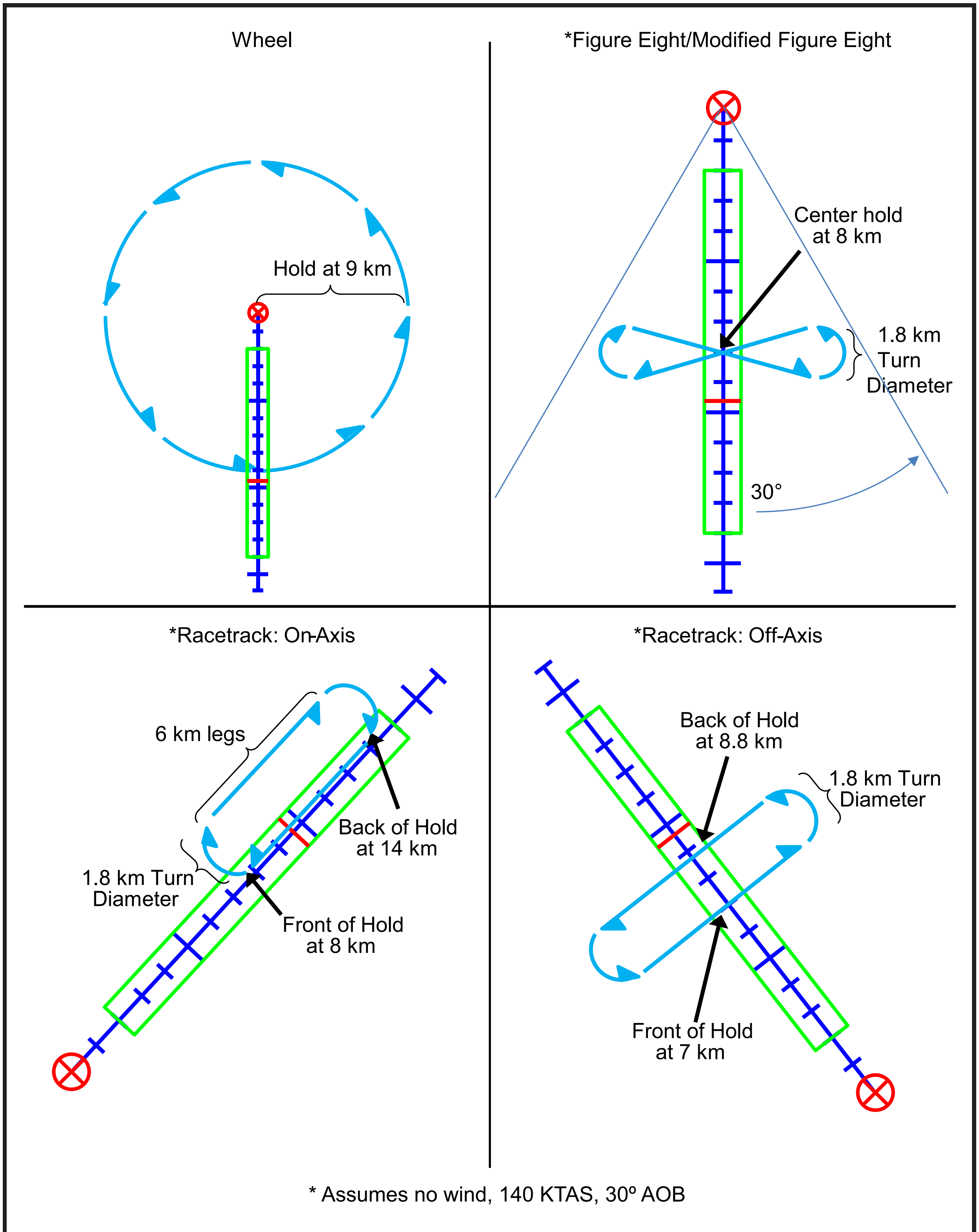
7.3.1.2.4.3 (FOUO) Racetrack. A Racetrack hold keeps the aircraft at a constant bearing to the target and oriented either on-axis with the run-in, or off-axis from the run-in. An on-axis Racetrack hold has the inbound leg along the run-in, the turn outbound at the minimum desired range in the hold, and the turn inbound at the maximum range desired in the hold less the turn radius. An off-axis Racetrack hold is oriented perpendicular to the run-in with the inbound leg one turn-radius from the desired point to roll-out on final for the attack, the turns outbound and inbound are bounded by the maximum bearing to the target from the run-in, and the outbound leg one turn-diameter into the target away from the inbound leg.

7.3.1.3 (FOUO) Hold. The Hold phase consists of entering and maintaining the hold, in addition to accomplishing the associated attack checks. The Hold phase ends once the crew turns in to conduct their attack.

7.3.1.3.1 (FOUO) Enter and Establish the Hold. Enter and establish the hold as discussed in **paragraph 3.4.2.5.1**, Entering Holding and Maintaining Standoff, in accordance with formulated holding game plan. As previously stated, initial actions are to immediately direct the aircraft to the side of the target with the anticipated run-in. Do this, by referencing the Tracker display, assuming the target is within the TGP field of view and the SMS is in auto update mode. If the SMS is in manual mode, an immediate target update is required to place the run-in on the Tracker display in the correct location and ensure the HUD information is relative to the target. If the refined holding game plan was not determined prior to reaching the initial 10 km or 6 NM point, maintain current sector, adhere to any airspace restrictions, and formulate the refined holding plan prior to beginning preattack checks.

7.3.1.3.2 (FOUO) Preattack Checks. Preattack checks prepare the aircraft, weapons, TGP, and crew for an attack. Preattack checks should begin after developing a hold plan and the aircraft is en route to, or established in, the hold. As proficiency is gained, the brief/preattack checks can be accomplished while turning to final, or once established on final—as long as they are complete prior to weapons employment. The SLAPUM and WTARSEC briefs are the primary reference for all MQ-9 deliveries.

Figure 7.1 Basic Attack Holds.



FOUO

Table 7.3 Basic Attack Holds Comparison.

Type	Advantages	Disadvantages
Wheel	• Enables a hold at a constant and specific range. • Least task intensive hold to maintain. • Aircraft always has approximately 90 degrees of turn for a Turn-In. • Off-azimuth AGM-114 attack immediately available. • Constant slant range provides stable conditions for picture optimization.	• Delays Turn-In for attacks with a required and/or restricted run-in if the aircraft is on the wrong side of the target when ready to commence the attack. • Potential for masking as the aircraft continues to arc around the target from vertically developed objects in the vicinity of the target or a low cloud deck.
Figure Eight/ Modified Figure Eight	• Enables maintaining a constant look angle to the target with minimal changes in slant range. • Keeps aircraft near a restricted run-in so as not to delay the attack once ready to commence the engagement.	• Most task intensive holding cross-check. • Increased potential for masking in the low HAT engagement environment. • Increased potential for nadir at close hold ranges.
Race Track	• On-axis keeps aircraft on restricted run-in. • Inbound leg enables the aircraft to be ready to immediately execute the attack with minimal additional maneuvers required.	• On-axis outbound leg range decreases TGP fidelity. • On-axis outbound leg can delay attack execution when ready to commence the engagement.
FOUO		

7.3.1.3.2.1 (FOUO) SLAPUM. The intent of the SLAPUM preattack check is to set up the aircraft, weapons, and TGP for the attack. It stands for SMS, laser/LAR (GBU-49/54/38), airspeed/autopilot, payload, update, and master arm. Some items may be accomplished during the FENCE check while other items may not be accomplished until moments before the attack. Regardless, running the entire check prior to the attack is a good technique to ensure all required items are complete. The SLAPUM check is not a challenge and response checklist between the crew. SO-specific items that may be verified visually by the pilot through an effective cross-check do not require extraneous communication if they are already set up correctly. **Table 7.4**, SLAPUM, summarizes the SLAPUM preattack checks for generic AGM-114, GBU-12, GBU-49, and GBU-54, and GBU-38 attacks.

7.3.1.3.2.1.1 (FOUO) Stores Management System. Most of the SMS settings should be set during the FENCE check (**paragraph 3.2.5.3**, Engage). The pilot should accomplish the top-to-bottom flow on the air-ground page to update the applicable items for the attack.

Table 7.4 SLAPUM.

	AGM-114	GBU-12	GBU-49/54/38
SMS	• Correct stores selected. • Release interval set (ripple release) • LOAL-mode set • PRF code set for each missile • Correct fuzing selected (R-variants) • Run-in mode and Run-in set	• Correct store(s) selected. • Release interval set (ripple release) • Nose/Tail Fuzing (BRU-15); Nose/Center/ Tail Fuzing (BRU-71) • Run-in mode/release mode set	• Correct stores selected • Release interval set (ripple release). • Nose/Tail fuzing set (BRU-15); Nose/Center/ Tail Fuzing (BRU-71) • Correct fuzing selected • Impact angle/azimuth set A/R • Offset targets set/verified (Ripple Release) • Manual target created and selected
Laser/LAR	• PRF code set for AGM-114 • ARM LRD	• Set PRF code for GBU • ARM LRD	• Tracker Display: verify presence of range and zone LAR. • HUD: verify range LAR carets, maximum range dot, and zone LAR are displayed • Set PRF code (GBU-49/54) • ARM LRD (GBU-49/54)
Airspeed/ Autopilot	• Set desired airspeed that provides full control authority • Altitude/Airspeed Holds—On • Heading Hold—Off • Speed Lever—HIGH	• Set 165 KTAS (or as preplanned) • Airspeed/Altitude Holds—ON • Heading Hold—OFF • Speed Lever—HIGH	• 180 KTAS or greater if required for LAR generation • Airspeed/Altitude Holds—ON • Heading Hold—OFF
Payload	1. Slew control—Optimized for employment. • Rate gain set A/R • Deadband set A/R 2. Picture optimized for: • DPI Breakout • Track Stability • Track Survivability 3. TXA Quality <2 (GBU-49/54/38)		
Update	• Select Auto Update (BOT) • Manual target created and selected (BOC)	• Auto update unless BOC, then create Manual target • Manual update against vertical targets	• Verify correct manual target is selected (as required)
Master Arm	• Set Master Arm to ARMED.		
FOUO			

7.3.1.3.2.1.1.1 (FOUO) Store Select. Select the weapon(s) for the attack, verify release order and interval for a ripple release, and then cross-check the HUD to verify the anticipated weapons are solid green (depending on TXA quality GBU-49/54/38 may be solid yellow—initiate S-Turns for alignment to turn icons solid green).

7.3.1.3.2.1.1.2 (FOUO) Store Settings. Update AGM-114, GBU-49, GBU-54, and GBU-38 specific items to achieve the desired effects. GBU-12 fuze and PRF settings should have been set during FENCE check. Then cross-check the HUD to verify the correct weapons coding such as PRF, fuzing, LOAL mode (AGM-114), impact angle (GBU-49/54/38), and release interval.

7.3.1.3.2.1.1.3 (FOUO) Select Target. Select the source for the SMS calculations: either Auto, Manual, or a Create Target.

7.3.1.3.2.1.1.4 (FOUO) Release Settings. Update the Run-In mode as required for the attack. Use Track mode for unrestricted run-ins. Use Manual mode for restricted run-in, displayed in Magnetic. Then set weapon release intervals if required.

7.3.1.3.2.1.1.5 (FOUO) Launch Status. Verify full stack of green indicator lights and red "System Not Armed." Verify green indicator light by the PRF codes for single PRF if self-lased attacks. Verify yellow indicator light by the PRF codes for split-PRF ripple-release coordinated attacks. Verify weapons and settings selected are correct. For attacks in Auto or Manual, verify CCTGP as the selected target; for Manual targets, verify display of the correct Manual target.

7.3.1.3.2.1.2 (FOUO) Laser. The SO will set the correct PRF and arm the LRD for any attacks requiring laser designation once the pilot begins the SLAPUM check. While the pilot is setting up the SMS, the SO will set-up and cross-check the LRD status/PRF code on the HUD and verbalize what is on the screen when "Laser" is called for (e.g., "LRD, ARMED LRD, [PRF]"). The pilot will verify those the settings on the HUD prior to moving onto the next step.

7.3.1.3.2.1.2.1 (FOUO) LAR-GBU-49/54/38. On the Tracker display, the pilot will verify the presence of the range and zone LAR. On the HUD, verify the display of range LAR carets, maximum range dot, and zone LAR. If no LAR is displayed on the Tracker display or HUD; verify HAT, winds, and SMS impact and azimuth angle settings are input. LAR size will decrease significantly as aircraft HAT decreases. LAR size may increase through an increase in HAT and/or airspeed. Additionally, Zone LAR size will increase with a decrease in impact angle and an aircraft run-in matching the impact azimuth.

7.3.1.3.2.1.3 (FOUO) Airspeed/Autopilot. Set the airspeed to meet the appropriate combination of weapons release parameters and desired aircraft maneuverability. Typically, setting an airspeed of stall +5 (AGM-114), 165

KTAS (GBU-12/38), 180 KTAS (GBU-49/54) will achieve both parameters. Set autopilot hold modes to the current altitude and desired airspeed with heading hold off. Recommend increasing the Speed Lever to the HIGH position.

7.3.1.3.2.1.4 (FOUO) Payload Setup. The SO sets the deadband, rate gain, geostabilization rate mode, and Payload Stick Zeroize settings that provide the highest fidelity of slew control during a weapons employment, while continually optimizing the picture for the attack. When deadband is OFF, the modifier set to zero, and joystick induced drift is noted, the SO may use "Payload Stick Zeroize" to mitigate control stick inputs caused by worn control stick springs. If the SO has deadband ON or has a modifier setting greater than zero, small inputs (less than 0.2 degrees in any axis) will be ignored and "Payload Stick Zeroize" will not be required. Rate gain settings will be operator and situation dependent. If the SO determines the need to change the rate gain settings to facilitate weapons employment, then make the required changes during this step. Geostabilized rate mode will change the pointing algorithm used by the TGP and mitigate the drift caused by errors in legacy TGP software. In order for geostabilized rate mode to be effective, there must be zero input into the SO's control stick. Once these settings have been configured by the SO, the SO will respond with "SET." The SO should then focus on optimizing the picture for the attack.

7.3.1.3.2.1.4.1 (FOUO) Picture Optimization. Picture optimization for weapons employment includes DPI breakout, track stability, track survivability, and postattack bomb hit assessment (BHA)/battle damage assessment (BDA). DPI breakout is the ability to identify the DPI in the TGP picture. Track stability refers to the amount of track shift around points of contrast within the track gates, primarily encountered when using area tracks. The greater the track stability, the lesser the track shift. Track survivability refers to the track not breaking prior to impact due to contrast changes as the aspect to the target changes. Based on these definitions, a track may be stable but not survivable, and vice versa. The SO should set camera/FOV and iris settings that provide sufficient track coverage around the target and picture contrast to increase track stability and survivability throughout TGP rotation that can occur during postrelease maneuvers, primarily during GBU-12/49/54 employment, and shoot-crank hellfire maneuvers. It is important to note that a picture optimized for weapons employment may involve exaggerating many contrast features from the image by exaggerating iris settings and using wider FOVs that allow AVTs to successfully encompass the desired target. This increased track stability/track survivability may come at the cost of diminished target area SA. Proper clearing procedures prior to optimizing the picture for weapons employment can mitigate these limitations. The SO should also consider target size versus FVW/FVH and maximum growth size of desired AVT when picking the proper FOV. If the SO is having difficulty achieving a

FOV that yields a good target size to FVW/FVH ratio, they should consider switching cameras (IR/DTV) to meet this intent as long as the DTV camera has been laser boresighted.

7.3.1.3.2.1.4.2 (FOUO) Camera/FOV planning considerations. Proper camera/FOV planning enables the SO to successfully guide weapons to DPI with a reduced workload and reduced likelihood of invalid impact criteria due to pilot maneuvering. The primary goal to achieve when planning camera and FOV settings is to ensure the track gate is capable of encompassing the entirety of the desired target to provide the highest level of track stability. This is especially critical during GBU-12 and GBU-49 deliveries, where the TGP will experience a dramatic perspective shift. For hellfire deliveries, the SO may elect to use a smaller track that is anchored on a portion of the overall target when encompassing the entire target is not achievable.

7.3.1.3.2.1.4.3 (FOUO) Manual Iris Considerations. When setting a manual picture to facilitate weapons employment, it is important that the SO balances track survivability, DPI breakout and target area/collateral SA. To optimize an image for track survivability, the SO will need to prioritize contrast between the intended target and the surrounding scene. To facilitate this contrast, lower brightness/level and increase contrast/gain in order to dim the image and increase the contrast in the scene. When increasing the amount of contrast between the scene and the target, the SO will need to ensure not jeopardizing the ability to breakout the DPI. To optimize an image for maintaining target area/collateral SA, the SO will need to ensure that they are able to identify any objects in, entering, and/or leaving the scene. Additional contrast may be needed to break out these details. This may cause a reduction in track stability and survivability, which could necessitate a manual engagement. High-CDE environments will prioritize target area/collateral SA which may shift the priority to maintaining target area/collateral SA. In either situation, the crew should ensure that target custody and aimpoint are not sacrificed.

7.3.1.3.2.1.4.4 (FOUO) GBU-49/54/38. In addition to the TGP, the payload step also refers to the GBU-49/54/38's alignment status. Cross-check the alignment status in the SMS for a transfer alignment (TXA) quality. If the TXA quality is greater than 2, execute a transfer alignment (TAL) maneuver by changing heading 30 degrees using 30 degrees angle of bank and then back to the desired run-in. Another technique is to hold in a Figure Eight or Racetrack pattern prior to turning IN to prosecute the target. Losing TXA quality may often be the result of long periods of straight-and-level flight. To help minimize alignment time from initial power on, perform two consecutive 360-degree turns to decrease alignment time to about four minutes if time permits.

7.3.1.3.2.1.5 (FOUO) Update. The pilot will select Auto, Manual, or Create Target in the SMS depending on weaponeering and the tactical situation. If selecting manual update, the crosshairs should be as close to the target as possible and ideally with the LRD firing to provide the most accurate target location data. Cross-check the Launch Status page in the SMS and verify the coordinates change when accomplishing a Manual Update. Then verify on the Tracker display that the red target designation icon has moved to the TGP sensor point of interest (SPI). A designation is acceptable when the aircraft is close to the target and the TGP crosshairs are on the target regardless of whether the LRD is firing; however, do not delay target prosecution to ensure the LRD is firing prior to a designation. An accurate target designation provides the highest fidelity information to the SMS for its calculations and displays.

7.3.1.3.2.1.6 (FOUO) Master Arm. Set the Master Arm to ARMED. Verify the button on the PSO-1 rack changes from white to an amber-colored "ARMED." Also check the red indicators on the Launch Status page in the SMS near "Master Arm—Off" and "System Not Ready For Launch" (AGM-114 only) change to green and "Master Arm—On" and "System Ready For Launch" (AGM-114 only); and also the red "ARM" on the right side of the HUD goes from flashing to steady. Under training conditions, adhere to AFI 11-214 and applicable range regulations.

7.3.1.3.2.2 (FOUO) WTARSEC. WTARSEC is the attack brief that prepares the crew for employment. It stands for weapon, target/track, aimpoint, restriction/run-in, shift, egress, and clearance. It is a verbal briefing accomplished by the crew after the SLAPUM check is complete and all required attack coordination is complete. **Table 7.5**, WTARSEC, summarizes the WTARSEC attack brief for generic AGM-114 and GBU-12/49/54/38 attacks.

7.3.1.3.2.2.1 (FOUO) Weapon. The pilot briefs the weapon(s) selected, fuzing (AGM-114, GBU-49/54/38 only), LOAL setting (AGM-114s only), station (and position, AGM-114 only), impact parameters (GBU-38/49/54), and PRF code from either the HUD or Launch Status page in the SMS.

7.3.1.3.2.2.2 (FOUO) Target/Track. The pilot defines the target and the SO should immediately brief the track plan. If not immediately, then the SO should brief the track plan after the "Clearance" step concludes and there are no further questions regarding the attack. The SO track brief will include the FOV, camera, automatic video track (AVT) technique, and AVT type for the attack. For example, "THIS WILL BE A NARROW, IR, POST-RIFLE AREA TRACK." If an AVT is not used, the SO may substitute "MANUAL TRACK" for the track type and employment TTP. The pilot must determine if the egress plan will be executable with the briefed track plan and identify ways to ensure track stability throughout the time of flight of the selected weapon. When assessing the track plan, the SO should consider atmospheric effects on track survivability, camera/FOV selected, and any limitations associated with the TGP.

Table 7.5 WTARSEC.

	AGM-114	GBU-12	GBU-49/54/38
Weapon	P/N/ R-#, Station #(s), PRF, LOAL, and fuzing	GBU-12, Station #(s), PRF	Station #(s), PRF (GBU-49/54), and fuzing
Target/Track	• Define the target • Track employment TTP and Track Type (Pre-/Post-Rifle Track, Delay Track, or Manual Track for AGM, Pre/Postrelease Track), or Manual Track for GBUs		
Aimpoint	• Brief Aimpoint based on tactical situation/desired effects		• Readback coordinates for the manually selected target and offset coordinates (ripple release)
Restriction/ Run-In	• Overall attack geometry (E to W), TOT, additional restrictions • Aircraft run-in restrictions or weapon(s) final attack heading restriction		
Shift	Shift Cold: • A/R for SPINS and ROE. • IAW coordinated and pre-approved PLA Procedures (CAS only) Shift X: as required for multiple attacks on a target array • NA for GBU-38s		
Egress	• Shoot-Press • Shoot-Crank • Aircraft positioning post-Splash	• Turning • Straight-through • Aircraft position post-Splash	
Clearance	• Clearance Authority/type of clearance/when to expect it (e.g., at IN call).		
FOUO			

7.3.1.3.2.2.3 (FOUO) Aimpoint. The SO should zoom-in, and the crew should define the exact desired point of impact (DPI) on the intended target that the weapon is going to impact. Various techniques are available to accomplish this step. The first technique is the pilot pointing to a specific DPI location on the HUD with the SO confirming the location by placing crosshairs on the specified point. A second technique is to talk the SO onto the exact DPI using specific corrections to the crosshairs by placing them on the target and the pilot directing either "GOOD CROSSHAIRS," or "HALF WHISKER LEFT…HOLD." The third and recommended technique is to brief the expected target sets for the mission and define the aimpoints in the briefing; this facilitates providing minor corrections, as necessary, based on the target during mission execution. Regardless of the technique used, the SO must understand where to put laser energy before allowing the attack to proceed.

7.3.1.3.2.2.4 (FOUO) Restrictions/Run-In. The pilot briefs all attack restrictions and the run-in. The SO must pay attention to the run-in heading to ensure they are able to remain Tally the target from weapons release through impact. The SO must also understand the weapon run-in/avenue of approach in relation to aircraft heading and adjust crosshair placement accordingly. Failure to do so could result in poor/unachieved weapons effects.

7.3.1.3.2.2.5 (FOUO) Shift. The pilot briefs the shift cold and/or shift plans for the attack. Shift cold is a post-launch abort tactic that moves the weapon off the originally intended target. The shift cold point is target-specific and based on the surrounding land/urban features and current ground situation. There are cases where shift cold is not possible due to CDE concerns surrounding the target and/or restricted through doctrinal execution guidance (e.g., JP 3-09.3, *Close Air Support, Postlaunch Abort Procedures*). It is critical to know the downrange and cross-range capability of the weapon when determining shift direction and distances to ensure the weapon can acquire the laser energy if the shift cold occurs prior to laser acquisition. In addition to shift cold, a shift plan can be briefed prior to the first attack when engaging multiple DPIs. In this case, identify and label/sort each DPI. The pilot will direct, "SHIFT X," where X is a number, labeled target, or colored Geo-Ref point (OFP 2408), and the SO will slew to the appropriate DPI (e.g., "SHIFT 1" after Splash). There is no shift for GBU-38s.

7.3.1.3.2.2.6 (FOUO) Egress. The pilot briefs the weapons-specific postrelease TTP as well as the overall egress plan to prepare the SO for TGP movement induced by aircraft maneuvering. The pilot should account for the SO track plan in the egress maneuver and adjust aircraft maneuvering to maximize track employment effectiveness to the max extent possible.

7.3.1.3.2.2.7 (FOUO) Clearance. Pilot will brief who the clearance authority is for the attack (JTAC, flight lead, FAC[A]), type of clearance (as required), and when it is expected (e.g., at the turn inbound).

7.3.1.4 (FOUO) Execute. The Execute phase consists of the mechanical procedures to conduct the attack. It begins at the Turn-In when departing the hold and lasts until postattack procedures are complete following Splash. Attack execution is divided into four steps: turn-in, final, release to Splash, and postimpact procedures.

7.3.1.4.1 (FOUO) Turn-In. The turn to final signifies the transition into the terminal attack phase. Pilots should turn to final to line up on the desired run-in heading and on steering (GBU) or at the desired release range/azimuth (AGM-114). For attacks requiring clearance from a third party, a common technique is to obtain clearance at the Turn-In to minimize time between clearance and weapons employment. For laser-guided weapons, recommend commanding the laser on at the "IN" call, if required.

7.3.1.4.2 (FOUO) Final. Rolling out on final requires deliberate, smooth control inputs to prevent Ku hits, over-turning to line up on steering, or arriving at desired AGM-114 shot azimuth. Once established on final, a technique for an effective pilot cross-check is the STAT acronym, while the SO cross-check uses a hub-and-spoke technique. The pilot's initial cross-check should focus on steering and drift. The SO should focus on picture optimization and establish the TGP settings briefed for the attack. In the event the SO identifies a deficiency in the plan, they should brief the updated plan to the pilot immediately upon achieving desired settings. Under no circumstances should the SO delay optimizing the TGP to brief the pilot. With all parts of SLAPUM WTARSEC complete, the focus is on flying the aircraft to the desired release point for a valid weapons employment and optimizing the picture and TGP settings for effective crosshair control.

7.3.1.4.2.1 (FOUO) Steering, Timing, Airspeed, and Track (STAT) Check. This is the pilot cross-check on final; it focuses on critical information from the HUD to enable a successful weapons employment. **Figure 7.2**, Attack Cross-Check on Final, depicts this cross-check. The STAT check is not a one-time check but continuous cross-check until release or until meeting another specified criteria/trigger (e.g., 1 minute to TOT).

7.3.1.4.2.1.1 (FOUO) Steering. Assess aircraft position relative to the bomb steering line (BSL), using the FPM, for GBU-12/49/54/38 attacks, and to desired WEZ positioning for AGM-114 attacks. Make small, finite corrections to maneuver the aircraft back to steering or desired azimuth.

7.3.1.4.2.1.2 (FOUO) Timing. Assess time remaining until release to maintain awareness of attack pacing. For GBU-12s, reference HUD time to release (TTR). For AGM-114s, assuming the R_{DL} is set correctly, reference the TOI on the HUD. For GBU-49/54/38s, reference time to range/zone LAR. For timed attacks, reference the applicable time reference (e.g., time at control point, timer, TOI, or Zulu clock) to determine if the aircraft is early or late.

7.3.1.4.2.1.3 (FOUO) Airspeed. Cross-check airspeed to ensure the aircraft has enough roll authority for any post-Rifle/release maneuvering as well as for valid weapons employment. On timed attacks, assess the need for an airspeed change to establish or terminate a timing correction.

7.3.1.4.2.1.4 (FOUO) Track. On most attacks, the range will decrease as the aircraft gets in position to employ a weapon. As the range changes, the picture also changes which can affect the TGP FOV choice and target features for track employment. Verify the FOV and features in the target area still provide a viable option for the chosen track plan.

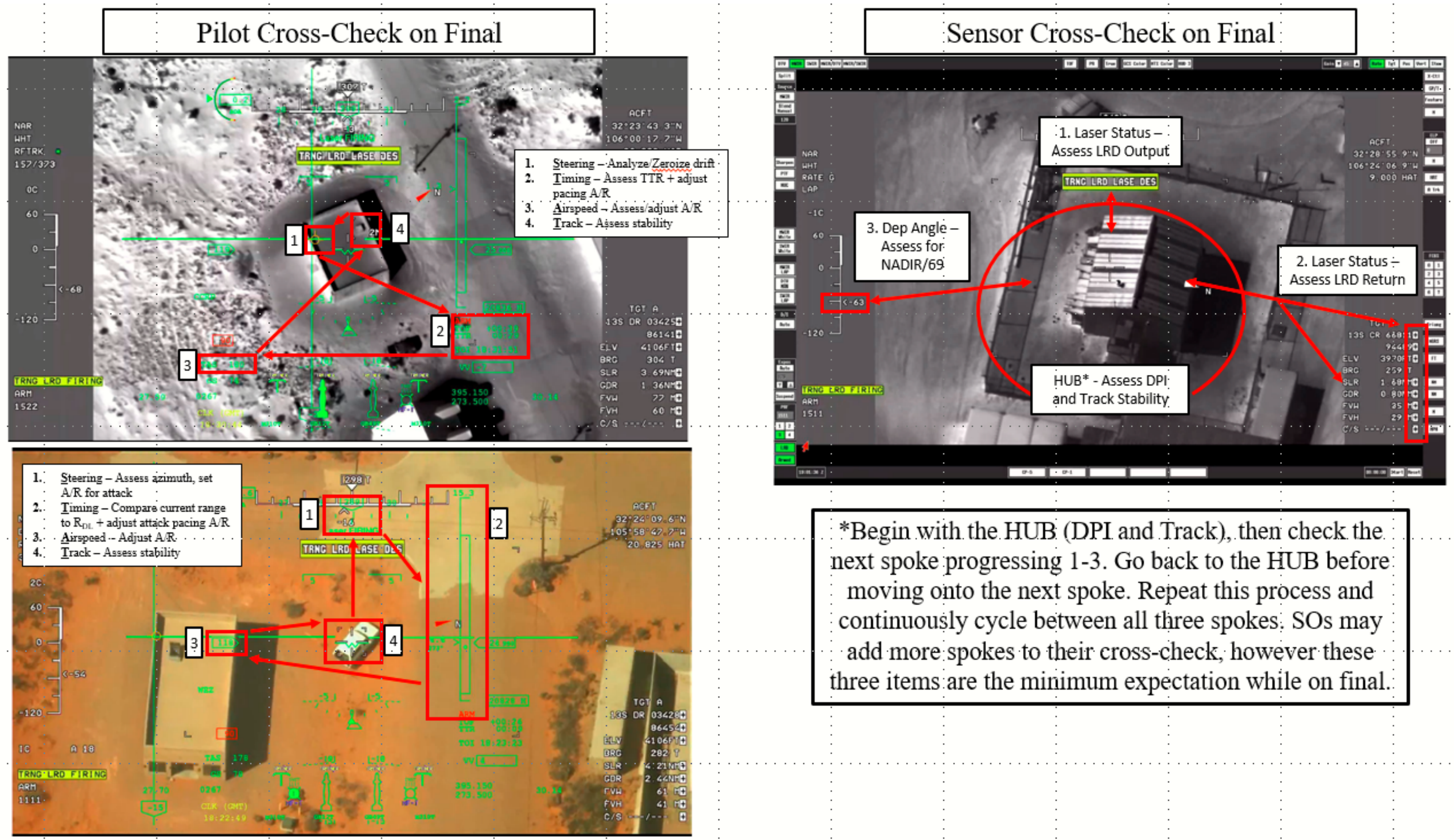
7.3.1.4.2.2 (FOUO) Sensor Operator Cross-Check on Final. The SO cross-check on final uses a hub-and-spoke technique with the DPI and track as the "hub," and laser indications and depression angle in the TGP graphics as the "spokes." The cross-check begins once the laser has been turned on and ends at weapons release. At laser on, begin cross-check at the hub, then first assess laser status (LRD output) followed by laser returns (LRD return data) returning to the hub between each spoke. The final spoke is assessing depression angle to mitigate nadir. Repeat this hub and spoke until weapons release. At the hub, the SO assesses the DPI relative to the crosshairs and provides smooth control inputs to correct the crosshairs to the

DPI, if required. The SO should then assess the track to determine track stability and track survivability. The SO should be looking for track drift, coast mode, track features within the track gate and the potential for track drift due to TGP rotation postrelease from aircraft maneuvering. If track drift is occurring or anticipated, the SO should manipulate the picture to emphasize the required track features for a stable track or regrow the track on a better feature. Once complete with the track assessment and any required corrections, the SO should cross-check a laser indication to verify effective lasing. Laser indication items the SO should cross-check are LRD status for laser failure (LRD LP DES), and laser ranging information (e.g., minimal slant range change, backfilled containers). The depression angle should also be checked for unexpected high depression angles. The SO should sequentially check each one of those three items between revisits to the DPI and track. Continue the cross-check until release. **Figure 7.2**, Attack Cross-Check on Final, depicts this cross-check. As able, the SO should cross-check RMIT prior to weapons release for avenue of approach when employing AGM-114s.

7.3.1.4.2.3 (FOUO) Release to Splash. Release occurs immediately when commanded by the pilot for AGM 114s, and all GBU manual deliveries, and GBU-49/54/38 deliveries within the range LAR. For GBU-12 CCRP deliveries and GBU-49/54/38 deliveries outside of the LAR, release does not occur until CCRP (GBU-12) or within LAR (GBU-49/54/38). Switch actuation for release should be near simultaneous with the habit pattern of depressing and holding the consent to release button on the throttle and then squeeze and hold the trigger until indicated weapons release. Pilots should continue to depress the consent to release button and trigger until all selected weapon icons have disappeared from the HUD. Once the weapon(s) is/are away, in accordance with the egress plan, the pilots focus is on smooth aircraft maneuvering for self-lase deliveries to provide a stable platform for the SO. The SO's focus is on crosshair placement, its refinement to the DPI, and manipulating the manual picture as necessary to ensure track survivability. The pilot should immediately provide a countdown for the initial TOF postrelease and then continue the countdown time for the weapon using 10 second intervals. Any aircraft attitude and/or angle of bank changes should be complete by 10 seconds TOF remaining for stationary targets (15 seconds TOF remaining for moving targets) to provide a stable platform for the SO, unless avoiding nadir.

7.3.1.4.2.4 (FOUO) Postimpact Procedures. The crew begins postimpact procedures at Splash. Timely and correct postimpact procedures are essential to maintaining target area SA after weapons impact. These procedures do NOT include the pilot commands for "CEASE LASER, SAFE LASER," or "MASTER ARM—SAFE," (which are executed once tactically relevant) but instead pertain to the SO tasks that shall be immediately executed in order: break track, select auto iris, and zoom out as required to maintain target area SA. Once commanded by the pilot, the SO will cease lasing and safe the laser.

Figure 7.2 Attack Cross-Check on Final.



FOUO

7.3.1.4.2.4.1 (FOUO) Break Track. If a track was established prior to weapons impact, the SO cannot guarantee how the track is going to react at impact. Therefore, it is critical the SO breaks the track first immediately after weapons impact to manage slew control in order to maintain target area SA. If no track was established at weapons impact, this step is not applicable.

7.3.1.4.2.4.2 (FOUO) Auto Iris. If the SO opted to use manual IR iris settings for track stability during the weapons run, they need to be postured to return to auto iris at weapons impact. This allows for improved visibility of the impact site in order to conduct BHA or follow on attacks. This is accomplished by placing the mouse cursor over the auto/manual button on the HUD toolbar prior to release or depressing the middle button at the top of the control stick postimpacts. If the SO is employing with auto IR iris, or if employing in DTV, this step is not required.

7.3.1.4.2.4.3 (FOUO) Zoom-Out. Depending on TWD/FVW and target size, the SO should zoom-out to a FOV that is wide enough minimize the effects of bloom and smoke, but still allows the crew to track the smallest possible target (e.g., Squirters). If the SO is already in the best FOV to maintain target SA, zooming out is not required.

7.3.1.5 (FOUO) Egress. The egress phase begins after accomplishing the postimpact procedures. The pilot will call "CEASE LASER" once it is determined all self-lased munitions have impacted or TOF plus 15 seconds has expired. The pilot should aggressively maneuver the aircraft to place it in position for a reattack, while the crew simultaneously conducts BHA/BDA. For attacks requiring a reattack (missed weapons effects, multiple DPIs, etc.), use the ASULT weapons check to expedite systems set-up; see **paragraph 7.4.2.3**, ASULT Check. Only once it is determined a reattack is unnecessary the crew should then safe systems and consider the attack complete. The sensor will command laser off and verbalize "LASER OFF, LASER SAFE" once HUD laser indications disappear.

7.3.2 (FOUO) AGM-114 Attack Procedures. AGM-114 attack procedures follow the attack phasing as outlined in **Table 7.2**, Attack Phases. For Hellfire specific weaponeering considerations see **paragraph 6.3.5**, Kill Mechanisms. R-guidance capabilities allow employment of Hellfire missiles from virtually any sensor offset, across nearly the entire flight envelope of the MQ-9, and still achieve a high probability of hit (P_H). The MQ-9 is typically in the WEZ, or very close to the WEZ, while holding and tracking a target. This allows attack pacing to happen very quickly and challenges crews to be proficient in the attack procedures. Aircraft positioning at Rifle is important as it can greatly affect the weapons impact parameters and effects. The Intent and Game Plan phases are unchanged, see **paragraph 7.3.1.1**, Intent, and **paragraph 7.3.1.2**, Game Plan, for specifics. The AGM-114 has two basic types of attacks, on-azimuth and off-azimuth, that can be employed against single or multiple DPIs. **Figure 7.3**, AGM-114 Basic Attacks, and **Figure 7.4**, AGM-114 Versus Multiple Targets, depict these attacks.

Figure 7.3 AGM-114 Basic Attacks.

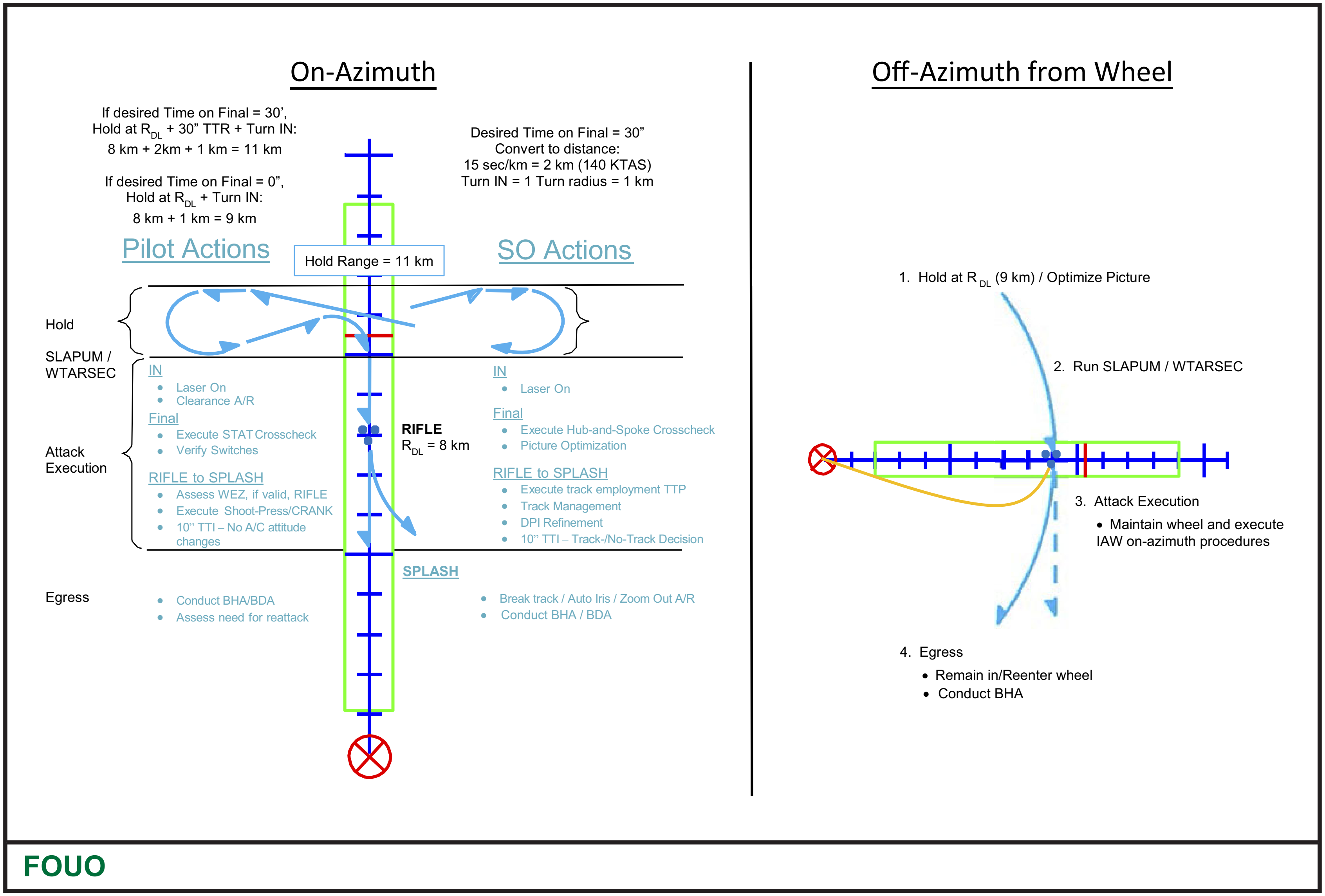
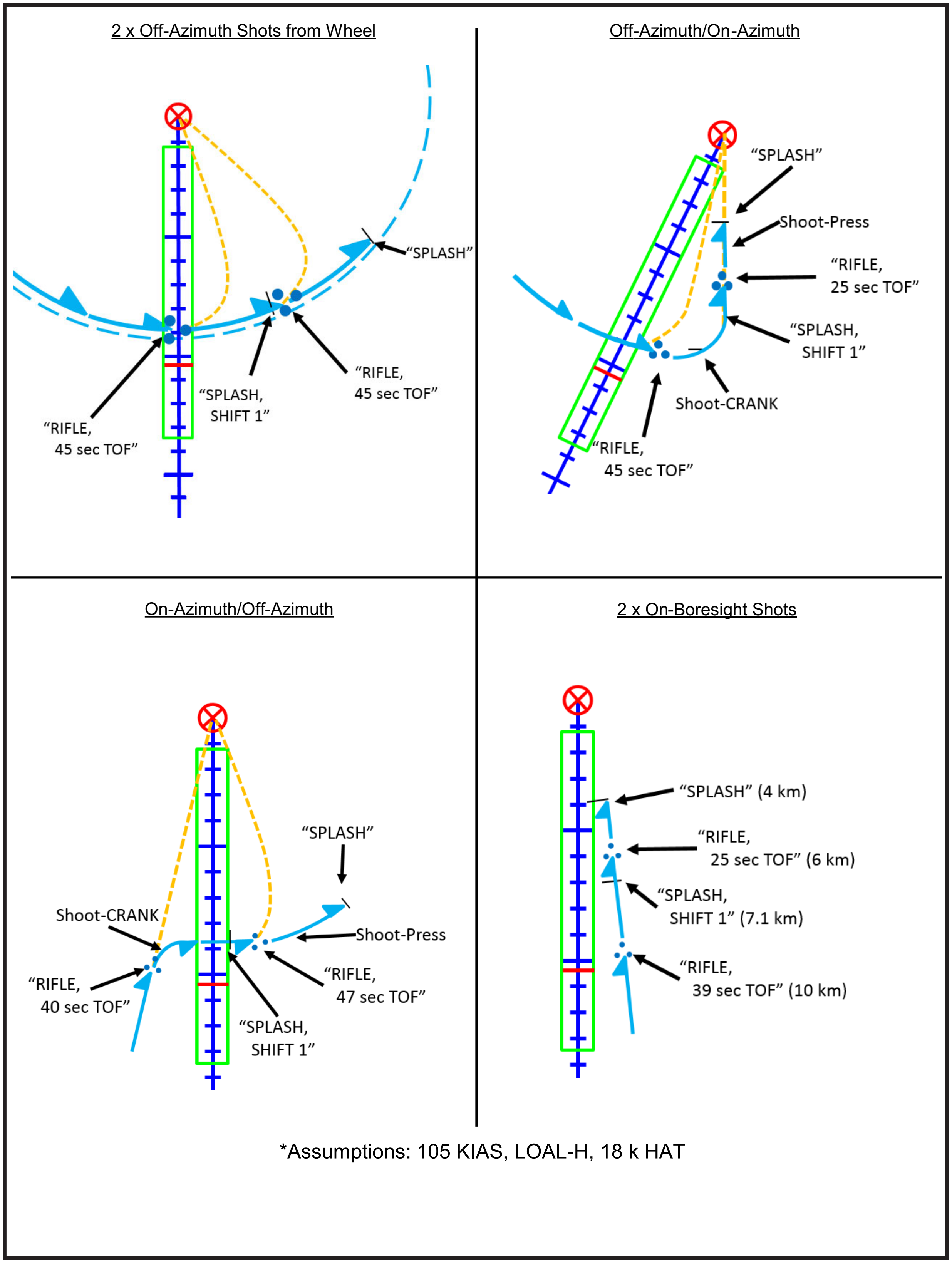


Figure 7.4 AGM-114 Versus Multiple Targets.



7.3.2.1 (FOUO) On-Azimuth. AGM-114 on-azimuth (or on-boresight) employments are defined as TGP azimuth being less than 45 degrees at release. On-azimuth employments are used to meet weaponeering-specific run-ins, to meet restricted run-ins, to maximize impact angle on LOAL-H shots, to minimize impact angle on LOAL-L shots, to minimize potential masking concerns, and to minimize acoustic warning (AW). Not all attacks require a specific desired launch range (R_{DL}); when that occurs, use an acceptable range within the WEZ to achieve weapons effects.

7.3.2.1.1 (FOUO) AGM-114 Hold. Basic off-axis holding for on-azimuth employments should place the aircraft at a range with predictable time on final prior to employment, after turning inbound. Enter and maintain the hold IAW paragraph 3.5.1.3.1, Entering Holding and Maintaining Standoff. The following process outlines how to determine a generic hold position. Planning Tool v11.65 also enables the desired time on final to be a variable when using the untimed hold section.

7.3.2.1.1.1 To assist in developing the holding game plan, initial actions should be IAW **Table 7.2**, Attack Phases. Pilots should then calculate R_{DL} and determine the holding position based on the Turn-In and desired time on final. Assuming 140 KTAS, 30 degrees angle of bank, and no wind, a Turn-In takes approximately 1 km of ground range. That range increases for a turn onto final with a tailwind and decreases with a headwind. See **Table 3.4**, MQ-9 Turn Radius as a Function of Airspeed, for turn calculations.

7.3.2.1.1.2 Next, convert the desired time on final into a distance. Using the previously stated assumptions, it takes approximately 15 seconds for each kilometer of travel on final. If 30 seconds on final is desired, the aircraft must plan to roll out with 2 km prior to R_{DL}.

7.3.2.1.1.3 Combining the Turn-In (1 km), and the desired time/distance on final (30 seconds, 2 km), the crews should anchor the hold no closer than 3 km from the R_{DL}. If 6 km were the planned R_{DL} to achieve desired impact angle and minimize acoustic warning, the following equation would apply.

$$\mathbf{R_{DL} + \text{Turn-In radius} + \text{Desired time on final} = \text{Front of Holding Distance}}$$

$$\mathbf{6\ km + 1\ km + 2\ km = 9\ km}$$

7.3.2.1.1.4 (FOUO) Wheel Hold. Choose the Wheel hold if there is no restricted run-in, but an on-azimuth employment is necessary to achieve weapons effects. Arc the target at one 90-degree turn radius from the R_{DL} and accomplish the preattack checks. Winds will affect the time on final if ground range remains constant while executing a Wheel hold. In order to achieve a constant time on final, increase the hold range on the upwind side of the target and decrease on the downwind side.

7.3.2.1.1.5 (FOUO) Figure Eight/Modified Figure Eight Hold. Choose the Figure Eight/Modified Figure Eight for on-azimuth attacks that require a specific or restricted run-in. While in the hold, use max angle of bank turns into the wind if greater than 30 knots to minimize the turn radius and accomplish the preattack checks. See **paragraph 3.4.2.4**, Figure Eight, and **paragraph 3.4.2.5**, Modified Figure Eight, for holding specific criteria. Keep the hold within a ±30 degree sector of the run-in; once ready to employ, turn in and execute the attack.

7.3.2.1.2 (FOUO) AGM-114 Preattack Checks. Accomplish SLAPUM WTARSEC preattack checks once the hold plan has been developed and the aircraft is moving to, or established in, the hold. **Table 7.4**, SLAPUM, and **Table 7.5**, WTARSEC, contain items for each check. The following are specific considerations for AGM-114 preattack checks with regards to payload setup, track, aimpoint, and egress.

7.3.2.1.2.1 (FOUO) AGM-114 Payload Setup. When the SO is setting up the TGP to facilitate a hellfire employment, they have multiple options to choose from. Initially, the SO should begin with a game plan of using IR/NAR for the attack, which will provide an effective balance between track sustainability/survivability, TGT area SA, and DPI breakout. Several factors may require either a narrower FOV, or alternate camera option. To assess which alternate camera/FOV settings are desirable, the SO should consider time of day, atmospherics, additional clutter near the target, and the ability to clearly identify the DPI for longer range engagements. When encountering atmospherics, the SO should alternate between IR/NAR and DTV/NAR initially to determine which camera provides the best mitigation. Once the camera is selected, the SO can then look at additional clutter near the desired target, which may cause the selected AVT to shift away from the desired DPI, increasing SO workload and/or decreasing P_H. When encountering clutter near the desired TGT, the SO should step in one FOV at a time to reject clutter. If a narrower FOV is not required, the SO may also elect to change track gate size in the HDDs.

7.3.2.1.2.2 (FOUO) AGM-114 Track. There are four types of track plans SOs can use for AGM-114 employment: pre-Rifle track, delay track, post-Rifle track, or manual track (Hand-fly). The target and engagement parameters will determine which track plan is optimal. When a track is established, the SO must ensure it is grown to maximize the chance of holding throughout the TOF of the missile. For a detailed discussion of track logic, see **paragraph 9.5.3.4**, Automatic Video Track. Attempts to regrow a track are not recommended inside of 10 seconds time to impact (TTI) for static targets and 15 seconds TTI for moving targets.

7.3.2.1.2.2.1 (FOUO) AVT selection for Hellfire employment. When the SO is selecting which AVT type they will use, they must consider several factors. These factors include the size of the target, any unique characteristics that may facilitate a particular AVT more effectively, and any EO/IR degradations that may be present. When considering TGT size, the SO should attempt to compare the TGT size to the selected AVT's maximum growth size to ensure the track gate will encompass the desired target features and remain stable and survivable. If there are smaller features associated with an object that will effectively facilitate a particular AVT, without sacrificing DPI management, the SO may elect to offset track and drag crosshairs to the DPI. The last factor to consider during AVT selection is the effect of atmospherics on the AVT algorithms. An example of this is the point track, which is a peak closed-contour contrast tracker. If atmospherics preclude creating a predictable AVT, the SO should select an alternate option, or a no-track engagement.

7.3.2.1.2.2.2 (FOUO) Pre-Rifle Track. A pre-Rifle track is when the SO builds a track around the target/track feature prior to the pilot commanding weapons release. Once the Hellfire leaves the M310, the TGP will initiate a five-second track suspend, if track suspend is not disabled. During the five seconds track suspend is active, the SO must compensate for TGP drift and maintain crosshairs on the DPI. During track suspend, the TGP will return to the SO selected rate gain setting, allowing for full control authority of the TGP. Pre-Rifle track reduces the effort required to control the TGP prior to weapons release but may require an increased effort to mitigate the track suspends effects.

7.3.2.1.2.2.3 (FOUO) Delay Track. A delay track is when the SO commands a track prior to weapon release but does not drop the track until Rifle plus 5 seconds (i.e., after suspend track). This allows the SO to maintain a constant fidelity of manual control of the TGP crosshair placement prior to track establishment. Fire the laser prior to opening track gates; doing this also increases SO workload prior to Rifle because the SO must hold the track gate open while maintaining crosshair control from the top of the control stick and commanding the LRD to fire; but it does allow for stable crosshair control throughout suspend track. Use of this technique forces the SO to accept a maximum-sized track gate.

NOTE: (FOUO): The laser cannot be commanded to fire simultaneously with an AVT commanded, but not established. To mitigate this on a delay track, fire the laser prior to commanding the AVT. If it is too late, release the track, command the laser and then assess the track.

7.3.2.1.2.2.4 (FOUO) Post-Rifle Track. A post-Rifle track is when the SO maintains the crosshairs on the target until the pilot commands the launch of the Hellfire and does not grow/establish a track until after track suspend. A Post-Rifle track allows the SO to solely focus on slew control from pre-Rifle through Rifle sequence but increases the SO workload to establish a track afterwards.

7.3.2.1.2.2.5 (FOUO) Manual Track (Hand-fly). Manual track is when the SO plans to not use an AVT and hand-fly the TGP throughout the weapon TOF. If the picture, target, or tactical scenario (e.g., coordinated attack with simultaneous impacts among multiple DPIs in close proximity) is not conducive to employ a track, a manual track engagement should be conducted. During a manual track engagement, SO success is predicated upon accurate and deliberate slew control and stable aircraft maneuvering from Rifle through Splash.

7.3.2.1.2.3 (FOUO) AGM-114 Aimpoint. Due to the different variants of AGM-114s and fuzings available, defining a specific aimpoint to achieve weapons effects is critical. The following are some recommended aimpoints based on possible tactical scenarios. In all weaponeering instances, crews should be familiar with current Hellfire Handbook data regarding P_K specifics and should also reference AFTTP 3-1.MQ-9, Chapter 3, "Weaponeering." In all cases, it is the crews' responsibility to ensure weapons effects achieve the desired intent.

- Small buildings: center mass with considerations for dimensions (length/width), composition (structural make up), and weapon fuzing (potential for the weapon to exit the building prior to detonation).
- Single PAX in open: base of the feet and ensure crosshair placement is between the target and the weapon heading.
- Multiple PAX in open: center mass of the largest group.
- Vehicles (non-armored): center mass of the roof of the vehicle.
- Armored vehicles: situation dependent.

7.3.2.1.3 (FOUO) AGM-114 Egress. The pilot has three options for egress: Shoot-Crank, Shoot-Press, and Straight-Through.

7.3.2.1.3.1 (FOUO) Shoot-Crank. Use the Shoot-Crank to maintain WEZ, standoff to the target, and/or slow the rate of apparent movement of objects in the TGP. Use this technique to set the aircraft up for a Wheel hold, pre-position for a reattack option, or to avoid a threat. The amount of Crank required (heading or azimuth change) is dependent on the tactical situation. It is critical the pilot understands the track employment TTP the SO has chosen to use on the attack and integrate it into this maneuver. This is because as the aircraft rolls into the turn, the SO crosshairs will drift. For example, in situations where track suspend is enabled, the sensor will not have a track grown until Rifle +5 seconds. Unless absolutely necessary for aircraft positioning considerations, the pilot should allow the SO one opportunity to drop the track after suspend track prior to beginning the Crank maneuver. With a stable track established, the pilot can aggressively roll with minimal impact to the SO. For short TOFs, the aircraft may remain in a bank the entire duration. For longer TOFs, it is possible the aircraft will turn the desired amount for the Crank maneuver (e.g., 90 degrees) prior to weapons impact. In this case, the pilot should balance the roll out with remaining TOF; do this by smoothly rolling out to allow a minimum of 10 seconds TOF remaining for static targets (15 seconds for moving targets). If required to roll out with less than 10 seconds TOF (e.g., approaching nadir), the pilot should verbalize to the SO prior to maneuvering so they can anticipate and counter TGP drift.

7.3.2.1.3.2 (FOUO) Shoot-Press. This egress option uses minimal maneuvering during weapon TOF. At release, the pilot maintains straight-and-level flight until impact. While this eases the SO's crosshair control, it decreases ground range and may put the aircraft out of an acceptable reattack position as the pilot continues towards the target on-azimuth. An effective depression angle cross-check during this maneuver is critical.

7.3.2.1.3.3 (FOUO) Straight-Through. This egress maneuver uses bank angle and rudder to cross-control the aircraft to fly straight over the target and slow the rate of rotation in the TGP. This maneuver for AGM-114 attacks is typically chosen when the R_{DL} is with-in a close proximity to the target and nadir is impending during weapon TOF (e.g., Rifle at min WEZ during a reattack). See **paragraph 3.4.3.2**, Straight Through, for execution specifics.

7.3.2.1.4 (FOUO) Execution. AGM-114 on-azimuth attack execution consists of the previously discussed steps: Turn-In, final, release to Splash, and postimpact procedures.

7.3.2.1.4.1 (FOUO) Turn-In. When the crew is ready for the attack, the pilot should turn using maximum angle of bank, and begin roll out when passing ±45 degrees of TGP azimuth. Request clearance if required and turn the laser on as you begin the turn to final (or once established).

7.3.2.1.4.1.1 (FOUO) Laser On. The sensor should turn the laser on with a minimum 30 seconds TTR in order to verify the laser is properly functioning. If the plan is to have 30 seconds time on final, then the pilot should command "LASER ON" once rolled out on final. If the plan is to roll out and immediately shoot, then 30 seconds prior begins at the Turn-In. In this case, the SO should cross-check for laser masking and once clear, command the laser on once directed by the pilot or through an established crew contract tied to the IN call. Once the laser is commanded on/firing, the SO will respond with "LASING, PRF, VALID INDICATIONS" after first cross-checking PRF, laser status and ranging indications. Crews should also assess valid R09 data during/following the SO call out primarily focusing on slant range, azimuth, and elevation. Continue hub-and-spoke cross-check until weapons impact.

NOTE: ULTN and NAR are the most optimal FOVs for lasing. If lasing in NM, FOV is required; align crosshairs with a clearly visible feature and zoom from NAR to NM and observe if the crosshairs move relative to the observed feature. If no movement is noticed, lasing in NM is acceptable.

7.3.2.1.4.2 (FOUO) Final. Once on final, the pilot executes the STAT cross-check while the SO executes the hub-and-spoke cross-check. For STAT, the pilot verifies the aircraft is on the desired run-in and assesses range to R_{DL} (e.g., timed attacks or specific weaponeering) to determine the time until Rifle.

7.3.2.1.4.3 (FOUO) Release to Splash. As the aircraft reaches the R_{DL} and is ready to employ, pilots should cross-check TGP azimuth, compare it to the range, and if in a valid WEZ, Rifle. OFP 2407 and beyond provides an accurate breathing WEZ via the common weapons library (CWL); additionally, the crew can use the RMIT real time footprint to cross-check WEZ validity prior to Rifle. A countdown to Rifle (e.g., "3, 2, 1…etc.") is unnecessary and delays the employment; the crew should already be aware weapons release is imminent. Once the pilot determines the aircraft is in a valid WEZ and they are going to shoot, they will verbalize Rifle when the associated icon(s) disappear. Post-Rifle the pilot executes the briefed postrelease egress maneuver (e.g., Shoot-Crank, Shoot-Press, Straight-Through) and makes any required radio calls. The SO should focus on TGP drift during suspend track to correct the crosshairs back onto the DPI while executing track employment TTP and hub-and-spoke cross-check. AGM-114 attacks do not typically have much TGP rotation, unless employed at close range and combined with a Shoot-Crank or Straight-Through egress maneuver. The potential for nadir, however, exists for all three egress maneuver types. Shoot-Crank can put the aircraft within 90 degrees azimuth and close to the target, meaning any bank angle away from the target increases depression angle. A Straight-Through or Shoot-Press with an on-azimuth shot continually decreases range to the target and the egress cross-check must include the depression angle, azimuth, and bank angle for nadir awareness. Depending on SMS/Common Weapons Library software limitations, the HUD-displayed TOF may not be accurate. In that instance, RMIT real time footprint will provide the most accurate missile TOF.

7.3.2.1.5 (FOUO) Egress. The focus of the egress is to aggressively maneuver the aircraft to be in a position for a reattack in the most efficient way possible, while conducting BHA/BDA, monitoring for Squirters and avoiding nadir.

7.3.2.1.5.1 (FOUO) Shoot-Crank Egress Execution. Immediately after Rifle the pilot cross-checks depression angle to determine how much bank angle for use then cross-checks the TGP azimuth to determine which direction to turn.

7.3.2.1.5.1.1 If the depression angle is less than 60 degrees, the pilot should have full bank authority and can use maximum bank angle. Cross-check TGP azimuth and make a turn away (e.g., TGP azimuth is 30 degrees = left turn) to expeditiously establish the aircraft into a reattack position while avoiding nadir. The pilot must continue to cross-check the depression angle while inputting/established in a bank to not exceed 80 degrees. If the depression angle increases above 80 degrees, the pilot should reduce bank angle to maintain between 75 to 80 degrees. At Splash, determine if bank angle is still required to build spacing from the target for a reattack, otherwise smoothly roll out of bank and progress to egress step of the attack.

7.3.2.1.5.1.2 If depression angle is greater than 60 degrees, the pilot may have limited bank authority. The pilot should execute in accordance with the above paragraph, but instead of using maximum bank authority, use a 20-degree bank angle and cross-check the depression angle maintaining between 75 to 80 degrees. At Splash, cross-check depression angle and smoothly roll out of bank once the depression angle begins to decrease naturally without further inputs and move to the egress step of the attack.

7.3.2.1.5.2 (FOUO) Shoot-Press Egress Execution. After Rifle, the pilot maintains a straight-and-level profile until Splash. Immediately after Splash, the pilot should assess the depression angle and TGP azimuth, then execute egress per Shoot-Crank above.

7.3.2.1.5.3 (FOUO) Straight-Through Egress Execution. Execute the straight-through egress IAW **paragraph 3.4.3.2**, Straight Through.

7.3.2.1.5.4 (FOUO) Postimpact Procedures. The SO executes postimpact procedures IAW **paragraph 7.3.1.4.2.4**, Postimpact Procedures, immediately after Splash and provides the pilot with an assessment of weapons effects.

7.3.2.2 (FOUO) Off-Azimuth. AGM-114 off-azimuth (off-boresight) employments are defined as TGP azimuth being greater than 45 degrees at release. The following are some considerations for off-azimuth attacks in relation to desired weapons effects: as the degrees off-azimuth increase, missile time of flight increases, the vertical impact angle shallows, and audible warning before impact increases. Based on the terminal attack geometry, it is critical to assess missile final attack heading/azimuth as it may require an adjustment to the aimpoint. Additionally, when electing to employ off-azimuth with a restricted run-in, crews must diligently cross-check missile final attack heading prior to employment to verify the restriction will be met. Off-azimuth shots also preserve target distance throughout the TOF which enables expeditious reattacks and provides immediate employment opportunities for fleeting targets or targets that do not require steep impact angles or minimal acoustic warning. Off-azimuth shots may be reactive in nature; or they may be taken from a preplanned hold if the intent is to preserve distance and/or maintain aircraft positioning on a specific side of a target. If electing off-azimuth employment from a preplanned sector hold (i.e., Figure Eight/Modified Figure Eight), hold IAW the on-azimuth section. The remainder of this section will discuss off-azimuth engagements from the wheel.

7.3.2.2.1 (FOUO) Hold. Off-azimuth attacks are typically employed from the wheel and arc the target at R_{DL}. Determine the R_{DL} and adjust the hold to arc the target at R_{DL} cross-checking the range in the staple and the TGP azimuth to maintain the wheel hold. Continue to maintain the Wheel hold during preattack checks through Rifle.

7.3.2.2.1.1 (FOUO) Preattack Checks. Execute SLAPUM WTARSEC as previously discussed. For decreased shot ranges, pay extra attention to the impact angle and missile run-in; adjust aimpoint according to the missile final attack heading.

7.3.2.2.2 (FOUO) Off-Azimuth Execution. Execute each step of an attack as previously discussed with the following highlights:

7.3.2.2.2.1 (FOUO) Turn-In. Off-azimuth employments from the wheel do not require a Turn-In. This dramatically reduces the time from completion of preattack checks to when the aircraft is ready to Rifle. With the compressed time line, do not forget to turn the laser on and obtain clearance, if required. Pilots should include weapon attack heading with any required 'IN' calls to provide SA to ground parties, e.g., "SAVAGE 11, IN, WEAPON HEADING 226."

7.3.2.2.2.2 (FOUO) Final. The aircraft is technically on final once established in the arc, at R_{DL}, for an off-azimuth wheel shot. The STAT and hub-and-spoke cross-checks still apply. The pilot must maintain the required azimuth to continue arcing the target and cross-check the Hellfire run-in heading to determine the time until release, if attack requires a specific run-in.

7.3.2.2.2.3 (FOUO) Release to Splash. The pilot should cross-check the range, azimuth, and WEZ to determine if the aircraft is in a valid WEZ for employment. If employing with a restricted run-in, cross-check the real time footprint for the missile heading and Rifle once within restriction parameters. The IR bloom as the missile separates from the aircraft may not be observed if releasing from the opposite rail as the TGP azimuth (e.g., right rail selected with a left TGP azimuth), but track suspend will still occur if not disabled and the SO should execute the briefed track plan. After release and once the SO has a track established, the pilot should maintain the Wheel, keeping the aircraft at a constant range throughout missile TOF, doing so mitigates the possibility of laser masking. Pilots may also elect to turn and cut inside the Wheel hold, then roll out and continue straight-and-level allowing azimuth to increase during the TOF with the aircraft being near 90 degrees azimuth at Splash. Aircraft adjustments to the hold should stop with 10 seconds remaining in the TOF for stationary targets (15 seconds for moving targets).

7.3.2.2.2.4 (FOUO) Postimpact Procedures. At Splash, the SO executes postimpact procedures IAW **paragraph 7.3.1.4.2.4**, Postimpact Procedures.

7.3.2.2.3 (FOUO) Egress. Shoot-Press is the common egress tactic maintaining the wheel hold from Rifle through Splash. Shooting an off-azimuth Hellfire from the wheel sets up the aircraft for an immediate reattack, whether from the wheel or executing a turn-in to conduct an on-azimuth attack with either an AGM-114 or another weapon. The crew also conducts BDA/BHA and reports back results as required.

NOTE: If releasing multiple missiles at the same time on DPIs that must be hit in a specific order, high-off boresight shots should not be taken due to the potential for second missile to impact before the first (depending on interval setting).

7.3.2.3 (FOUO) Multiple Desired Points of Impact. Several targets can be engaged quickly with Hellfires using a combination of on and off-azimuth shots with Shoot-Press or Shoot-Crank techniques. This paragraph will discuss multiple, sequential releases of a single AGM-114. As a technique, this publication does not recommend Rifling a second missile with minimal TOF remaining on the first missile as the track suspend from the second missile may interfere with the SO crosshair control on the first DPI.

7.3.2.3.1 (FOUO) Hold. Develop and execute a hold plan for the attacks that encompasses the preattack hold and aircraft maneuvering through each additional AGM-114 employment. The hold plan may be as simple as each shot from the wheel at R_{DL}, or it may be complex using on-azimuth shots with a Shoot-Press technique, or even a combination of on and off-azimuth shots with Shoot-Press/Shoot-Crank egress techniques. Once the hold plan is determined, hold IAW **paragraph 7.3.2.1.1**, AGM-114 Hold, at the planned hold range while preattack checks are completed.

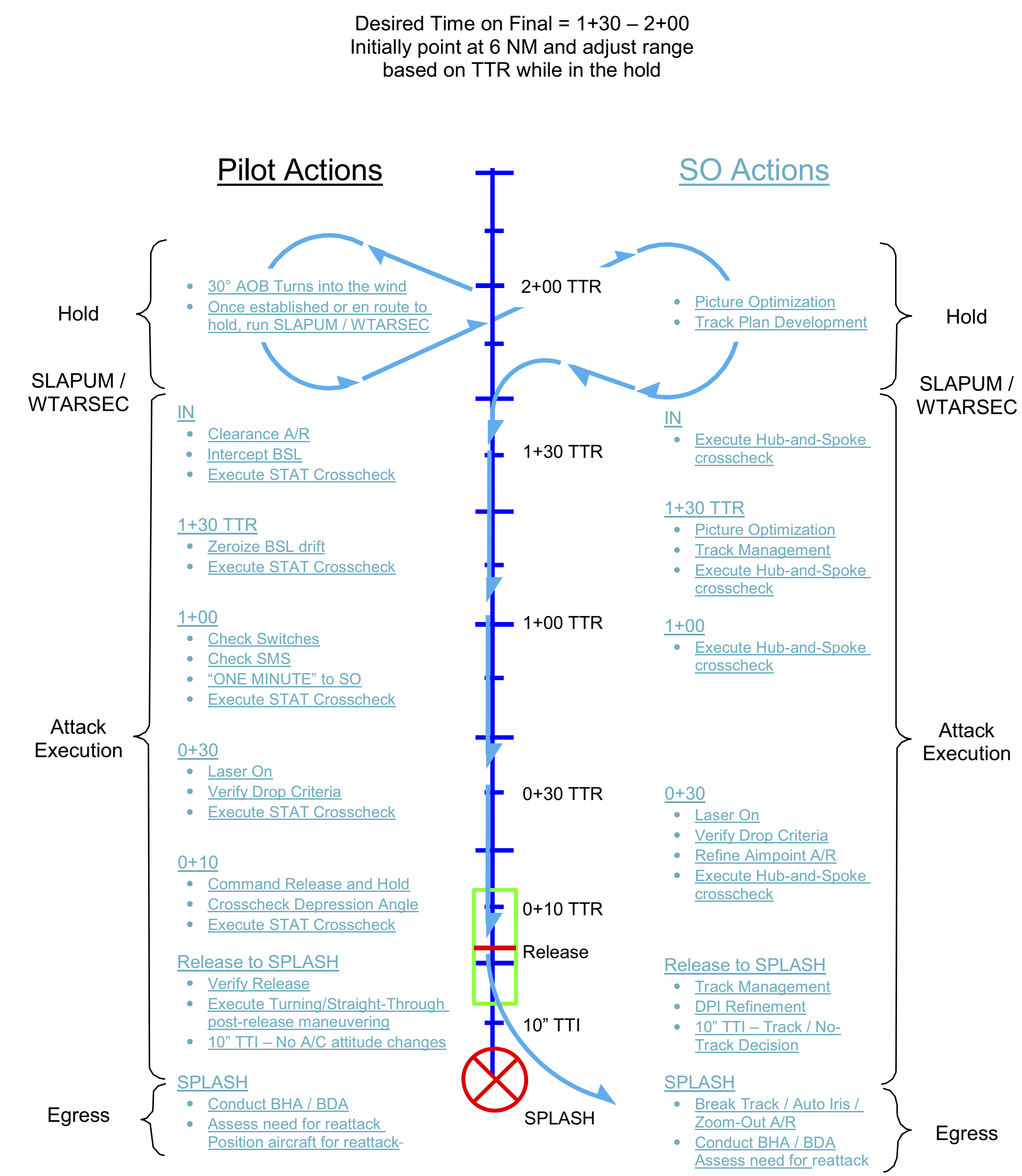
7.3.2.3.1.1 (FOUO) Wheel. The Wheel hold is the simplest hold to execute for an attack with multiple DPIs. Enter and execute the Wheel hold at R_{DL} as discussed in **paragraph 7.3.2.3.1**, Hold. This is the recommend technique for multiple DPIs as the large WEZ of the AGM-114 allows for easier accomplishment of attacking multiple targets with minimal aircraft maneuvering. Maintain the Wheel hold throughout all employments.

7.3.2.3.1.2 (FOUO) On-Azimuth Shoot-Press. If weaponeering requires multiple shots on the same azimuth in one pass, additional time and distance calculations are required to determine the hold range: the distance traveled at Turn-In, the distance traveled during first missile TOF, the distance traveled during shift between DPIs and Rifle, and the distance traveled during second/final missile TOF. All time/distance calculations must result in a non-nadir aircraft position at final Splash to determine if the attack can be executed on a single pass. Use RMIT Advanced Calc tab to determine "Ground Range" at "First Msl Impact" for the most refined distance calculations based on planned Rifle points. If RMIT is not available, set 140 KTAS and use the rule of thumb of 15 seconds/km. For example, the plan is to shoot two targets on one pass at 140 KTAS: the first planned shot at 10 km with a 45 second TOF. Additionally, the crew factors 15 seconds for DPI shift and next missile release. After first missile Splash and shift, the aircraft has traveled 4 km and is now at 6 km for the second shot. At 6 km, the TOF is 30 seconds, bringing the aircraft to 4 km ground range and 54-degrees depression angle at Splash. These parameters permit execution on a single pass. The min hold range should be at 11 km to account for the Turn-In and the desired hold pattern flown while accomplishing preattack checks. **Figure 7.4**, AGM-114 Versus Multiple Targets, depicts an example of this tactic.

7.3.2.3.1.3 (FOUO) On-Azimuth/Off-Azimuth Combination. Engaging multiple DPIs can be accomplished using a combination of on and off-azimuth shots. The first shot can be off-azimuth from the wheel followed by a Shoot-Crank egress that places the aircraft on-azimuth at/near Splash to enable an on-azimuth shot for the second target. Another possibility would be to shoot the first missile on-azimuth egressing with a Shoot-Crank to end up in a Wheel hold ready to employ the second missile off-azimuth. There are many combinations of attacks that may be executed that leverage the flexibility of the AGM-114 WEZ. Regardless of the combination, all ranges must factor the same times/distance considerations as outlined in the above paragraph. Once employment plan is determined, establish the hold and complete preattack checks.

7.3.2.3.2 (FOUO) Preattack Checks. The preattack checks for multiple DPI attacks are conducted as previously discussed; the main difference is accounting for two targets to be attacked versus one. The SMS should be set up for single release, but the next weapon in the release order should also be set up for its DPI. In the WTARSEC attack brief, include the SMS set up for both weapons, define the aimpoints for both targets, and brief the attack plan for the run-in and Post-Rifle egress maneuvers. The shift plan has some additional considerations as well.

Figure 7.5 GBU-12 Basic Attack.



FOUO

7.3.2.3.2.1 (FOUO) Shift. For the "shift" portion of WTARSEC, brief a "shift one" and/or a "shift cold" plan as required. The "shift one" plan will be executed post first missile impact and will minimize time required to get the second missile off the rail. Example: "SHIFT ONE WILL BE TO THE SECOND TANK 250 M EAST, AIMPOINT AND PRF WILL BE THE SAME AS TARGET ONE. SHIFT COLD FOR BOTH ATTACKS WILL BE TO THE FIELD 80 M SOUTH OF BOTH TARGETS." The sequence of targets should start with the target furthest downwind with the aircraft on the upwind side of the target array. The SO should zoom out to a practical FOV that will provide target area SA with regard to the next shift location without losing PID of the initial target (as required).

7.3.2.3.2.1.1 (FOUO) Geo Reference Points. SOs can use the Geo Reference Points feature of OFP 2408 to identify shift points for the pilot. Example: "SHIFT PLAN WILL BE: SHIFT ONE—PURPLE, SHIFT TWO—GREEN, SHIFT THREE—BLUE. AIMPOINT AND PRF WILL BE THE SAME FOR ALL TARGETS.

7.3.2.3.3 (FOUO) Execution. For multiple targets, use the applicable attack procedures outlined previously for on-azimuth/off-azimuth attacks to attack the first target. Post-Rifle, the pilot should maneuver as briefed for the second attack, maintain a stable platform, and then step to the second missile, as time permits. Stepping to the next missile with the first AGM-114 still in flight will stop the HUD TOF countdown for that missile, and instead display the TOF for the currently selected missile. At the first impact, the pilot should call "SHIFT ONE" at which time the SO should move the crosshairs IAW the shift one brief to set up for the second attack. Unless the specific situation dictates otherwise (changing PRF) the laser should be left on and firing during the shift to minimize delay between Rifles. When ready to Rifle, cross-check the WEZ, and command the launch. In environments with minimal collateral damage concerns, the second Rifle can occur immediately after Splash, as long as the second target is within the target handover boundary at launch and the crew is confident the SO can slew to the next target and refine crosshairs to the exact DPI.

7.3.2.3.4 (FOUO) Postimpact Procedures. The SO accomplishes postimpact procedures after each Splash. After the first attack, the TGP should maintain Auto Iris for remaining attacks (e.g., multiple DPI attack, on-azimuth Shoot-Press, on-azimuth Shoot-Crank to off-azimuth, Wheel to on-azimuth, etc.). See **Figure 7.4**, AGM-114 Versus Multiple Targets.

7.3.3 (FOUO) GBU-12 Attack Procedures. Typically, the MQ-9 delivers the GBU-12 using level deliveries employed from medium altitudes between 140 to 200 KTAS (airspeeds vary based on weaponeering decisions). The aircrew enters hold at a distance that corresponds to the desired time on final (prior to release). Usually, crews will complete as much of the preattack checklists as possible (prior to commencing the final attack run). Once on final, the GBU-12 attack pacing uses time-based procedures, as opposed to distance-based like the AGM-114 attack. Postrelease, crews execute continuous lase profiles; also, egresses are typically use immediate/near-immediate constant bank angle turns away from the target or cross-controlled straight-through passes, avoiding nadir effects (covering medium-altitude attacks). **Figure 7.5**, GBU-12 Basic Attack, depicts attack procedures. For attacks conducted below 10,000 feet HAT, see **paragraph 7.6.4**, GBU-12 Low HAT, for GBU-12 Low HAT attack procedures. The GBU-12 has two types of delivery methods: continuously calculated release point (CCRP) and manual release.

7.3.3.1 (FOUO) CCRP Deliveries. CCRP deliveries are the primary method for GBU-12 employments. For specifics on BRP generation, CCRP calculations, and HUD cuing, refer to "GBU-12/51 Release Settings" in the 1Q-9(M)A-34-1. The attack procedures use the same five attack phases as outlined in **paragraph 7.3.1**, Attack Phases. The Intent phase is unchanged, see **paragraph 7.3.1.1**, Intent, for specifics.

7.3.3.1.1 (FOUO) Game Plan. For all attacks continue development working target backwards. For recommended target/weapon pairings, see **paragraph 6.3**, MQ-9 Bomb Variants. As previously mentioned, initial vector is to place the aircraft 5 to 7 NM ground range from the target. Crews may reduce this range with either increased proficiency and/or when tactically necessary.

7.3.3.1.1.1 (FOUO) Holding Game Plan Considerations. To assist with initial vector, update the SMS with the correct/intended target. Next, determine the desired run-in direction, if one is not directed, then direct the aircraft to the 6 NM point. The ground range will place the aircraft approximately within the 1+30 to 2+00 TTR range, no wind. As a rule of thumb, decrease the initial hold range by 1 NM per 30 knots of headwind on final and increase by 1 NM for every 30 knots of tailwind on final. Adjusting the exact aircraft positioning requires the aircraft to be abeam the desired run-in, then turning-in and centering up on steering and cross-checking the range that provides 1+00 to 1+30 TTR on final; or by using a 1:1 ratio between wind speed and seconds on final when 90 degrees off azimuth to the run-in. The Planning Tool also provides this information through its Untimed Holding Distance section, assuming correct/updated 9-pack. Once the hold range is determined, select the appropriate type of hold for the attack, enter the hold and begin executing the preattack checks.

7.3.3.1.1.2 (FOUO) Crosswind Restrictions. In accordance with shot/kill criteria, to be valid release, the flightpath marker (FPM) must be completely visible and within 100 mils of the BSL. Planning Tool v11.65 calculates and displays valid run-ins below the Untimed Hold ranges. See **Figure 6.11**, Planning Tool Features for specifics. Use 45 knots of crosswind component as a rule of thumb to restrict GBU-12 run-ins. Increasing speed on final decreases the crab required to track the BSL and can increase the maximum allowable crosswind component that still provides valid steering indications.

7.3.3.1.2 (FOUO) Hold. The intent of the hold is to place the aircraft at a position with predictable time on final prior to employment, after turning inbound. See **Table 7.3**, Basic Attack Holds Comparison, for holding strengths and weaknesses. Enter and maintain the hold IAW **paragraph 3.4.2.4.1**, Entering Holding and Maintaining Standoff. The following considerations outlines how to determine a generic hold position in addition to differences in preattack checks.

7.3.3.1.2.1 (FOUO) Figure Eight/Modified Figure Eight. Execute a Figure Eight or modified Figure Eight into the wind in order to minimize range changes to the target and time to turn onto final when ready to attack; while also staying within 30 degrees of bearing to the desired run-in. If the azimuth tolerance of the desired run-in is low (e.g., a restricted run-in of 270 ± 15 degrees), decrease the boundaries of the hold to keep the aircraft closer to the desired run-in or the pilot can hold further from the target to increase the distance of radials. In either situation, cross-checking bearing to the target is essential in maintaining desired positioning.

7.3.3.1.2.2 (FOUO) Racetrack. Execute a Racetrack hold on-axis with the desired run-in for the attack. The front of the hold should be at the corresponding range for a 1+00 TTR on final. The back of the hold should be bounded by a range that corresponds to a desired maximum time on final once on the inbound leg. It is not recommended to use an on-azimuth Racetrack hold if the distance the aircraft travels from the target on the outbound leg causes a loss of target custody.

7.3.3.1.2.3 (FOUO) Wheel. Execute a Wheel hold when crosswind limitations are not a factor which allow a constant range to the target. Adjust the range to the target while on the upwind and downwind sides of the target to keep the desired time on final constant. The Wheel hold keeps the aircraft in a position to always immediately Turn-In and conduct an attack.

7.3.3.1.3 (FOUO) Preattack Checks. Conduct SLAPUM WTARSEC preattack checks as discussed generically in **paragraph 7.3.1.3.2**, Preattack Checks, the following are GBU-12 specific considerations.

7.3.3.1.3.1 (FOUO) SLAPUM. **Table 7.4**, SLAPUM, consolidates the GBU-12 SLAPUM specific items with the following highlights below.

7.3.3.1.3.1.1 (FOUO) SMS. Set the Run-In mode to Manual and enter the desired run-in (verify if run-in is degrees true or magnetic and set accordingly).

7.3.3.1.3.1.2 (FOUO) Airspeed/Autopilot. Per AFTTP 3-1.Shot-Kill, the minimum airspeed for a GBU-12 delivery above 10,000 feet height above terrain (HAT) is 0 knots ground speed (KGS). 165 KTAS is the recommended airspeed to provide maximum aircraft maneuvering performance.

7.3.3.1.3.1.3 (FOUO) Payload. The SO should adjust payload settings as previously discussed. Focus picture optimization on providing highly contrasting features for track stability and determining the best FOV to provide terminal guidance. Unlike AGM-114 employment where the look angle and range stays relatively constant from Turn-In to Splash, the look angle and range changes dramatically through a GBU-12 employment and will typically require a FOV change between the holding position and weapons release. A rule of thumb to assist with assessing whether to use IR/NAR or DTV/NM is to assess based on the relationship of a fully grown track gate compared to the size of the object. To perform this assessment, the SO much first ensure the aircraft is at the standard GBU hold distance of 5 to 7 NM. In this envelope, the SO will grow a track to the full growth size. Holding the gate open, the SO will compare the size of the target relative to the track gate. If the target takes up

2/3s or more of the track gate, the SO should consider either using DTV/NM, or a no-track engagement. If the SO identified that the aircraft is beyond 7 NM, this rule of thumb should be adjusted to 1/2 of the track gate size.

7.3.3.1.3.2 (FOUO) WTARSEC. Table 7.5, WTARSEC, consolidates the GBU-12 WTARSEC specific items with the following highlights below.

7.3.3.1.3.2.1 (FOUO) Target/Track. The pilot should brief the target and the SO should brief the track plan. The SO faces two main factors that affect crosshair control during a GBU-12 attack: track shift and TGP rotation. Track shift is identified by the SO selected track moving off of the original track location due a major change in the scene and the inability of the track to maintain the original features. On a GBU-12 attack, this major change in the scene occurs between the aircraft holding position and the weapon release point. Aircraft postrelease maneuvering yields rotation in the TGP as the aircraft is almost directly overhead the target. These two factors will influence the decision to employ a GBU-12 with or without a track established.

7.3.3.1.3.2.2 (FOUO) Tracked Engagement. To mitigate track shift, the SO should refine the track while the aircraft is on final and plan to establish the final track immediately prior to aircraft postrelease maneuvering, as the scene is relatively constant from weapon release to impact. A poorly bounded track will either break or slew off of target during TGP rotation. To mitigate this, the SO should optimize the picture and select a track type and size that bounds the selected track to its optimal features. Track engagements are recommended during GBU-12 employments as a proper track solves the crosshair control errors induced by rotation during the most critical time of a GBU-12 employment. For area tracks, the SO should attempt to establish a track that is centered on the DPI and its track gates encompass the entirety of the desired target without introducing ambient clutter nearby. This will minimize the corrections a SO needs to make during TGP rotation by preventing track shift due to track gate spillover. For point or feature tracks, the SO should attempt to keep the track as close to the DPI as possible. Point or feature tracks offset from the DPI are susceptible to inducing crosshair movement when the track gates breathe during the TGP rotation. To prevent the track gates from breathing during the TGP rotation and inducing crosshair movement, the tracks must be established on dramatically contrasting symmetric features that will have line of sight to the TGP at Splash.

7.3.3.1.3.2.3 (FOUO) Manual Track Engagement “hand flying.” Manual track engagements negate track shift; however, they rely on accurate slew control during TGP rotation. SA on the direction of aircraft postrelease maneuvering will give the SO the initial anticipated crosshair movement, but as rotation occurs, the SO will have to continually update slew inputs to correct induced crosshair movement. This should be used in the event that a track cannot be established due to atmospherics, weather, or lack of contrast points.

7.3.3.1.3.2.4 (FOUO) Aimpoint. Select the DPI as the aimpoint if surface winds are not known. Winds from the surface to 4,000 feet AGL generally affect the precise spot where the bomb will impact, sometimes requiring minor corrections to crosshair placement to compensate. If surface winds are known, move the aimpoint upwind of the DPI one foot per knot of wind speed. Do not correct the aimpoint so that it is off the target, or more than 20 feet, with the correction. If surface winds are not known, then do not attempt to establish a wind-corrected aimpoint. Refer to AFTTP 3-1.MQ-9 Chapter 3, “Surface Attack Tactics,” for specific target/aimpoint considerations.

7.3.3.1.3.2.4.1 (FOUO) GWTS wind calculation. The MQ-9 wind model in GWTS takes the current winds at altitude and linearly decreases the wind velocity to 20 percent of its total for calculated winds at target elevation. For example, winds are 270/50, the assumption for surface winds are 270/10. This wind model can cause kinematic issues for the GBU-12 in cases where winds at the surface differ significantly from the winds at altitude.

7.3.3.1.3.2.5 (FOUO) Egress. The MQ-9 GBU-12 bomb release range places the aircraft in a position where nadir will occur during the TOF if the aircraft continues without maneuvering after release. Postrelease maneuvering has two options to avoid nadir: straight-through or turning.

7.3.3.1.3.2.5.1 (FOUO) Straight-Through Egress. Barring no other positioning requirements/limitations, this egress maneuver is typically the preference due the slow the rate of rotation in the TGP, when compared to the turning egress. See **paragraph 3.4.3.2**, Straight-Through.

7.3.3.1.3.2.5.2 (FOUO) Turning Egress. Prioritize a turning egress when a straight-through does not suffice due to limitations. Limitations may include airspace restrictions, target masking, weapon deconfliction, and other factors. This maneuver uses bank angle and as a result, the turn places the nadir spot long of the target throughout the GBU-12 TOF. If the run-in has a crosswind component, plan the egress turn into the wind to minimize depression angle increase during the TOF. A turning egress induces crosshair drift and a high rate of rotation during the TOF.

7.3.3.1.4 (FOUO) Execution. Begin the attack once preattack checks are complete and the aircraft is in position to execute. Once on final, the priority is an effective cross-check to enable a valid release. Execute each step of the attack execution in accordance with the following guidance.

7.3.3.1.4.1 (FOUO) Turn-In. If the attack requires clearance, pilots should call “IN” prior to or while initiating the Turn-In. Execute the Turn-In when the aircraft is one turn radius away from the desired run-in using max degrees of bank into the bomb steering line/target. When case break occurs, decrease bank angle in half. At approximately 2 FPM widths from the BSL, reduce bank to 5 degrees. Once BSL touches FPM, smoothly roll out to wings level.

7.3.3.1.4.2 (FOUO) Final. On final, the pilot will pick up the STAT cross-check IAW **paragraph 7.3.1.4.2.1**, STAT Check. To mitigate BLS drift on final, during Steering portion of the STAT check pilots should continuously assess the required bank angle needed to maintain BSL centered on FPM by referencing VIT 99/HUD; and as a technique, trim the required bank on final provided it is no more than 5 degrees (IAW AFTTP 3-1.Shot-Kill). Corrections to line up BSL with FPM should be no more than 5 degrees to mitigate over-shooting.

7.3.3.1.4.2.1 (FOUO) Attack Pacing. To assist with attack packing, pilots cross-check will include the TTR as a portion of the Timing step in STAT to provide the crew awareness on the attack pacing and tasks to accomplish while on final. Be aware that as the ground range between the target and the aircraft decreases (approaching CCRP), pilots must have an increase in sensitivity to steering corrections. The pilot should provide the SO a "ONE MINUTE TO RELEASE" call for attack pacing awareness.

7.3.3.1.4.2.1.1 (FOUO) 30 Seconds TTR. Assuming a continuous lase profile, pilot should direct "LASER ON," and the sensor should reply, "LASING, [PRF], valid indications." The pilot should verify the laser indications and the SO should pick-up the hub-and-spoke cross-check. If picture optimization is not complete by this point and picture quality results in difficulty breaking out the DPI or providing track stability during the attack, then the SO should select auto iris. If auto iris also does not provide a usable picture, then the SO should recommend an abort on the attack.

7.3.3.1.4.2.1.2 In the event of a laser malfunction, 30 seconds TTR provides the SO enough time to cycle LRD power and, if the malfunction remains, set the LRD to SAFE, then re-ARM and fire the laser prior to release.

7.3.3.1.4.2.1.3 (FOUO) 20/10 Seconds TTR. At 20 seconds TTR the release cue will appear towards the top of the BSL and start dropping down towards the FPM. The pilot should cross-check its presence and press/hold the Launch Enable button. At 10 seconds TTR, squeeze and hold the trigger while simultaneously depressing the Launch Enable button; all while maintaining the FPM on the BSL until after weapons release. The sequential switch actuations will prevent an invalid console command.

7.3.3.1.4.2.1.3.1 (FOUO) SO Responsibilities at 10 Seconds TTR. On attacks with a turning egress, the SO should refine the crosshairs for the center point of the track and establish the track immediately prior to the pilot's egress turn. On a GBU-12 attack with a straight-through egress, the SO should establish the track immediately prior to release. Delaying until approximately 69 degrees (Turning Egress) or prior to release (Straight-Through) increases the probability the track will hold throughout the TOF as the slant range to the target remains relatively constant during the TOF. As a technique, delay the "69" call until after weapons are AWAY.

7.3.3.1.4.3 (FOUO) Release to Splash. Release indications are a small wing rock and the selected GBU-12 icon disappearing. For simulated deliveries, release indication is the first uptick of the release cue after it drops down the BSL to the same level as the horizon line and the FPM. After release, the pilot executes the briefed egress maneuver and the SO focuses on the track, crosshair control, and the DPI. Pilots should provide the SO TTI calls every 10 seconds (from expected TOI) and should avoid TOF calls inside of 10 seconds.

7.3.3.1.4.3.1 (FOUO) Straight Through Egress Execution. Execute IAW **paragraph 3.4.3.2**, Straight-Through.

7.3.3.1.4.3.2 (FOUO) Turning Egress Execution. Execute the turning egress when the depression angle reaches 69 degrees, or immediately after weapons release if the depression angle is already greater than 69 degrees. The depression angle at release depends on HAT and ground speed. On no wind attacks at medium altitude, the depression angle will be in the mid-60s at release. On headwind attacks, release typically occurs at a decreased ground range to the target which leads to the aircraft being greater than 69 degrees depression angle at release. In these cases, execute the turning egress maneuver immediately after release. On tailwind attacks, depression angle is shallower as release typically occurs at an increased ground range to the target due to increased ground speed. In these cases, delay the turning egress maneuver until the depression reaches 69 degrees. Execute the turn in the briefed direction using 20 to 25 degrees of bank, referencing HUD turn carat or VIT 99. Once established at desired bank, pilot cross-check focuses on the HUD and depression angle to maintain no greater than 80 degrees. If depression continues to increase beyond 80 degrees, increase bank to maintain desired depression angle. At Splash, transition to the egress step as the postrelease egress maneuver is complete.

7.3.3.1.4.3.3 (FOUO) Track Management and Crosshair Control. After release the sensor continues the hub-and-spoke cross-check. For track engagements, the focus is on the track and assessing it for drift and stability throughout the TOF. If the track is unstable or breaks, the SO should attempt to regrow the track and optimize the picture to provide more contrasting features for the track. At 10 seconds TTI, if unable to establish a track, the SO should transition from a track engagement to a no-track engagement and focus on slew control and crosshair placement on the DPI until Splash. At Splash the SO should execute the postimpact procedures.

7.3.3.1.5 (FOUO) Egress. At Splash, conduct BDA/BHA and maneuver the aircraft back into a hold for a follow-on attack, if anticipated. The pilot should direct the SO to "CEASE LASER" after Splash. When compared to an AGM-114 impact, the GBU-12 impact has significantly more IR bloom and debris degrading picture quality. Debris can remain in the air for up to 30 seconds after Splash. To mitigate the debris cloud, position the aircraft upwind of the target. If no reattack is required, set the laser to safe unless the tactical situation dictates otherwise.

7.3.3.2 (FOUO) GBU-12 RIPPLE. When two targets require simultaneous effects, or one target requires multiple bombs, a RIPPLE release (weaponeered appropriately) is the preferred technique over multiple aircraft self lasing single GBU-12s. It is the pilots responsibility to ensure that the ripple setting meets the downrange and cross-range capabilities of each weapon.

7.3.3.2.1 (FOUO) Verify Targets in LAR. Due to limitations in GWTS 1.7, when rippling two GBU-12s on separate DPIs, do not use a manual release. To verify both DPIs are within the cross-range and downrange capabilities, the distance between the two targets must be known. Use the TGP, Zeus, or another TACSIT to plot/measure target distances.

7.3.3.2.1.1 (FOUO) GWTS Envelope. Calculate a GWTS envelope using expected parameters. Note: downrange capability is greatest when run-in course is along the same axis as the targets. Most run-ins will not be perfectly east-west or north-south; when this happens, discerning total downrange capability is difficult since GWTS only provides the northing and easting as separate numbers. If the run-in does not align N/S or E/W, use the most conservative number of the CR/DR. For example, if the CR capability is 249 meters and the DR is 209 meters, use 209 meters as the CR/DR capability.

7.3.3.2.1.2 (FOUO) Assessing LAR. Compare the distance between the two DPIs to the distance between the impact point and the downrange point in the LAR (center to far point of LAR output). If the distance between the two DPIs is LESS, then set the manual update to the near DPI (from run-in to the target array).

7.3.3.2.1.2.1 (FOUO) Assessing Update. If the distance between the two DPIs is MORE than the impact and downrange distances but LESS than the total distance of the downrange and “min range” points (the distance from the impact point to the “near” edge of the LAR), set the manual update point between the two DPIs.

7.3.3.2.1.2.2 (FOUO) Applying Manual Update. Using meters or NM, verify the total distance from min range to the farthest downrange point. Adjust crosshairs long of the near DPI, along the planned attack axis, until both DPIs fall within the assessed distance. Then either Manual Update via the TGP or create a target in the SMS and select this point for steering/release cues.

7.3.3.2.1.2.3 (FOUO) Distance Exceeded. If the distance between the two DPIs is greater than the total distance of the LAR, then executing the attack at the current altitude/airspeed/run-in is not possible. Change one of these parameters and reassess LAR or execute the attack using two shooters if intent requires simultaneous impacts.

7.3.3.2.2 (FOUO) Set Ripple Timing. When the two bombs have different downrange distances, the TOF can vary from 1 to 5 seconds. If the attack requires simultaneous impacts, set the release order so that the first bomb travels to the far DPI and the second bomb travels to the near DPI. Set the ripple release timing to equal the TOF difference between the first and second weapon. Verify this TOF difference using the GWTS output. Select “BRP to selected target” and click on the LAR at both points to see the TOF.

7.3.3.2.2.1 (FOUO) Modifications. When releasing two weapons with a similar downrange and different cross-range distance, the TOF variation will be negligible. If near simultaneous impacts are acceptable, then continue the attack with the default 0.3 seconds ripple spacing. With different cross-range DPIs, recommend matching the pylon to its associated target (i.e., left DPI to station 3, right DPI to station 5).

7.3.3.2.2.2 (FOUO) Ripple timing and remaining in the LAR. When selecting ripple release in the SMS, the system determines when bomb release will occur by dividing the specified release interval before and after the CCRP. For example, setting 8 second ripple spacing will release the first bomb 4 seconds prior to CCRP and the second bomb 4 seconds after CCRP.

CAUTION: Use GWTS to ensure enough time to/from BRP exists for nonstandard ripple timing. For example, if the maximum LAR is 30 seconds prior to BRP and 9 seconds after BRP, then the max interval is 18 seconds (most restrictive time x2).

7.3.3.3 (FOUO) Manual Deliveries. Manual deliveries leverage the acquisition envelope of the GBU-12 to provide different impact angles and velocities that CCRP cannot provide. A manual delivery prior to the CCRP will decrease impact angle and velocity, while a manual delivery after the CCRP will increase impact angle and velocity. Run GWTS in order to determine release point for the GBU-12 to verify it will acquire the laser spot and guide to the target, as well as calculate the impact angle and velocity. It is the pilot’s responsibility to verify planned parameters will achieve the desired effects prior to executing the attack.

7.3.3.3.1 (FOUO) Game Plan. Determine impact conditions using either the envelope or the text output on GWTS. If maximizing impact angle and velocity is desired, use the minimum release range provided. If minimizing impact angle and velocity is desired, use the maximum range information provided on the envelope output. Use the text output to determine exact impact parameters or a minimum/maximum impact angle and/or impact velocity for an attack. See **Figure 7.6**, Example GWTS Envelope Output, and **Figure 7.7**, Example GWTS Text Output. The envelope display is precise to 100 feet, while the text output is precise to one foot. The pilot has three options to determine when to command release: time, slant range and ground range. **Figure 7.8**, Determining a Manual Delivery Release Point, depicts each type of release point.

7.3.3.3.1.1 (FOUO) Time Based Release. Time-based release uses the time relative to the BRP to determine release point. However, for OFP 2407 and later, time-based releases are not a recommended technique as TTR will display zero once inside of BRP. However time-based cuing is still an option for manual employments prior to CCRP (e.g., max range employment). When using time-based cuing, cross-check TTR as with standard CCRP delivery. The pilot should choose the desired release time then adjust the hold and attack pacing off releasing with the desired TTR. For example, if the envelope has the maximum range at 30 seconds from BRP, adjust the hold to account for the additional time required, then command release at 30 seconds TTR on final.

7.3.3.3.1.2 (FOUO) Slant Range Based Release. A slant range based release uses the slant range as displayed in the TGP graphics for the release point. Once GTWS calculates the input parameters, on the Output display select "Slant Range View" on the right side to display slant range on the envelope. To find the desired release point, select meters for the units on the bottom of the display, move the cursor to the desired release point, click on it, and verify the impact parameters in the lower left corner meet the desired effects. Note the slant range at the release point for release.

7.3.3.3.1.3 (FOUO) Ground Range Based Release. A ground range based release uses the range to the target carat in the HUD for the release point. In the GWTS Output display, change the range units to "Nmi." To find the desired release point, click on the run-in envelope and reference the impact parameters in the lower left corner to determine the release point that will achieve desired effects. The GWTS output will have a precision of three decimal places (thousandths of a NM), but the A-G HUD only shows one decimal place (tenths of a NM). Round the GWTS output towards the A-G HUD to ensure the weapon is employed in the allowable LAR.

Figure 7.6 Example GWTS Envelope Output.

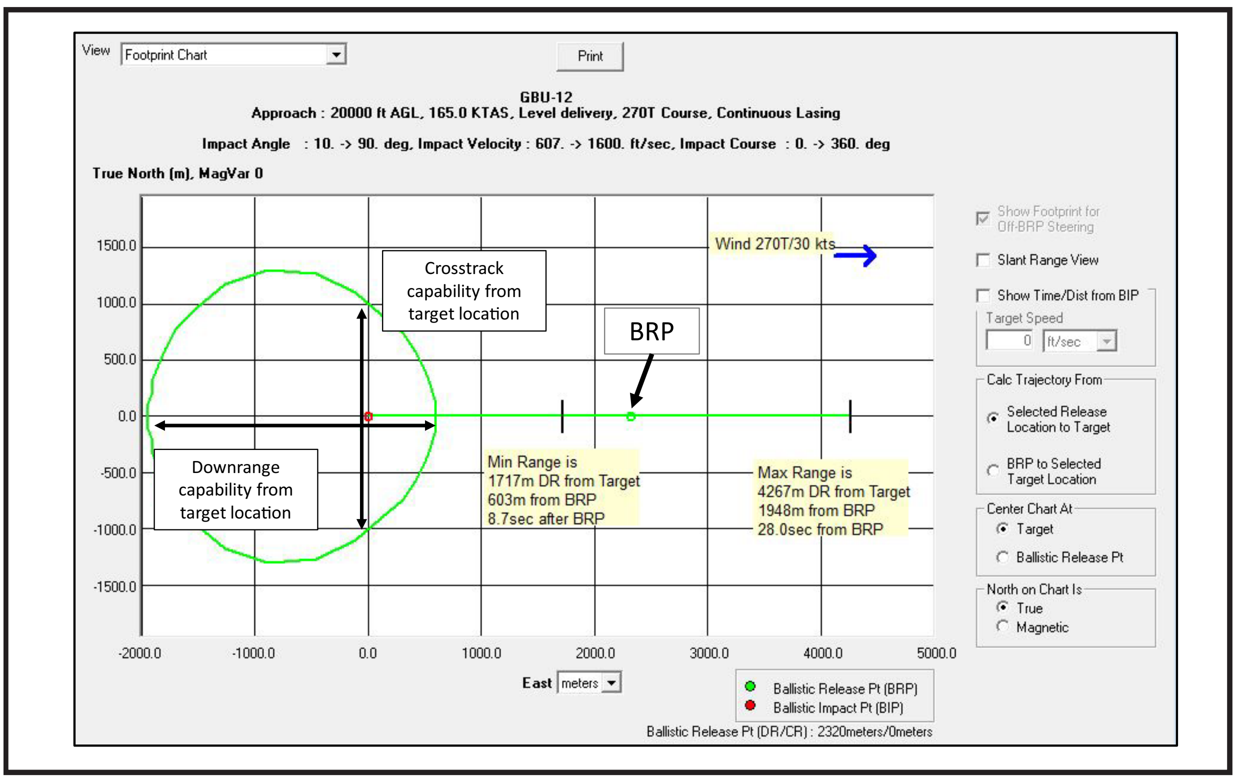


Figure 7.7 Example GWTS Text Output.

UNCLASSIFIED

GWTS 6.4.1 16 Feb 2012

Thu Nov 13 20:17:04 2014

Input file: (no name)

Weapon Type : GBU-12
Weapon Weight : 614.8
Level/Dive Delivery

Laser Delay Time : 0.00 seconds

Standard Day (Table)
Target Elevation : 5200.0 ft.
Target Density Alt : 5200.0 ft.

Impact Condition Requirements :

Impact Angle (deg)	Min Impact Velocity (ft/sec)	Max Impact Velocity (ft/sec)
10.0	607.0	1100.0
90.0	607.0	1100.0

Impact Course : 0.0 -> 360.0

Limits on the Envelope Solution Independent Variables:
Approach Downrange : -40000 -> 140000 ft
Approach Crossrange : 0 -> 100000 ft

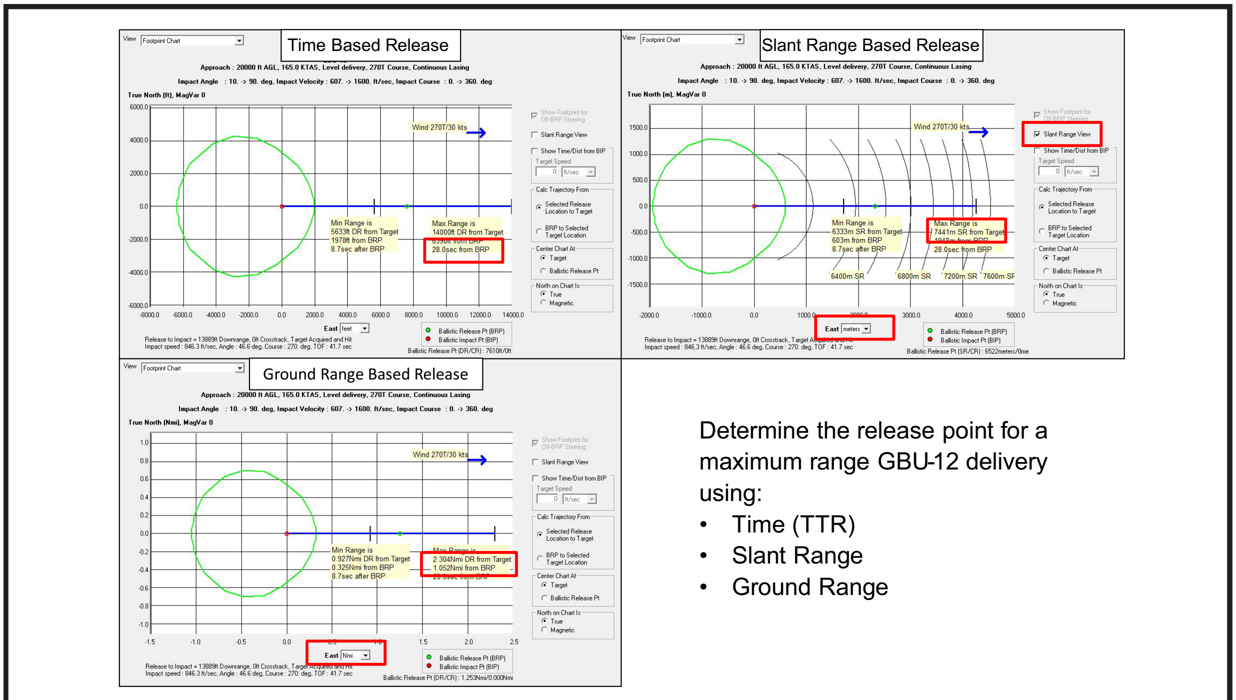
Approach												--Ground Plane--	
Alt (ft)	Speed (KTAS)	Angle (deg)	Down Range (ft)	Cross Range (ft)	Laser Turn-On Time (sec)	Laser Acquis Time (sec)	Impact Velocity (ft/sec)	Impact Angle (deg)	Impact Course (deg)	Angle of Attack (deg)	Time of Fall (sec)	Down Range Miss (ft)	Cross Range Miss (ft)
20000	165	0.00	5632	0	0.0	22.2	931.3	84.97	360.00	0.94	37.1	-1.3	0.0
20000	165	0.00	5638	348	0.0	22.6	933.8	84.72	343.71	4.71	37.1	-4.7	-1.5
20000	165	0.00	5760	696	0.0	21.2	932.9	81.93	325.75	4.27	37.2	-2.9	-1.9
20000	165	0.00	5861	1070	0.0	21.1	923.3	79.50	312.08	6.74	37.3	-5.5	-2.3
20000	165	0.00	6019	1477	0.0	20.9	933.7	76.97	313.90	6.04	37.3	-2.1	-2.2
20000	165	0.00	6274	1923	0.0	20.5	937.9	76.39	317.41	5.02	37.3	-7.1	2.3
20000	165	0.00	6612	2451	0.0	20.8	916.8	72.41	309.10	1.29	37.7	-0.8	-1.4
20000	165	0.00	7211	2969	0.0	18.9	898.4	69.22	318.81	4.26	38.2	-1.2	-1.2
20000	165	0.00	7993	3599	0.0	18.1	898.2	64.99	321.95	4.38	38.7	-1.1	0.1
20000	165	0.00	9125	4169	0.0	18.5	869.9	58.95	321.17	6.03	39.4	-8.1	4.5
20000	165	0.00	10524	4273	0.0	19.4	869.3	54.14	324.22	4.29	40.2	-1.5	-0.9
20000	165	0.00	11767	3852	0.0	20.1	861.3	48.88	331.03	7.48	40.8	-3.5	3.3
20000	165	0.00	12589	3160	0.0	20.5	853.4	47.07	335.42	6.47	41.2	-7.6	1.5
20000	165	0.00	13191	2582	0.0	20.8	842.7	44.45	339.75	5.34	41.5	-7.0	-3.1
20000	165	0.00	13499	2000	0.0	20.9	844.3	44.73	344.44	6.57	41.6	-6.9	8.1
20000	165	0.00	13695	1509	0.0	21.0	846.0	44.88	348.08	5.35	41.7	-6.7	4.2
20000	165	0.00	13863	1095	0.0	21.1	845.6	46.86	351.73	5.86	41.7	-11.0	6.1
20000	165	0.00	13872	696	0.0	21.1	848.4	46.50	352.79	4.84	41.7	-3.1	-3.2
20000	165	0.00	13994	348	0.0	21.2	840.8	45.99	355.48	6.10	41.8	-6.8	-4.8
20000	165	0.00	14000	0	0.0	21.2	859.0	46.66	360.00	8.68	41.7	-7.5	-0.0
20000	165	0.00	13994	-348	0.0	21.2	840.8	45.99	4.52	6.10	41.8	-6.8	4.8
20000	165	0.00	13872	-696	0.0	21.1	848.4	46.50	7.21	4.84	41.7	-3.1	3.2
20000	165	0.00	13863	-1095	0.0	21.1	845.6	46.86	8.27	5.86	41.7	-11.0	-6.1
20000	165	0.00	13695	-1509	0.0	21.0	846.0	44.88	11.92	5.35	41.7	-6.7	-4.2
20000	165	0.00	13499	-2000	0.0	20.9	844.3	44.73	15.56	6.57	41.6	-6.9	-8.1
20000	165	0.00	13191	-2582	0.0	20.8	842.7	44.45	20.25	5.34	41.5	-7.0	3.1
20000	165	0.00	12589	-3160	0.0	20.5	853.4	47.07	24.58	6.47	41.2	-7.6	-1.5
20000	165	0.00	11767	-3852	0.0	20.1	861.3	48.88	28.97	7.48	40.8	-3.5	-3.3
20000	165	0.00	10524	-4273	0.0	19.4	869.3	54.14	35.78	4.29	40.2	-1.5	0.9
20000	165	0.00	9125	-4169	0.0	18.5	869.9	58.95	38.83	6.03	39.4	-8.1	-4.5
20000	165	0.00	7993	-3599	0.0	18.1	898.2	64.99	38.05	4.38	38.7	-1.1	-0.1
20000	165	0.00	7211	-2969	0.0	18.9	898.4	69.22	41.19	4.26	38.2	-1.2	1.2
20000	165	0.00	6612	-2451	0.0	20.8	916.8	72.41	50.90	1.29	37.7	-0.8	1.4
20000	165	0.00	6274	-1923	0.0	20.5	937.9	76.39	42.59	5.02	37.3	-7.1	-2.3
20000	165	0.00	6019	-1477	0.0	20.9	933.7	76.97	46.10	6.04	37.3	-2.1	2.2
20000	165	0.00	5861	-1070	0.0	21.1	923.3	79.50	47.92	6.74	37.3	-5.5	2.3
20000	165	0.00	5760	-696	0.0	21.2	932.9	81.93	34.25	4.27	37.2	-2.9	1.9
20000	165	0.00	5638	-348	0.0	22.6	933.8	84.72	16.29	4.71	37.1	-4.7	1.5
20000	165	0.00	5632	0	0.0	22.2	931.3	84.97	360.00	0.94	37.1	-1.3	0.0

Center of the Envelope:

20000	165	0.00	9906	0	0.0	18.1	921.1	63.56	360.00	6.26	38.5	-9.8	-0.0

UNCLASSIFIED

Figure 7.8 Determining a Manual Delivery Release Point.



FOUO

7.3.3.3.2 (FOUO) Hold. Enter and maintain the hold IAW **paragraph 3.4.2.4.1**, Entering Holding and Maintaining Standoff. As previously mentioned, for manual deliveries adjust the hold range further from the target in order to maintain standard attack pacing. Adjust hold distances for wind as discussed in **paragraph 7.3.3.1.1.1**, Holding Game Plan Considerations. As a rule of thumb at 165 KTAS, assume 20 seconds per NM on final (no wind), then adjust hold range to account for the additional desired time on final. For example, typical hold ranges equal 1+30 to 2+00 TTR and the release point is 1 mile prior to BRP; add an additional 20 seconds to the TTR in the hold. For manual deliveries past the CCRP, keep the hold range the same as a CCRP delivery (1+30-2+00 TTR) as this will provide extra time on final.

7.3.3.3.2.1 FOUO) Preattack Checks. Execute SLAPUM WTARSEC in accordance with CCRP deliveries as outlined in **paragraph 7.3.3.1.3**, Preattack Checks, with the following exceptions.

7.3.3.3.2.1.1 (FOUO) Set SMS release mode to Manual. Verify on HUD for red MANUAL under the airspeed container.

7.3.3.3.2.1.2 (FOUO) Set airspeed to planned attack speed per GWTS input.

7.3.3.3.2.1.3 (FOUO) A straight-through postrelease maneuver is recommended for manual deliveries; however, there may be tactical situations that require the pilot to maintain as much of a standoff as possible to keep laser energy on the desired aimpoint and prevent podium effect. In these situations, execute the attack in accordance with **paragraph 7.5.2**, GBU-12/49/54. For deliveries inside of CCRP, accomplish either a straight-through or turning egress.

7.3.3.3.3 (FOUO) Execution. Begin the attack once preattack checks are complete and aircraft is in position to prosecute.

7.3.3.3.3.1 (FOUO) Turn-In. Execute the Turn-In in the same manner as a CCRP delivery as outlined in **paragraph 7.3.3.1.4.1**, Turn-In.

7.3.3.3.3.2 (FOUO) Final. Adjust and execute CCRP pacing as outlined in **paragraph 7.3.3.1.4.2**, accounting for the manual release point. Add the time prior to release to the pacing. For example, the laser is turned on at 30 seconds TTR during a CCRP delivery. On a manual delivery with a release point 29 seconds prior to the CCRP, the laser should be turned on when the TTR displays 59 seconds to give the crew the desired 30 seconds of laser fire. For deliveries past CCRP (e.g., minimum range) execute the same attack pacing as a CCRP delivery. Once within 30 seconds of release, the TTR cross-check should move to the primary reference for release (e.g., TGP slant range, HUD ground range).

7.3.3.3.3.2.1 (FOUO) Trigger Actuation. ***Caution:*** Unlike a CCRP delivery where the Launch Enable button and trigger actuation are sequential, they must be two distinct steps on a manual delivery. At 10 seconds prior to the release point, the pilot should press the Launch Enable button ONLY and not squeeze the trigger until at the intended release point.

7.3.3.3.3.3 (FOUO) Release to Splash. Unlike CCRP mode, the pilot should squeeze the trigger at the point of intended weapon release. **Figure 7.9**, HUD Manual Delivery Release Cues, depicts the cross-check for manual delivery release points. The SO responsibilities remain the same as a CCRP delivery as discussed in **paragraph 7.3.1.4.2.3**, Release to Splash.

7.3.3.3.3.3.1 (FOUO) Time Based Release. When the TTR in the HUD graphics matches the desired release time, squeeze the trigger and execute the postrelease egress maneuver.

7.3.3.3.3.3.2 (FOUO) Slant Range Based Release. When the slant range in the TGP graphics matches the desired release slant range, squeeze the trigger and execute the postrelease egress maneuver. If the TGP graphics color does not contrast to sufficiently see the slant range and the crosshairs, the crew should prioritize the color to be able to read the slant range prior to release. After release, change the TGP graphics color to prioritize crosshair visibility.

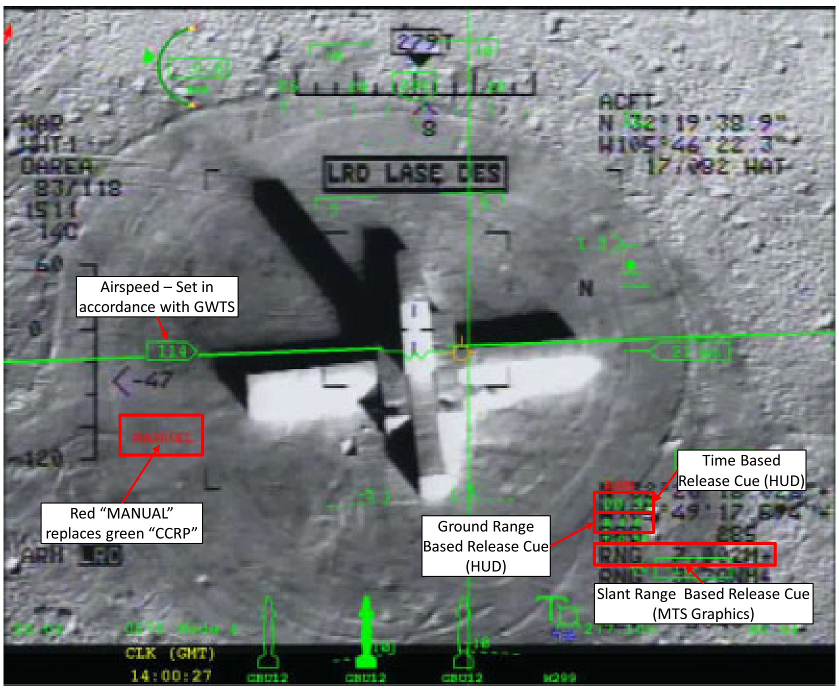
7.3.3.3.3.3.3 (FOUO) Ground Range Based Release. When the ground range carat on the HUD matches the desired release ground range, squeeze the trigger. In OFP 2407 or later, the range carat is predictive of ground range at release. Reference this number instead of the ground range in the TGP graphics display.

7.3.3.3.3.3.4 (FOUO) Postrelease Maneuver. Execute the postrelease egress plan using the procedures outlined in the CCRP delivery **paragraph 3.4.3.2**, Straight-Through Egress, or paragraph 7.3.3.1.4.3.2, Turning Egress Execution. If podium effect is a factor on a maximum range delivery, execute GBU-12 vertical target attack procedures IAW paragraph 7.5.2.3.2, Release to Splash.

7.3.3.3.3.3.5 (FOUO) Postimpact Procedures. The SO executes the postimpact procedures at Splash IAW paragraph 7.3.1.4.2.4, Postimpact Procedures.

7.3.3.3.4 (FOUO) Egress. Execute CCRP egress procedures as outlined in paragraph 7.3.3.1.5, Egress. If any GBU-12s remain after the manual delivery, it is recommended to immediately switch the release mode back to CCRP on the SMS Release Settings page, unless anticipating another manual delivery.

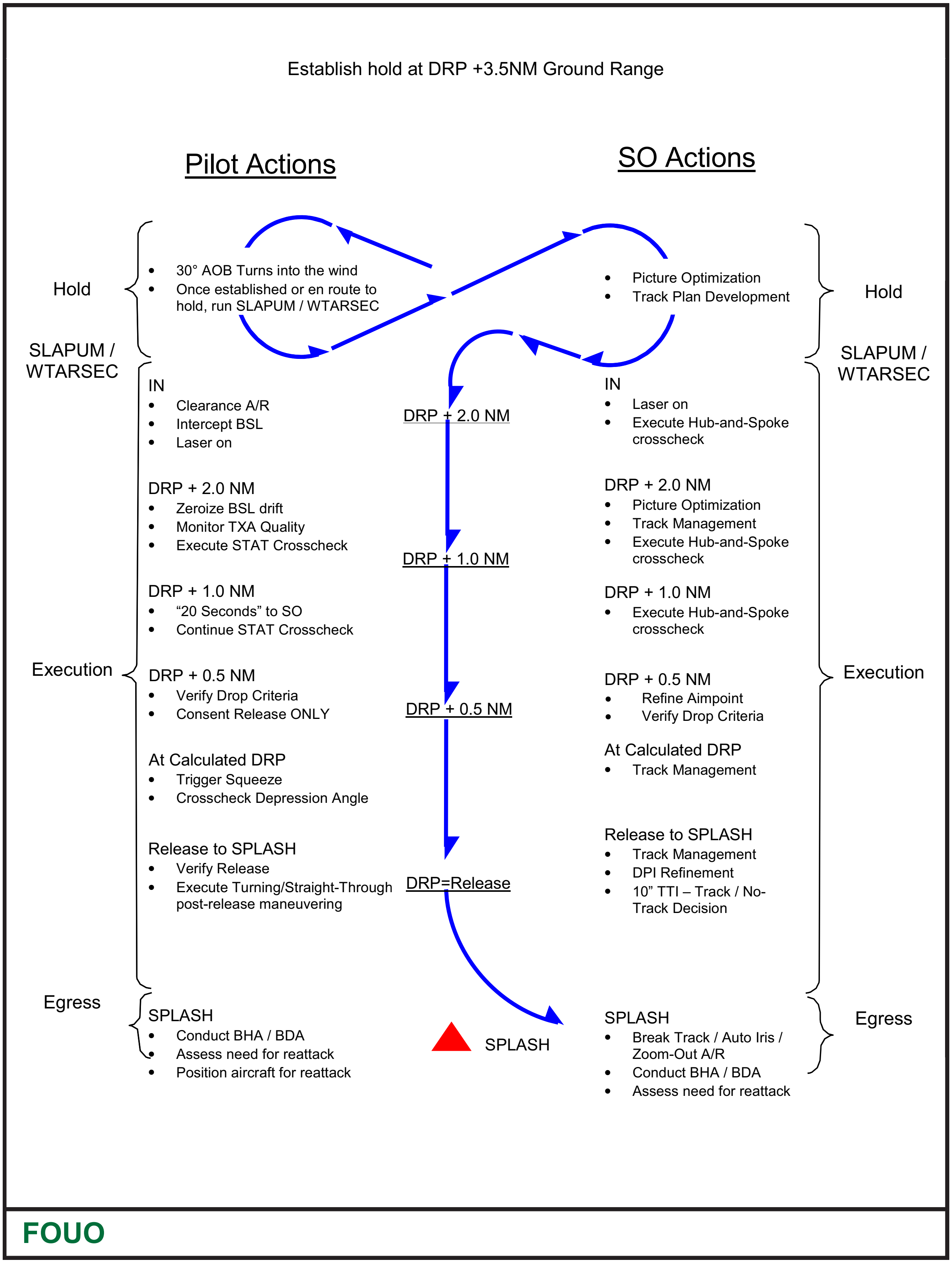
Figure 7.9 HUD Manual Delivery Release Cues.



FOUO

7.3.4 (FOUO) Inertially Aided Munitions Attack Procedures (GBU-49/54/38). The MQ-9 delivers GBU-49/54/38s using level deliveries from medium altitudes with similar attack procedures, hold ranges, airspeeds, employment and egress TTP with a few differing considerations. For all inertially aided munitions (IAM), initial considerations are whether to release the weapon in LAR (preferred) or Manual. The second consideration is that there are more fuzing options available with the Joint Programmable Fuzes (JPF), to include delayed or height of burst (HOB) fuzing. Figure 7.10, GBU-49/54/38 Basic Attack, depicts basic attack procedures. Whether employing using a manual or a LAR delivery, IAM attacks follow the same basic attack phases as outlined in paragraph 7.3.1, Attack Phases, with the intent portion remaining unchanged. This section will focus on deliveries against stationary targets; for GBU-49/54 moving target attacks, see Chapter 9, "Moving Target Engagement;" the GBU-38 has no moving target capabilities.

Figure 7.10 GBU-49/54/38 Basic Attack.



7.3.4.1 (FOUO) Laser Guidance. The GBU-49/54 are both laser joint direct attack munitions (LJDAM) weapons and as such have laser seeker capabilities, something the GBU-38 does not. The GBU-49/54 have selectable options for Laser Only Mode (GBU-49 only), GPS Laser (recommended), or GPS only.

7.3.4.2 (FOUO) Limitations. OFP 2408 has addressed previous deficiencies regarding the GBU-38 employment restrictions below 12,000 feet HAT. A LAR now may be displayed below 12,000 feet HAT, but rarely does; GBIT is the primary source for GBU-38 LAR below 12,000 feet HAT. Additionally, employing any IAMs in degraded environments requires thorough mission planning; it is recommended to employ the GBU-49/54 in GPS Laser mode when in those environments.

7.3.4.3 (FOUO) LAR Deliveries. Zone LAR deliveries ensure the GBU-49/54/38 acquisition envelope will impact the target with the desired impact parameters. To assist with a LAR generation, though not required, recommend flying at 180 KTAS and on a tailwind profile.

7.3.4.4 (FOUO) Determining a Desired Launch Range (R_{DL}). Similar to RMIT, GBIT will produce a specific ground range (NM) for crews to release at based on input parameters. Pilots can input specific impact angles required to achieve desired weapons effects. Manual deliveries use ground range release queuing. Previous GBIT versions required additional calculations to determine "LAR Buffer," version 2418 alleviates that requirement.

7.3.4.4.1 (FOUO) Manual Deliveries. Run GBIT in order to determine the release point for the GBU-49/54/38 which will still acquire the laser spot/guide to the target based on desired weapons effects input into GBIT. For GBIT set up, see **Figure 6.10**, GBIT Setup and Displays. Consideration must be given to creating a target versus selecting manual update due to the potential for laser anomalies. For stationary and/or BOC attacks, creating a target is preferred. Otherwise, select auto update for BOT (GBU-49/54 only).

7.3.4.5 (FOUO) Game Plan. Once aircrew have a clear understanding of the intent, direct the aircraft to the initial hold as outlined for GBU-12s in **paragraph 7.3.3.1.1.1**, Holding Game Plan Considerations, with the caveat of holding time to zone (TTZ) versus TTR. For all deliveries (manual or LAR), time and conditions permitting, run GBIT, if not already complete, to determine the appropriate R_{DL}, adjusting refined hold plan for any additional required time on final. SOs will work through the initial track plan and be ready to brief DPIs during the hold phase while the Pilot determines attack parameters. There are two different types of releases: single-DPI or multiple-DPI deliveries. Single-DPI releases deliver one or multiple GBUs with a ripple release intended for the same target; whereas multiple-DPI deliveries use ripple releases to separate targets.

7.3.4.5.1 (FOUO) Self-Derived Attack Data. If the situation requires the crews to self-derive CAT I grids/cords for GPS only engagements, execute the currently established procedure immediately after receiving the intent. Depending on the available the TTP, this process can take 5.5 to 6.0 minutes to accomplish and should not be delayed to expedite the entire engagement.

7.3.4.6 (FOUO) Hold. Enter and execute the hold using the same procedures as a GBU-12 CCRP hold as outlined in **paragraph 7.3.3.1.2**. The hold range should provide approximately 1+00 to 1+30 TTZ, or 5 to 7 NM ground range from the R_{DL} if executing a manual delivery. Higher altitudes, an increase in airspeed, and/or tailwind attacks (in that order) are preferred methods of providing a larger available LAR.

7.3.4.6.1 (FOUO) Preattack Checks. Execute preattack checks as outlined in **paragraph 7.3.1.3.2.1**, SLAPUM, and **paragraph 7.3.1.3.2.2**, WTARSEC with the following specifics.

7.3.4.6.1.1 (FOUO) SMS. Select the desired bomb from the Store Select page. If releasing multiple munitions, select the stores for release and set the release interval to 0.3 seconds. Set the desired impact angle and azimuth, as required, on the Store Settings page and verify Offset Target data in empty (single-DPI deliveries). For GBU-38s and GBU-49/54 attacks in GPS only, create a manual target in the SMS on the Select Target page and select that target once complete. Once selected, verify the target, coordinates, and elevation are correct on the Launch Status page. For GBU-49/54 attacks in GPS Laser/Laser Only mode, creating a manual target is an option, however it is recommended to employ in CCTGP. Finally, check for green indicators, focusing on the TXA quality; a TXA quality of 1 desired. Verify in appropriate desired release mode (LAR/Manual) on both HUD and Tracker Display.

7.3.4.6.1.1.1 (FOUO) Multiple-DPI deliveries. OFP 2407 and beyond provide composite LAR capabilities when employing against separate DPIs. For SMS setup, pilots must input the alternate DPI coordinates and elevation into the desired munition on the Store Settings page. For GBU-38s and GBU-49/54 in GPS only mode, create a manual target for the primary DPI (which generates Tracker/HUD steering cuing), then input offset target data directly into the intended ripple munition. For GBU-49/54s in GPS Laser/Laser Only mode, recommend selecting CCTGP for Tracker/HUD cuing, while entering the offset coordinates manually into the alternate munition. Additionally, for GBU-49/54 in GPS Laser/Laser Only mode, ensure the correct PRF code is set for the appropriate munition(s). It is possible to release multiple munitions in different modes (e.g., GPS and GPS Laser).

7.3.4.6.1.1.2 (FOUO) On Wing Tracking (OWT). For GBU-54, recommendation is to use OWT, however it is subject to drift. If OWT has been enabled for greater than 40 minutes, recommend cycling OWT to OFF, then back to ON prior to employment, time and conditions permitting. Or alternatively, leave OWT OFF until weapons checks are being completed for the attack.

7.3.4.6.1.1.3 (FOUO) GBU-54 GPS Only. When releasing in GPS only, delivery profiles should attempt to provide TOF of 32 seconds or greater to ensure sufficient time for GPS satellite acquisition and GPS loop closure, and time for steering out navigation errors prior to impact.

7.3.4.6.1.2 (FOUO) LAR. Verify the presence of the LAR on the Tracker display and on the HUD. If it is not present, first verify LAR mode is selected in the SMS and/or that LAR/WEZ is not decluttered on the Tracker Display. Other options to display LAR include climbing to a higher altitude (HAT increase), increasing airspeed, or changing the impact angle, in that order. On the Tracker display, the LAR will rotate around the target based on the current aircraft heading. The LAR on the HUD will likely have no displayed range/azimuth data until the aircraft turns to final and flies into the LAR. As the aircraft flies towards the release point, the range and azimuth LARs will both expand for release cuing and HUD cross-check.

7.3.4.6.1.3 (FOUO) Airspeed/Autopilot. Set airspeed as required for LAR generation, recommend 180 KTAS, although 165 KTAS will work in most situations.

7.3.4.6.1.4 (FOUO) Payload. The payload step refers to the TXA quality on the SMS Launch Status page. If TXA quality is greater than 1, execute S-turns to improve the transfer alignment. Additionally, for GBU-49/54 releases in GPS Laser/Laser Only, verify TGP setup similar to GBU-12 CCRP deliveries.

7.3.4.6.1.5 (FOUO) Update. GPS only deliveries, verify the intended target matches the created manual target in the SMS and not the CCTGP. For GPS Laser/Laser Only deliveries, verify CCTGP is selected in Auto update.

7.3.4.6.1.6 (FOUO) Target/Track. GPS Laser/Laser Only deliveries, execute as outlined in **paragraph 7.3.3.1.3.2.1**, Target/Track.

7.3.4.6.1.7 (FOUO) Aimpoint. For GBU-38 and GBU-49/54 GPS only deliveries, read the target coordinates/elevation from the selected manually created target from the Launch Status page cross-checking them against the passed/intended target information. Additionally, read any offset munition data as required. If target data does not match, modify the target information as required. For GPS Laser/Laser Only deliveries, see **paragraph 7.3.3.1.3.2.4**, Aimpoint.

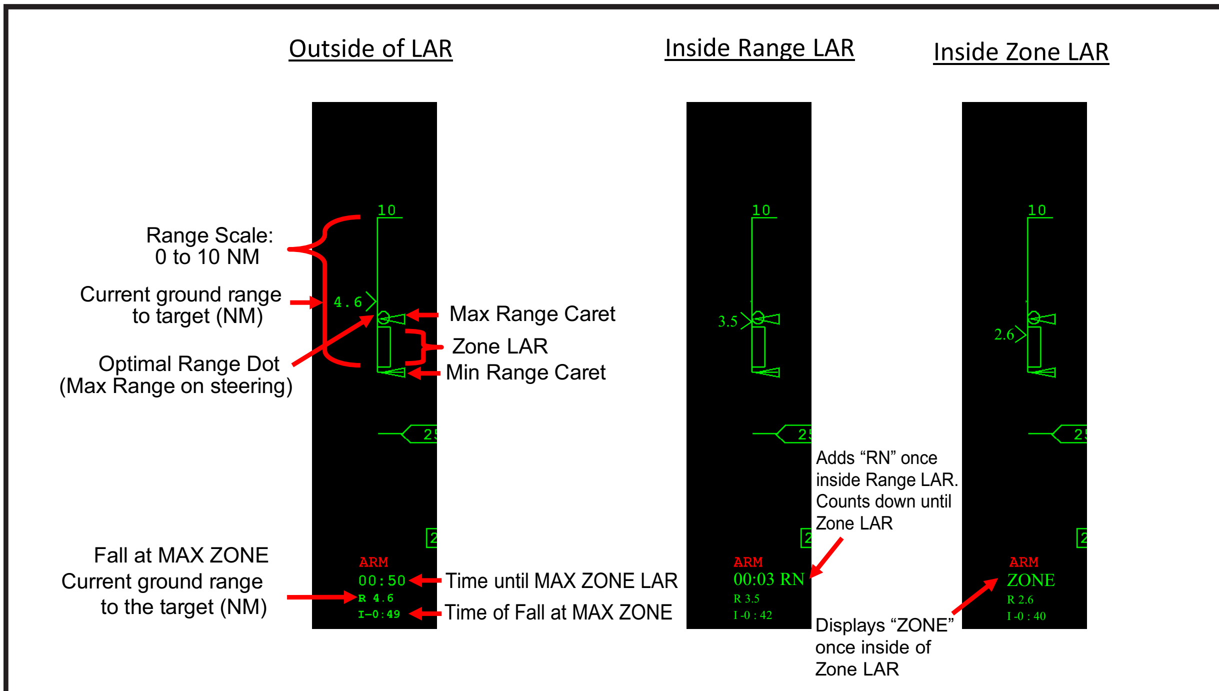
7.3.4.6.1.8 (FOUO) Egress. GPS only releases, as there is no laser terminal guidance, the pilot can maneuver as required immediately postrelease to setup for follow-on attacks without concerns for inducing crosshair drift. For GPS Laser/Laser Only deliveries, execute as described in **paragraph 3.4.3.2**, Straight-Through, and **paragraph 7.3.3.1.4.3.2**, Turning Egress Execution.

7.3.4.7 (FOUO) Execution. Begin attack execution after the preattack checks are complete and the aircraft is in position to intercept final. All GPS Laser/Laser Only deliveries are similar to GBU-12 CCRP deliveries with the notable difference of TTZ as the indication for release pacing/cuing. For GBU-38 and GBU-49/54 GPS only deliveries, pacing is unchanged but there are no SO requirements.

7.3.4.7.1 (FOUO) Turn-In. Turn-In and intercept the BSL like a GBU-12 delivery outlined in **paragraph 7.3.3.1.4.1**, Turn-In.

7.3.4.7.2 (FOUO) Final. Once on final the pilot will pick up the STAT cross-check IAW **paragraph 7.3.1.4.2.1**1, STAT Check. The main difference in STAT execution is the last T stands for TXA quality in addition to track (Track is only applicable for Laser delivery modes). The pilot's cross-check while on final cycles between the steering (maintaining BSL on FPM will fly a wind corrected heading to the middle of the zone and azimuth LARs as displayed on the HUD), time to zone LAR, airspeed and TXA quality. Be prepared to execute 30-degree S turns if the TXA quality increases while on final. The time to zone LAR cross-check provides awareness on the attack pacing and tasks to accomplish while on final. A range caret will fall down the "staple" (range/zone LAR as depicted on the right hand side of the screen) as the aircraft maneuvers closer to the target; the max range is fixed at 10 NM and min range at 0 NM. On that staple, the larger "cones" indicate the max/min range LAR and a rectangular container indicates the zone LAR. The circle is indicative of max range should the aircraft immediately point directly at the target, referred to as ROPT. When outside of the range LAR, time is counted down until the aircraft reaches the range LAR. Once within the range LAR, the timer continues to count down to the zone LAR and adds an "RN" next to it. When the aircraft is in the zone LAR, "ZONE" replaces the countdown and remains until the aircraft exits the zone LAR. On the tracker display, the range LAR and zone LARs turn from blue to green as the aircraft enters the respective LAR. If the timer reads "TTMR NA," then there is no zone LAR and as such, no countdown to max zone. The HUD carets will continue to be accurate to show max and min range of the range LAR. **Figure 7.11**, GBU-38/49/54 Tracker and HUD LAR, depicts the LAR as displayed in the HUD.

Figure 7.11 GBU-38/49/54 Tracker and HUD LAR.



FOUO

7.3.4.7.2.1 (FOUO) Range Launch Acceptability Region. The range LAR depicts release ranges where the munition can be released with the kinematics to fly to the target. It does not guarantee the impact angle or impact azimuth for its minimum and maximum ranges like the zone LAR.

7.3.4.7.2.2 (FOUO) Zone Launch Acceptability Region. The zone LAR is the range where the munition can be released and achieve the desired impact angle and azimuth parameters entered in the SMS.

7.3.4.7.2.3 (FOUO) 1+00 Time to Range LAR. Preattack checks should be complete and BSL drift corrected. Execute the STAT cross-check and focus on airspeed and drift at this point to identify any corrections early in the pacing to ensure a valid LAR is displayed.

7.3.4.7.2.4 (FOUO) 45 Seconds Time to Range LAR. Pilots continue STAT cross-check providing the SO attack pacing awareness with a "ONE MINUTE TO RELEASE" call.

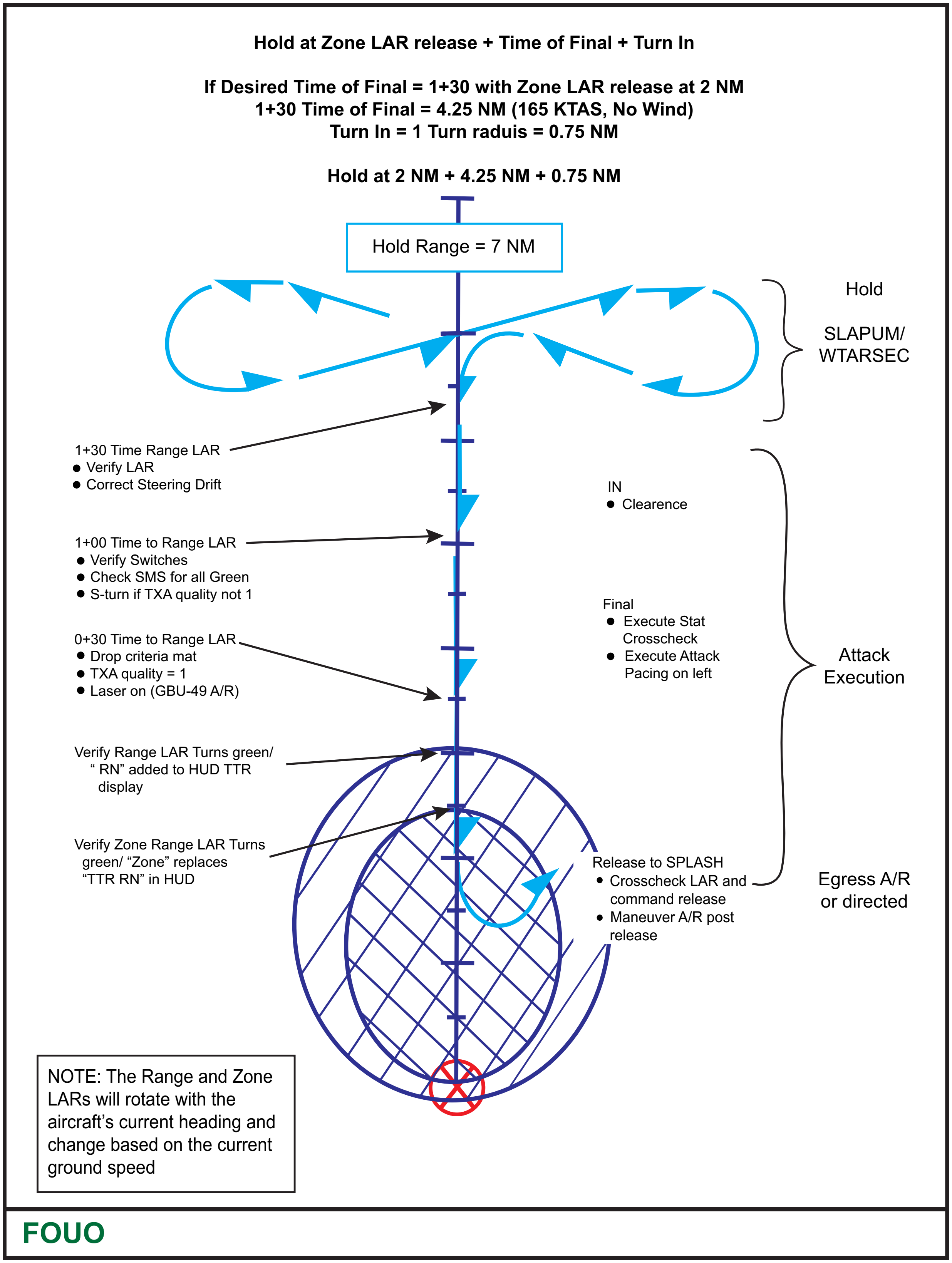
7.3.4.7.2.5 (FOUO) 30 Seconds Time to Range LAR. Verify drop criteria is met. At a minimum, drop criteria should include full stack of green indicators in the SMS and the aircraft within release parameters (e.g., steering, airspeed). If TXA quality is greater than one (e.g., TXA 2 or 3), execute "S" turns or spin. Momentary deviations of TXA 2 for less than two seconds are acceptable but may be an indication of degradation. GPS Laser/Laser Only delivery, Laser ON.

7.3.4.7.2.6 (FOUO) 10 Seconds Time to Zone LAR. Prepare for release. When outside of the range LAR, if the pilot actuates and holds the controls for release (Launch Enable and trigger), as soon as the aircraft enters the range LAR the munition will release, meaning that once the aircraft enters range LAR, the trigger is HOT. If a maximum range employment in the range LAR is desired, press and hold the Launch Enable button and squeeze and hold the trigger. If a maximum range zone LAR release is desired, press and hold the Launch Enable button ONLY and wait until "ZONE" is displayed on the HUD, then squeeze and hold the trigger to command release. If the SOs duties during the attack are to maintain awareness of the target, they should optimize the picture to maintain Tally and if the target begins to move notify the pilot and recommend an abort.

7.3.4.7.3 (FOUO) Release to Splash. Release indications are a small wing rock and the GBU icon selected for release disappearing. Some munitions have shown that it may take up to five seconds to release from the aircraft. Pilots must be aware of the length of the intended LAR for release as a short LAR may have the potential to be flown through the minimum range during this release delay causing the bomb to be released outside of the LAR making it unable to sufficiently pitch over and guide to the target.

7.3.4.8 (FOUO) Egress. Execute briefed egress maneuver. For GBU-38s and GBU-49/54 in GPS only, if the SO is CAPTURED/TALLY, the possibility for nadir exists following any aggressive banking. However, nadir will not affect bomb performance in those instances, but in most cases should still be avoided to minimize the delay for BHA/BDA. **Figure 7.12**, Inertially Aided Munitions Basic Attack, illustrates a basic IAM attack.

Figure 7.12 Inertially Aided Munitions Basic Attack.



7.4 (FOUO) Reattack Procedures. Reattack procedures generally emphasize minimizing time from weapon impact on a first run attack to any follow-on attacks. This section discusses the TTP used to execute effective and efficient reattacks. Crews must take care not to rush and miss checklist items or fly out of a valid WEZ due to the expedited nature of reattacks. The key to conducting an effective and efficient reattack is to plan for the possibility of a reattack prior to the initial attack. However, do not sacrifice first run attack execution for reattack considerations. Once the first weapon impacts the target, the SO must execute postimpact procedures as quickly as possible to provide a usable picture for the aircrew to assess the need for a reattack. Likewise, the pilot should expeditiously reposition the aircraft for a reattack, even if the need for a reattack has yet to be decided. Adjust reattack pacing based on proficiency and the tactical situation.

7.4.1 (FOUO) Reattack Flow. Generally, Intent and Game Plan phases are implied from the previous attack. The reattack flow prioritizes aggressive aircraft maneuvering (the Hold) followed by accomplishing of reattack checks once the aircraft is on an intercept to the intended hold for the reattack weapon, then followed by attack Execution and Egress.

7.4.1.1 (FOUO) Aircraft Maneuvering. The pilot must aggressively maneuver the aircraft from its position at the first weapon's impact into a valid AGM-114 WEZ or onto final for a GBU employment, as required. Continue aircraft maneuvering accomplishing reattack checks with the goal of finishing the checks with the aircraft intercepting a point that corresponds to the attack pacing on final for the reattack weapon.

7.4.1.1.1 (FOUO) ASULT Checks. Aircrew should us the acronym ASULT to help ensure they are ready for a reattack. ASULT can be used for similar-type weapons (Hellfire to Hellfire reattack) or dissimilar weapons (GBU to Hellfire reattack). See **Table 7.6**, ASULT, for specifics on each weapon type reattack check.

7.4.1.1.1.1 (FOUO) Airspeed. Determine if a change in airspeed is required or desired for follow on attacks. Transitioning from an AGM-114 attack to a GBU attack may require an increase in airspeed to ensure a valid release. Conversely, when transitioning from a GBU attack to an AGM-114 attack it may be advantageous to decrease airspeed. The pilot should consider desired maneuvering airspeed, winds at altitude affecting aircraft positioning, and final attack airspeed.

7.4.1.1.1.2 (FOUO) Stores Management System. The SMS will not automatically select the next available weapon. The pilot must go to the Select Store page and select the next weapon for release. Step to the Store Settings page and adjust any settings as required (e.g., AGM 114R-2/9 or GBU-49 fuzing). Then go back to the Launch Status page and verify target information and that weapons state is green.

7.4.1.1.1.3 (FOUO) Update. Confirm the Target Update mode accurately captures the target location, and update if appropriate. If a manual target was used on the first attack, go to the Select Target page and select the next target or switch to the Launch Status page and select Auto.

7.4.1.1.1.4 (FOUO) Laser. As soon as it is known, the SO should set the PRF for the reattack weapon and verify the LRD is still armed. For a GBU-49/54/38 reattack, the pilot should verify a valid LAR.

Table 7.6 ASULT.

	AGM-114	GBU-12/49/54	GBU-38
Airspeed	A/R for A/C maneuvering	A/R for A/C maneuvering	A/R for A/C maneuvering and/or LAR
SMS	Select AGM-114 for release, set fuzing and LOAL mode A/R	Select GBU for release. GBU-49/54 set desired fuze/impact parameters	Select GBU-38 for release. Set desired impact parameters.
Update	Verify/Set Auto	Verify/Set Auto or Manual Target (GBU-49/54)	Create new Manual Target, or step to next target in the SMS
Laser	Set to AGM-114 PRF code	Set per selected GBU PRF code, verify LAR display on HUD and Tracker Display (GBU-49/54)	Verify LAR display in HUD and Tracker display
Target	At a minimum, brief Weapon, Target/Track, Aimpoint, and Shift		At a minimum, brief Weapon, Target/Track (A/R), Aimpoint (coordinate verification and offset target locations for ripple release)
FOUO			

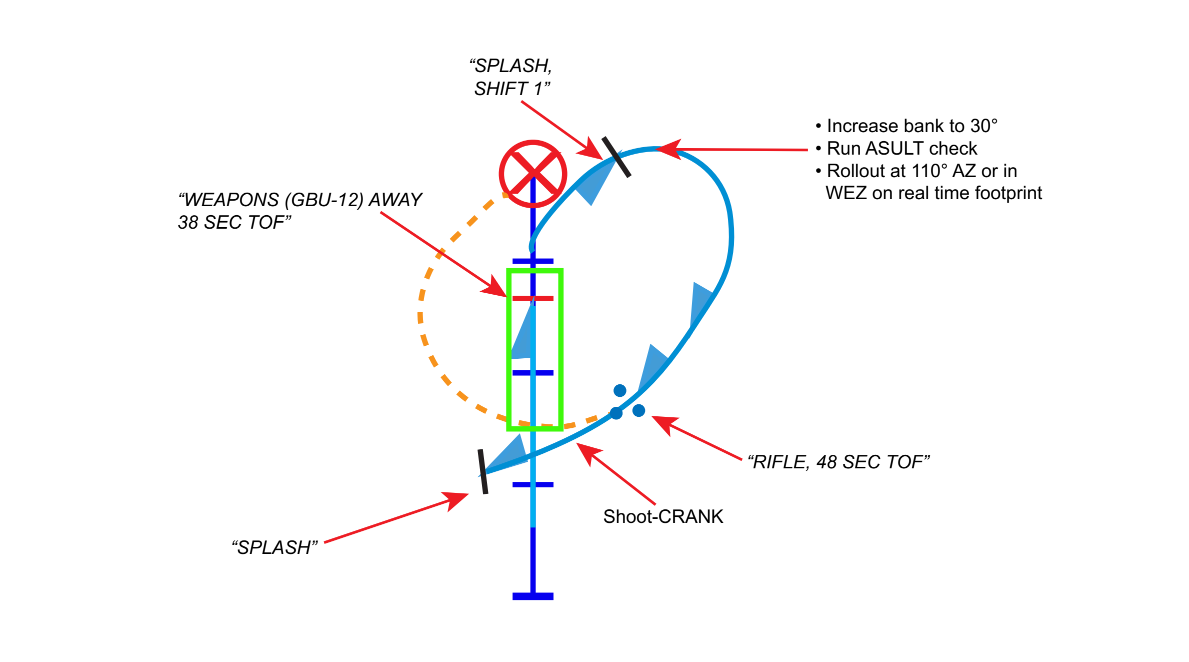
7.4.1.1.1.5 (FOUO) Target. The reattack target brief can be abbreviated or as in-depth as necessary. At a minimum the pilot should brief the target, aimpoint/avenue of approach, and shift plan. The SO should brief the track plan. A more thorough reattack brief will be required if, for example, the intentions of the attack have changed, the disposition of friendly forces are different, or if the shift points have been moved. Tailor the reattack target brief to the tactical situation.

7.4.2 (FOUO) AGM-114 Reattacks. Tactical situations drive Hellfire reattacks. Immediate effects with an unrestricted run-in may facilitate an off-azimuth release once applicable reattack checks are complete. If the target has a restriction (e.g., restricted run-in, specific weapons effects required), accomplish an immediate Post-Splash maneuver for position followed by reattack checks during repositioning. In any case, consider TGP limitations and the ability to maintain target area awareness. If multiple specific weaponeering/run-in restrictions are required for a reattack, execute the AGM-114 attack procedures as previously discussed in **paragraph 7.3.2**, AGM-114 Attack Procedures, to ensure all restrictions are met. For less restrictive reattacks, the AGM-114 reattack aircraft maneuvering varies based on the first attack weapon type, while the reattack checks remain the same.

7.4.2.1 (FOUO) GBU-12 to AGM-114 Reattack Aircraft Maneuvering. At GBU-12 Splash, the aircraft is typically directly over the target. The target type and required impact parameters will dictate the aircraft maneuvering required to put the aircraft in the portion of the WEZ that provides desired weapons effects. The tactical situation may require a specific weaponeering (e.g., impact angle, restricted run-in) in order to achieve effects. In this case, maneuver the aircraft as required to meet desired weapons effects. For targets that do not require specific weaponeering for a reattack, the pilot should take the first available shot to minimize time between impacts. This typically occurs around 135 degrees azimuth and minimum range and will result in an impact angle typically between 30 and 40 degrees. **Figure 7.13**, GBU-12 to AGM-114 Reattack, depicts the GBU-12 to AGM-114 reattack. At impact complete the following.

- (FOUO) Set bank to 30 degrees until target is in WEZ, either on RMIT Real Time Footprint or HUD (approximately 110 on azimuth while in bank for medium/high altitude attacks).
- (FOUO) Once bank is established, run ASULT check.
- (FOUO) Cross-check Real Time Footprint/Azimuth and Range for a valid WEZ and roll-out of bank (as required).

Figure 7.13 GBU-12 to AGM-114 Reattack.



FOUO

7.4.2.1.1 (FOUO) Planning Tool and AGM-114 Reattacks. Planning Tool v10 and later incorporate 180-IN numbers to the Untimed Holding Distance section. Using v11.65 and assuming an updated 9-pack, the numbers inside the red ring represent the ground range to begin the turn back into the target at the planned bank angle. This will position the aircraft on final with the desired time on final remaining prior to release at the R_{DL}.

7.4.2.2 (FOUO) AGM-114 to AGM-114 Reattack Maneuvering. Due to the large nature of the Hellfire WEZ, reattacks are driven by aircraft location at impact of first missile. The first step is to assess the current aircraft parameters to estimate the aircraft location once ready to employ. In some cases, the aircraft might not need to be maneuvered (e.g., off-azimuth shot from the wheel, first run on-azimuth maximum range shot) or only require a check turn of 20 to 30 degrees to keep the aircraft in a WEZ while setting up for a reattack. If the aircraft is towards the front of the WEZ at first missile impact, positioning the aircraft in a Wheel orbit around the target should allow the aircraft to maintain a WEZ while reattack checks are completed. Regardless, the first step for the reattack should be to position the aircraft or at least get it pointed in the right direction and then run the ASULT checklist.

7.4.2.3 (FOUO) ASULT Check. Run the ASULT check once the aircraft repositioning for the reattack has started and the SO is CAPTURED the next target. Execute IAW **Table 7.6**, ASULT, with the following highlights.

7.4.2.4 (FOUO) Airspeed. There is no min airspeed required for AGM-114 employments. Airspeed should be set to help max perform the aircraft; this may include slowing down to minimize turn radius or speeding up to get back to a required run-in.

7.4.2.4.1 (FOUO) SMS. Select the station for release on the Store Select page that meets desired effects. For weapons with multiple fuzing options, step to the Store Settings page and select the fuzing for the reattack target if current fuzing will not meet desired weapons effects. Verify the anticipated weapon for release is solid green on the HUD and the Launch Status page has all green indicators.

7.4.2.4.2 (FOUO) Update. If transitioning from an attack not using Auto Update, select Auto Update to obtain valid WEZ data, especially if the target is moving.

7.4.2.4.3 (FOUO) Laser. Set the PRF for the AGM-114. The laser may be left on when shifting to the next target, or CEASED and then turned on again once on final. The pilot should be directive with the desired laser commands.

7.4.2.4.4 (FOUO) Target. The pilot will brief the target aimpoint, avenue of approach, and shift location (if applicable). In the case of an immediate shot over 100 degrees off-azimuth, ensure the SO understands the missile avenue of approach relative to the screen for aimpoint selection. In these cases, the missile will typically impact 90 degrees off of the target in the TGP FOV and run-in opposite the azimuth at launch (e.g., the missile for an off-azimuth shot at -129 degrees azimuth will run-in from the right side of the TGP FOV). The SO should brief the track plan and AGM-114 track employment TTP.

7.4.2.5 (FOUO) AGM-114 Reattack Employment. Once the aircraft is in a valid WEZ with desired impact parameters and the ASULT check is complete, the crew should use the habit patterns established from normal AGM-114 attack procedures and pick up the crew-specific cross-check and duties as outlined in the AGM-114 attack execution **paragraph 7.3.2.1.4**, On-Azimuth Execution; and **paragraph 7.3.2.2.2** Off-Azimuth Execution, with expedited pacing. Postrelease, the pilot should maneuver the aircraft with consideration for another reattack if necessary. For an off-azimuth attack with greater than 90 degrees azimuth at release, the pilot should bank into the target to maintain a valid

WEZ. Once inside 90 degrees azimuth with TTI of greater than 10 seconds, the pilot should roll out to provide the SO a stable platform. Otherwise, the pilot should remain in a bank until Splash.

7.4.3 (FOUO) GBU-12 Reattacks. GBU-12 reattacks require additional maneuvering for execution and typically take longer to accomplish because the aircraft has to be maneuvering to the CCRP. The extent of aircraft maneuvering will depend on the previous weapon expended, desired time on final, and any run-in restrictions.

7.4.3.1 (FOUO) Determining Turn-In Distance (Planning Tool Method). Use the Planning Tool to calculate a turn-in distance that provides the desired time on final. Prioritize this for a preplanned reattack as it requires additional attack planning.

7.4.3.1.1 (FOUO) First, update the 9-pack, then set the desired time on final in the Untimed Holding Distance section. (e.g., 0+30).

7.4.3.1.2 (FOUO) Verify the hold range per the chosen sector.

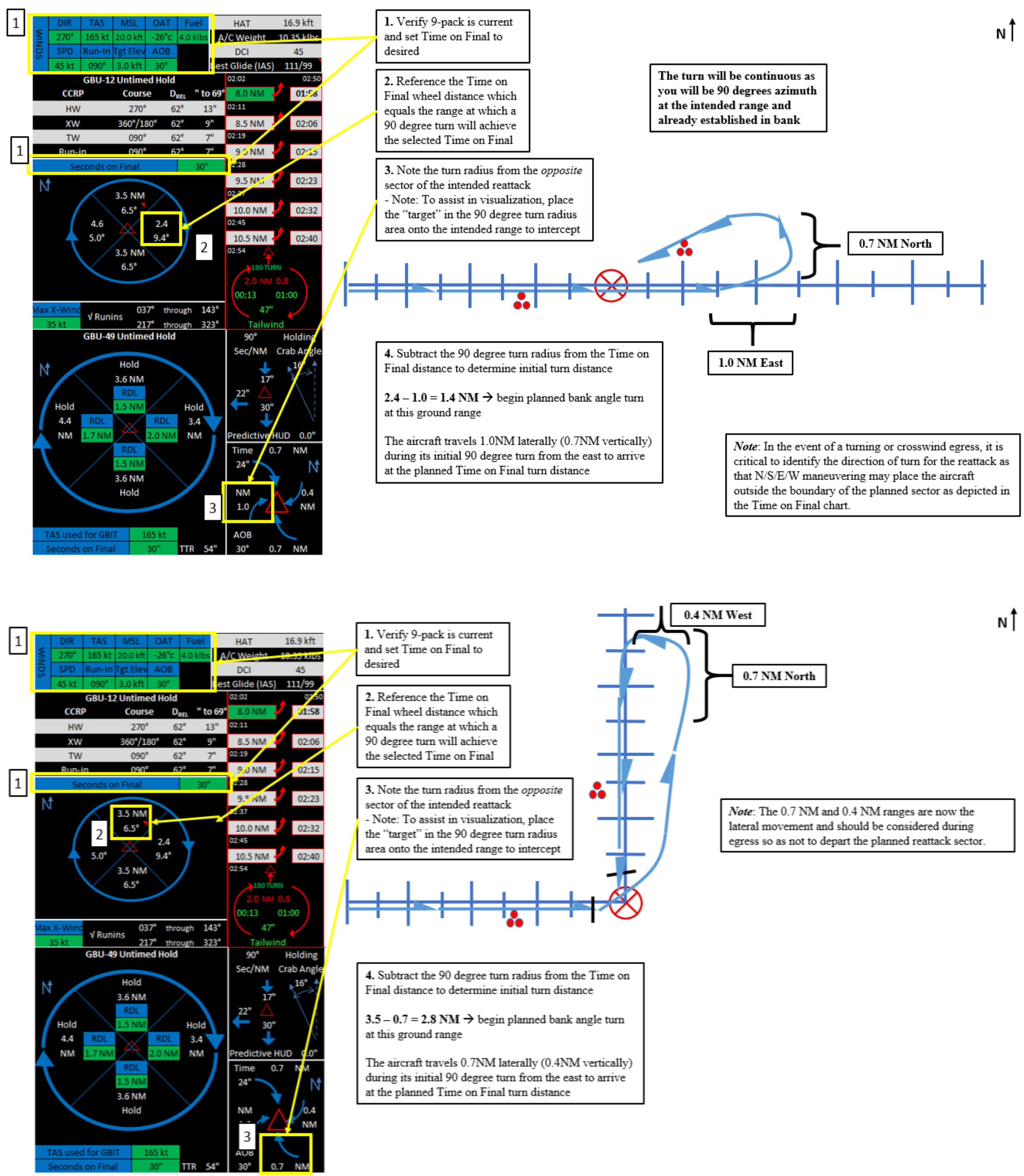
7.4.3.1.3 (FOUO) Next, reference the "Hurricane Chart" in the bottom right side of the planning tool (red triangle surrounded by four turn arrows and numbers). Subtract the applicable 90-degree turn radius, as derived from the hurricane chart, from the planned sector hold range.

7.4.3.1.3.1 (FOUO) For example, **Figure 7.14**, Planning Tool and GBU-12 Reattacks, displays a planned reattack egress to the east and a 180 degree turn to the west. Since the HUD distance carat is predictive, reference the targeting pod (TGP) graphics ground range to initiate a 180 degree turn inbound at the planned range.

7.4.3.2 (FOUO) Determining Turn-In Time (TOI Method). If properly executed, the TOI method will provide the pilot 20 to 30 seconds on final prior to release. To start, after weapon release and established in the egress, select the next GBU-12 for release. Then assess the planned egress direction and winds at altitude to determine turn-in timing. For winds less < 60 knots at altitude, regardless of direction, the pilot should drive away from the target (>135 azimuth) until the TTR reads 1+45 before executing turn at a minimum 30 degrees AoB towards final. In some instances (tailwind to a headwind) this may occur soon after crossing the CCRP dot. For situations with winds between 60 to 80 knots at altitude, the pilot should execute one of the following.

- (FOUO) Egress crosswind to final with crosswind: Turn at 1+45 TTR into the wind to minimize turn radius and errors in calculations.
- (FOUO) Egress headwind to final with tailwind: Turn at 1+50 TTR.
- (FOUO) Egress Tailwind to final with headwind: Turn once crossing the CCRP dot.

Figure 7.14 Planning Tool and GBU-12 Reattacks.



FOUO

7.4.3.3 (FOUO) GBU-12 to GBU-12 Reattack Maneuvering. GBU-12 to GBU-12 reattacks require the aircraft to be flown away from the target and past the BRP, before turning back inbound to intercept desired range/TTR on final. After Splash, maneuver the aircraft to fly outbound to a calculated turn-in distance. Plan to fly the outbound leg with a tailwind to minimize time-outbound prior to the turn-in distance, unless prohibited by a specific run-in requirement. With minimal wind effects (e.g., less than 30 knots), turn the aircraft outbound from the target and set azimuth to be greater than 150 degrees, left or right, for the outbound leg and roll out. Once established on the outbound leg, drive until reaching the calculated turn-in distance, then initiate the turn back to target intercepting final as outlined in **paragraph 7.3.3.1.4.1**, Turn-In.

7.4.3.3.1 (FOUO) Reattack from a Straight-Through Egress. After Splash, release cross-controls to begin the outbound leg of the reattack with an azimuth of 150 degrees or greater. Upon reaching the turn-in distance, turn back towards the target using planned bank angle from the Planning Tool and intercept the BSL. If necessary (e.g., when meeting a reciprocal run-in restriction or minimizing crosswind effects on final), choose an offset direction and instead turn to set the azimuth to greater than 135 degrees immediately after Splash. Intercept a teardrop pattern, with the calculated turn-in distance as the outbound fix.

7.4.3.3.2 (FOUO) Reattack from a Turning Egress. After Splash, continue the egress turn, initially setting 150 degrees azimuth, until the aircraft is outbound and parallel to the desired run-in. Upon reaching the calculated turn-in distance, turn back towards the target using planned angle of bank to intercept the BSL. If reattacking with a run-in restriction, use the planned angle of bank to intercept a final run-in that meets the restriction.

7.4.3.4 (FOUO) AGM-114 to GBU-12 Reattack Maneuvering. Maneuvering to employ a GBU-12 after the AGM-114 depends entirely on the tactical situation and aircraft position relative to the BSL and GBU-12 TTR at Splash. If first run AGM-114 attack weaponeering allows an R_{DL} at a sufficient range, the GBU-12 reattack could occur on the same run-in. Typically, the aircraft will likely be too close to the target to complete the ASULT check and successfully intercept the BSL before reaching the BRP.

7.4.3.4.1 (FOUO) Reattack on the Same Run-In. Plan the AGM-114 R_{DL} for Splash to occur before reaching a minimum planned GBU-12 TTR (30 seconds recommended). Immediately after Splash, select the GBU-12 to assess steering and aggressively maneuver to the BSL if not already lined up.

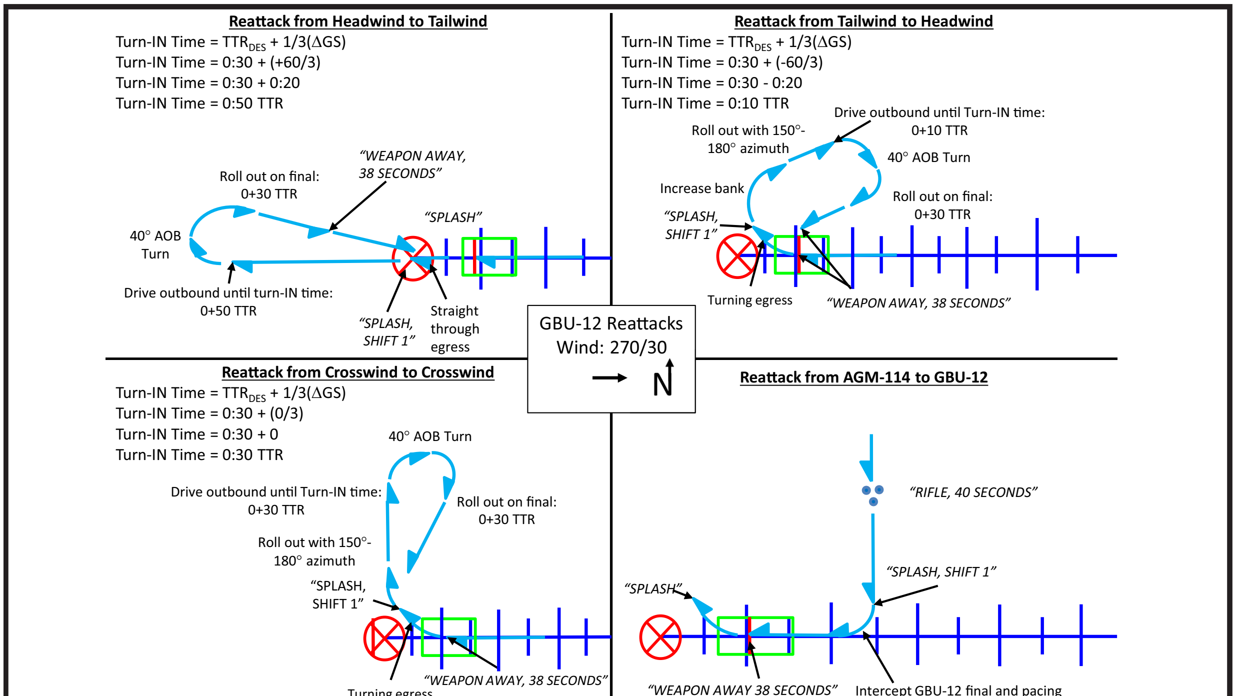
7.4.3.4.2 (FOUO) Additional Maneuvering Required Post-Splash. Weaponeering may not allow for a medium to max range AGM-114 R_{DL}, or the tactical situation might dictate a GBU-12 reattack without prior planning. In these cases, choose an appropriate egress for the AGM-114 attack and then execute maneuvering IAW **paragraph 7.4.3.3.1**, Reattack from a Straight-Through Egress, for straight-through attacks, or **paragraph 7.4.3.3.2**, Reattack from Turning Egress, for a shoot-crank egress. For shoot-press attacks, immediately select the GBU-12 NLT at Splash and determine if a reattack is feasible on the same run-in. If not able and there is not sufficient enough maneuvering space or a restriction exists, turn away from the target, set an azimuth greater than 135 degrees, and conduct reattack positioning for a turning egress. If no restrictions and sufficient maneuvering space is available, crews may attempt to enter a wheel hold with desired release of 0+30 to 1+00 TTR post AGM-114 Splash and accomplish ASULT check prior to turning in.

7.4.3.5 (FOUO) ASULT Check. Run the ASULT check after the aircraft is either established in, or proceeding to its reposition location and the SO has CAPTURED the reattack target. See **Table 7.6**, ASULT, for summary of weapons checks.

7.4.3.6 (FOUO) GBU-12 Reattack Employment. Execute the GBU-12 reattack using the steps outlined **paragraph 7.3.3.1.4**, Execution, but plan to expedite pacing due to decreased TTR. The pilot follows the STAT cross-check and the SO uses the hub-and-spoke cross-check once established on final. It is acceptable to have the SO updated PRF and continue lasing during a planned shift reattack; or to have the SO automatically turn-on the laser at the IN call on the reattack.

7.4.3.6.1 (FOUO) **Figure 7.15**, GBU-12 Reattacks, depicts a GBU-12 to GBU-12 reattack and an AGM-114 to GBU-12 reattack.

Figure 7.15 GBU-12 Reattacks.



FOUO

7.4.4 (FOUO) GBU-38 Reattacks. Reattacks with GBU-38s are mechanically similar to GBU-12 reattacks but offer more flexibility in immediate maneuvering if the first attack was also a JDAM. The reattack flow is generally the same as discussed in **paragraph 7.4.3**, GBU-12 Reattacks. For AGM-114 to GBU-38 reattack maneuvering, execute the AGM-114 to GBU-12 reattack maneuvers as described in **paragraph 7.4.3.4**, AGM-114 to GBU-12 Reattack Maneuvering; and then run the ASULT check.

7.4.4.1 (FOUO) GBU-38 to GBU-38 Reattack Maneuvering. A GBU-38 reattack following a GBU-38 attack is similar to a GBU-12 to GBU-12 reattack from **paragraph 7.4.3.3**, GBU-12 to GBU-12 Reattack Maneuvering, but the aircraft maneuvering can be more aggressive immediately after release of the first GBU-38. For turning egresses, use maximum allowable bank angle (satellite dependent) to turn away from the target and accomplish maneuvering IAW **paragraph 7.4.3.3.2**, Reattack from Turning Egress. Otherwise, conduct a straight through egress and maneuver IAW **paragraph 7.4.3.3.1**, Reattack from a Straight-Through Egress.

7.4.4.1.1 (FOUO) Turn-In Distance. Use the GBU-38/49 Untimed Hold Section and the three steps found in **paragraph 7.4.3.1**, Determining Turn-In Distance. The GBU-38/49 section allows a manual R_{DL} to be set per sector. Set the R_{DL} to max zone LAR distance if known (generally, selecting a range between 1.5 and 2 NM will also provide sufficient time on final), then set the TAS and seconds on final.

7.4.4.2 (FOUO) ASULT Check. Crews should account for additional time required to manually enter target coordinates if reattack target was not previously input into the SMS. In this case, either add time to desired time on final when calculating the turn-in distance using the Planning Tool, or plan to establish a hold. Execute the ASULT check IAW **Table 7.6**, ASULT, with following highlights:

7.4.4.2.1 (FOUO) SMS. Select the GBU-38 on the Select Store page. Verify impact angle and impact velocity on the Store Settings page for the currently selected store for release will meet desired effects. Select the next manual target for the reattack on the Select Target page. If the reattack target has not been created, the aircraft should enter a hold approximately 30 seconds from the Zone LAR while the new target is created in the SMS.

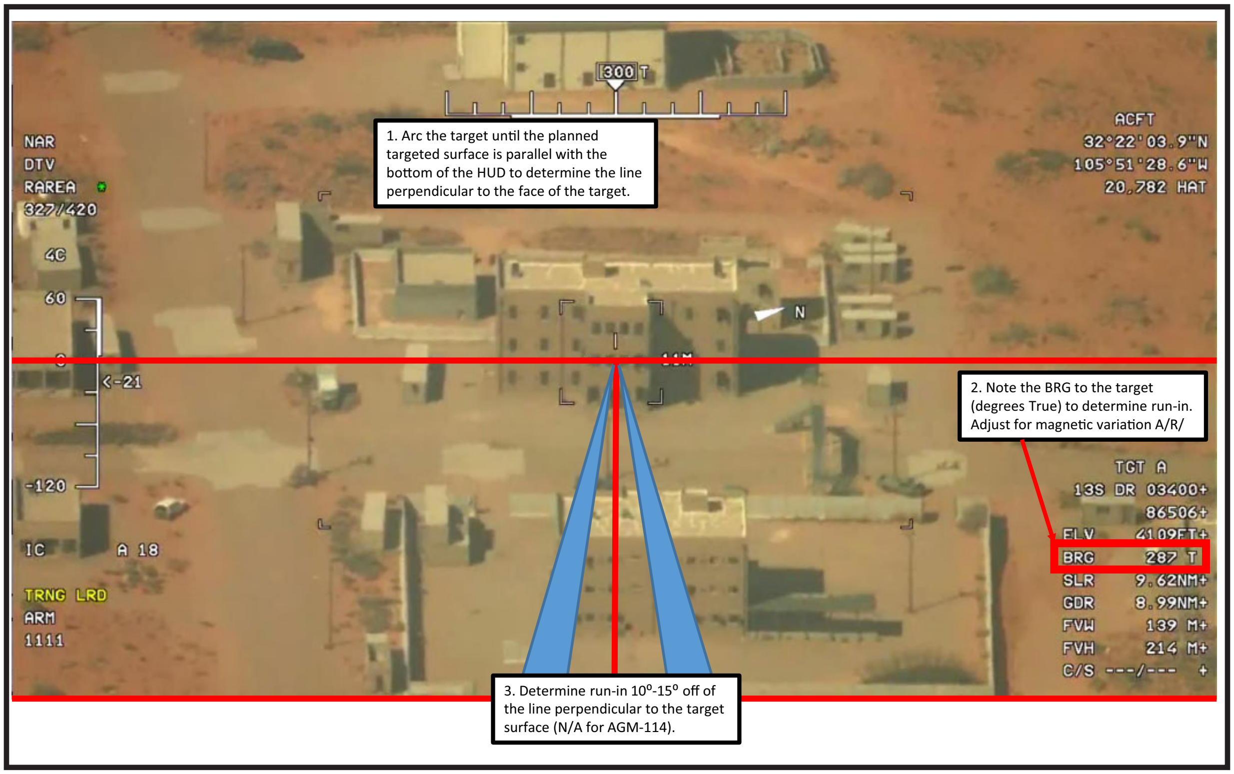
7.4.4.3 (FOUO) GBU-38 Reattack Employment. Once on final, execute the GBU-38 reattack in accordance with attack procedures from **paragraph 7.3.3.3.3**, Execution, for Single-Desired Point of Impact Deliveries.

7.4.5 (FOUO) GBU-49/54 Reattacks. Using the GBU-38/49 Untimed Hold section of the Planning Tool, accomplish GBU-49/54 reattacks in the same manner as GBU-12 reattacks, following the procedures in **paragraph 7.4.3**, GBU-12 Reattacks. If the crew uses GPS/INS guidance only, or does not self-lase the weapon, execute reattacks following GBU-38 procedures outlined in **paragraph 7.4.4**, GBU-38 Reattacks.

7.4.5.1 (FOUO) ASULT Check. Execute the ASULT check IAW **Table 7.6**, ASULT.

7.5 (FOUO) Vertical Attack Procedures. Vertical target attack procedures apply to a vertically developed target with a weaponeering solution to impact the vertical face. In order to provide continuous laser spot for the weapons to guide to the target, the single-ship AGM-114, GBU-12, GBU-49, and GBU-54 attacks must be modified in order to strike the vertical face of a target. For all attack types, initial action is to assess the bearing to the target to determine run-in. To do this, arc the target, on the side of intended effects, until the bottom of the target is parallel with the bottom of the HUD, then cross-check TGP bearing (displayed in True). This bearing will be used for the run-in (convert to magnetic as required). See **Figure 7.16**, GBU-12 Vertical Target Attack Run-In Orientation, for a graphical depiction.

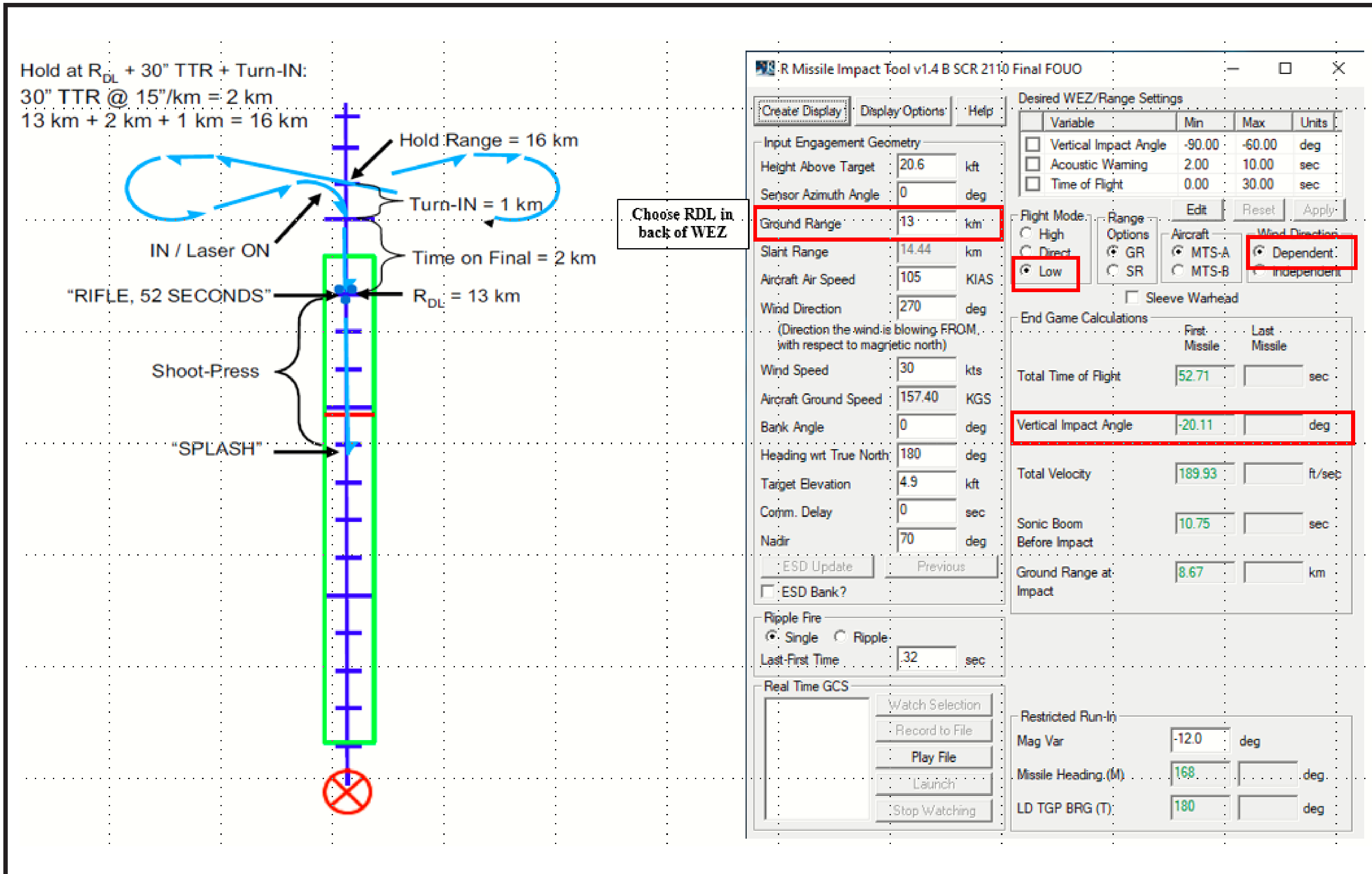
Figure 7.16 (FOUO) GBU-12 Vertical Target Attack Run-In Orientation.



7.5.1 (FOUO) AGM-114. AGM-114 employments against a vertical face require the weapon to impact as close to perpendicular to the face as possible (lowest vertical impact angle in RMIT) to minimize the amount of material the weapon must penetrate before the weapon fuzes. Typically, a LOAL-L flight profile launched on-azimuth from maximum range provides this weaponeering solution. Figure 7.17, AGM-114 Vertical Target Attack, depicts the setup and attack pacing for an AGM-114 attack against a vertical target.

7.5.1.1 (FOUO) Game Plan. Run RMIT to determine impact parameters and R_{DL} for a LOAL-L attack. Recommended using Wind Direction—dependent to assist in calculations. Note the impact angle to determine the lowest possible impact angle on the attack and clear for obstacles. Accomplish obstacle clearing on a LOAL-L engagement in one of two ways: first method is to drive outbound on the planned attack run-in until the depression angle matches the lowest possible impact angle for the attack. If there is LOS to the target (i.e., no objects behind the crosshairs other than the target), then the run-in is clear. If there are small obstructions, then adjust the run-in accordingly. For larger obstructions, consider striking a different face of the target if able (if unable, assess possibilities of steeper impact angles based on intent). When using this method, crews should be aware that the greater the HAT, the further the aircraft will be from the target. This results in increased loss of TGP fidelity. The other method to clear for obstacles is to have the SO scan towards the aircraft along the run-in while the aircraft is in the back of the hold to assess if there are any obstructions. Once the run-in is clear of obstacles and the release point is determined, enter the planned hold.

Figure 7.17 (FOUO) AGM-114 Vertical Target Attack.



FOUO

7.5.1.2 (FOUO) Hold. Enter and establish a Figure Eight hold. Adjust hold as required to achieve the desired time on final using the ROT of 15 seconds/1 km. In addition to losing TGP fidelity at greater ranges; at lower HATs, aircraft masking becomes a concern as well. Set up a manual run-in on the Release Settings page to assist with maintaining positional awareness.

7.5.1.2.1 (FOUO) Preattack Checks. Execute the preattack checks in accordance with **paragraph 7.3.2.1.2**, AGM-114 Preattack Checks, for AGM-114 on-azimuth employment with the following considerations for a vertical target attack.

7.5.1.2.1.1 (FOUO) SMS. Set missile flight profile to LOAL-L and apply weaponeered fuze settings. Set run-in to Manual and enter planned run-in. Update R_{DL} based on RMIT calculations.

7.5.1.2.1.2 (FOUO) Aimpoint (WTARSEC). Determine the exact DPI for the LOAL-L impact. Avoid lasing on glass or through open windows. For aimpoint specifics, reference AFTTP 3-1.MQ-9.

7.5.1.2.2 (FOUO) Execution. Execute the same as an AGM-114 on-azimuth employment as outlined in **paragraph 7.3.2.3.1.2**, On-Azimuth Shoot-Press. The increased range in the hold may cause laser and aircraft masking on the turn to final.

7.5.1.2.3 (FOUO) Egress. After Splash with a Shoot-Press, the aircraft is typically located in the middle of the WEZ. As a technique, the pilot has the option to pick up a Wheel hold and assess BHA/BDA and determine the need for a reattack.

7.5.2 (FOUO) GBU-12/49/54. GBU-12/49/54 attacks against a vertical target require a maximum range manual delivery and aggressive maneuvering immediately postrelease to prevent potential loss of laser spot acquisition (podium effect) as well as possible nadir situations during terminal guidance of the weapon. The maximum range delivery decreases the impact angle relative to the ground but maximizes impact angle relative to the vertical face of the target. The aggressive maneuvering immediately after release minimizes closure to the target and ensures the aircraft will remain on the same side as the desired run-in and minimizes podium effect. If a buddy laser is available, then the crew can execute these attack procedures through release and have the buddy laser provide the laser spot with less concern for podium effect. If a buddy laser is not available, the crew must execute the following procedures of the attack flow.

7.5.2.1 (FOUO) Game Plan. Initial actions are to determine the release point and planned run-in. Release point is determined using GWTS (GBU-12) and GBIT (GBU-49/54). Planned run-in must be 10 to 15 degrees off the line perpendicular to the face of the target. 10 to 15 degrees off the perpendicular yields a balance between the weapon horizontal impact angle, laser to target line, and closure to the target after release. Determine the initial bearing to the target as described in **paragraph 7.5**, Vertical Attack Procedures, and depicted in **Figure 7.16**, GBU-12 Vertical Target Run-In Orientation, then adjust run-in to offset that bearing (account for magnetic variation when necessary); and finally input the adjusted run-in into the SMS.

7.5.2.1.1 (FOUO) Calculating Release Point for GBU-12. Open GWTS and ensure envelope is selected for the output on the general tab. Set up GWTS in accordance with **Figure 7.18**, GWTS Vertical Target Attack Setup. Specifics not already discussed from the GWTS setup for vertical target attack include HAT and airspeed. The combination of an 11,000 HAT and 140 KTAS results in an ideal mixture of bomb range at release and turn performance, minimizing the potential for podium effect. GWTS output should result in a time, slant range, or ground based release cuing.

7.5.2.1.1.1 (FOUO) HAT. Plan HAT to 11,000 feet for no wind attacks with the following additions:

- FOUO) For every 20 knots of headwind add 1,000 feet HAT.
- (FOUO) For every 20 knots of tailwind subtract 1,000 feet HAT.
- (FOUO) Example: An attack run-in with 40 knots of headwind component should be flown at 13,000 feet HAT.

7.5.2.1.1.2 (FOUO) Airspeed. 140 KTAS is a good ROT starting point. 140 KTAS balances bomb range and turn radius (assuming 30 degrees AOB) to decrease podium effect potential. See **Figure 7.19**, GBU-12 Vertical Target Attack Podium Effect Mitigation.

7.5.2.1.2 (FOUO) Calculating Release Point for GBU-49/54. Update all GBIT input engagement geometry with current parameters. Next, update target and weapon inputs with the caveat that crews should plan to achieve an impact angle of 40 to 50 degrees. An adjustment of the desired impact angle may be necessary to achieve a valid LAR. Unlike the GBU-12, there is no need to fly (or plan) the attack at 11,000 feet HAT. Instead, input current aircraft altitude (MSL) from VIT 99 in GBIT. Plan on flying the delivery at 140 KTAS, however, an adjustment to this airspeed may be required based on impact angle and achieving a valid LAR. See **Figure 7.20**, GBIT Vertical Target Attack Setup, for GBIT specifics.

7.5.2.2 (FOUO) Hold. Plan the hold to be a Figure Eight anchored on the planned offset run-in as discussed in **paragraph 7.5.1.1**, Game Plan. Hold in accordance with the GBU-12 manual delivery procedures from **paragraph 7.3.3.3.2**, Hold.

7.5.2.2.1 (FOUO) Preattack Checks. Execute the brief in accordance with **paragraph 7.3.3.3.2.1**, Preattack Checks, with the following highlights.

7.5.2.2.1.1 (FOUO) SMS. Set Run-In mode to manual, enter Run-In in degrees (true or mag as required), and set the Release Mode to manual. Verify Red Manual displayed on HUD below the airspeed container. For GBU-54 releases, input an impact angle less than 45 degrees into the SMS while in LTKS mode.

7.5.2.2.1.2 (FOUO) Airspeed/Autopilot. Set 140 KTAS and climb/descend to the optimal release HAT, or as weaponeered.

7.5.2.2.1.3 (FOUO) Payload. Adjust payload settings for anticipated high depression angles during TOF.

7.5.2.2.1.4 (FOUO) Update. Perform a manual update with the crosshairs on the base of the target with the laser off. If dropping GBU-49/54's, ensure a Manual Target is created.

Figure 7.18 GWTS Vertical Target Attack Setup.

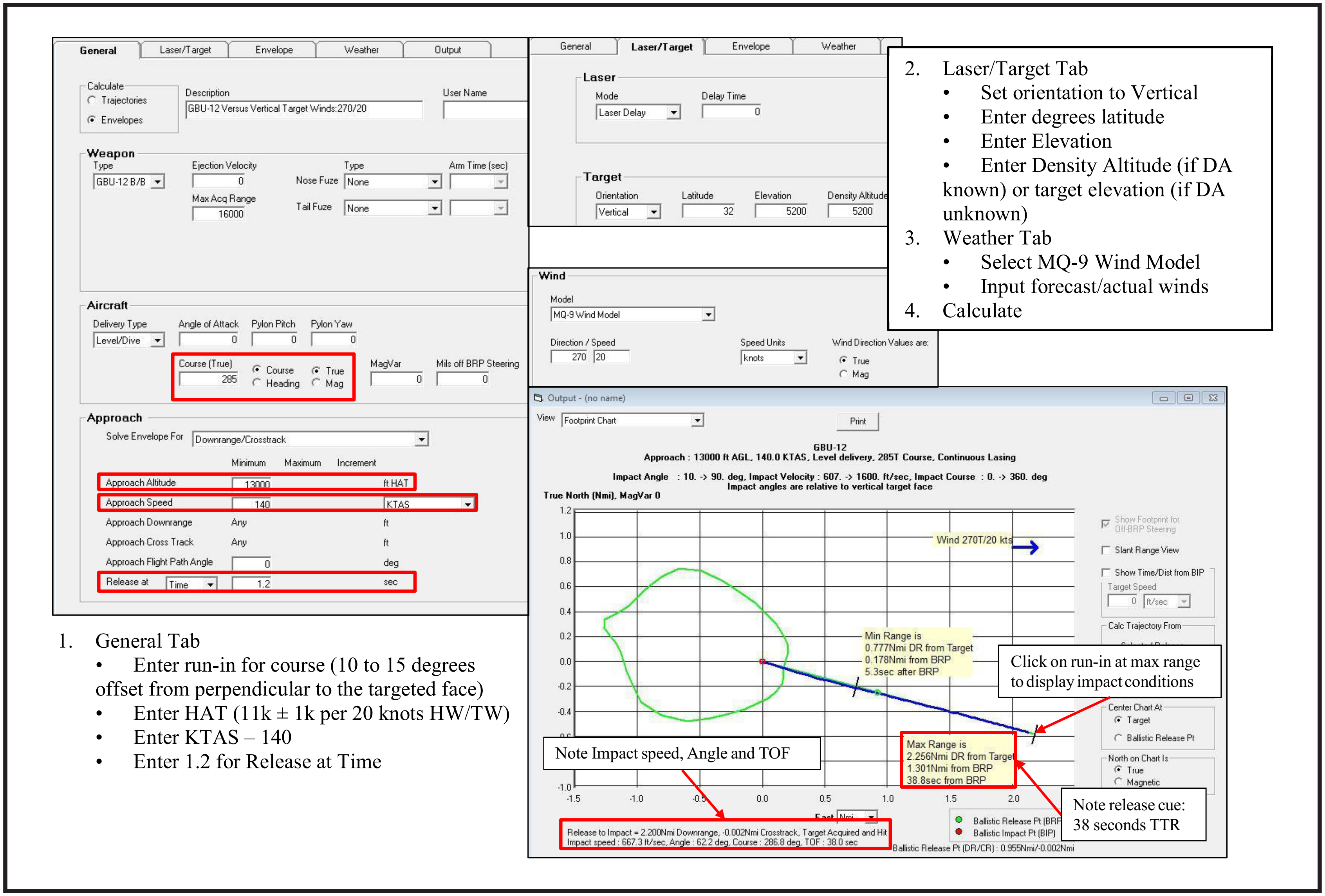
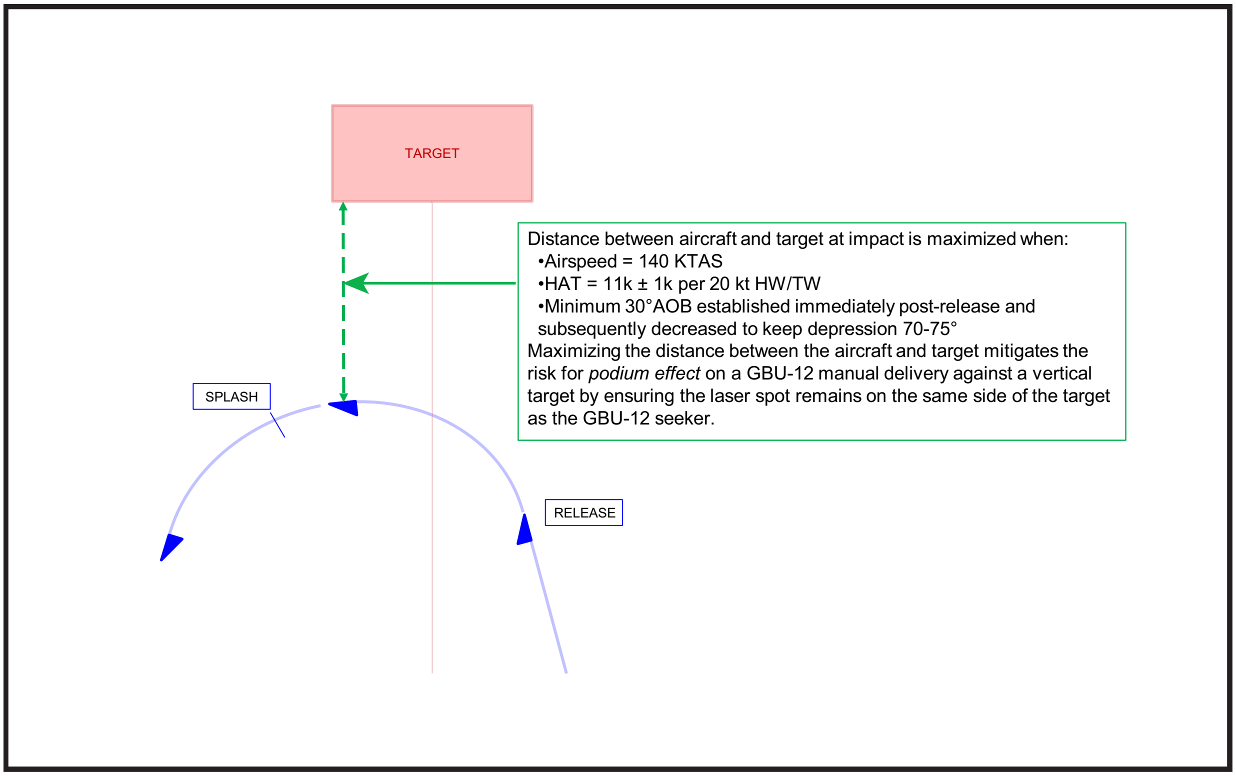


Figure 7.19 GBU-12 Vertical Target Attack Podium Effect Mitigation.

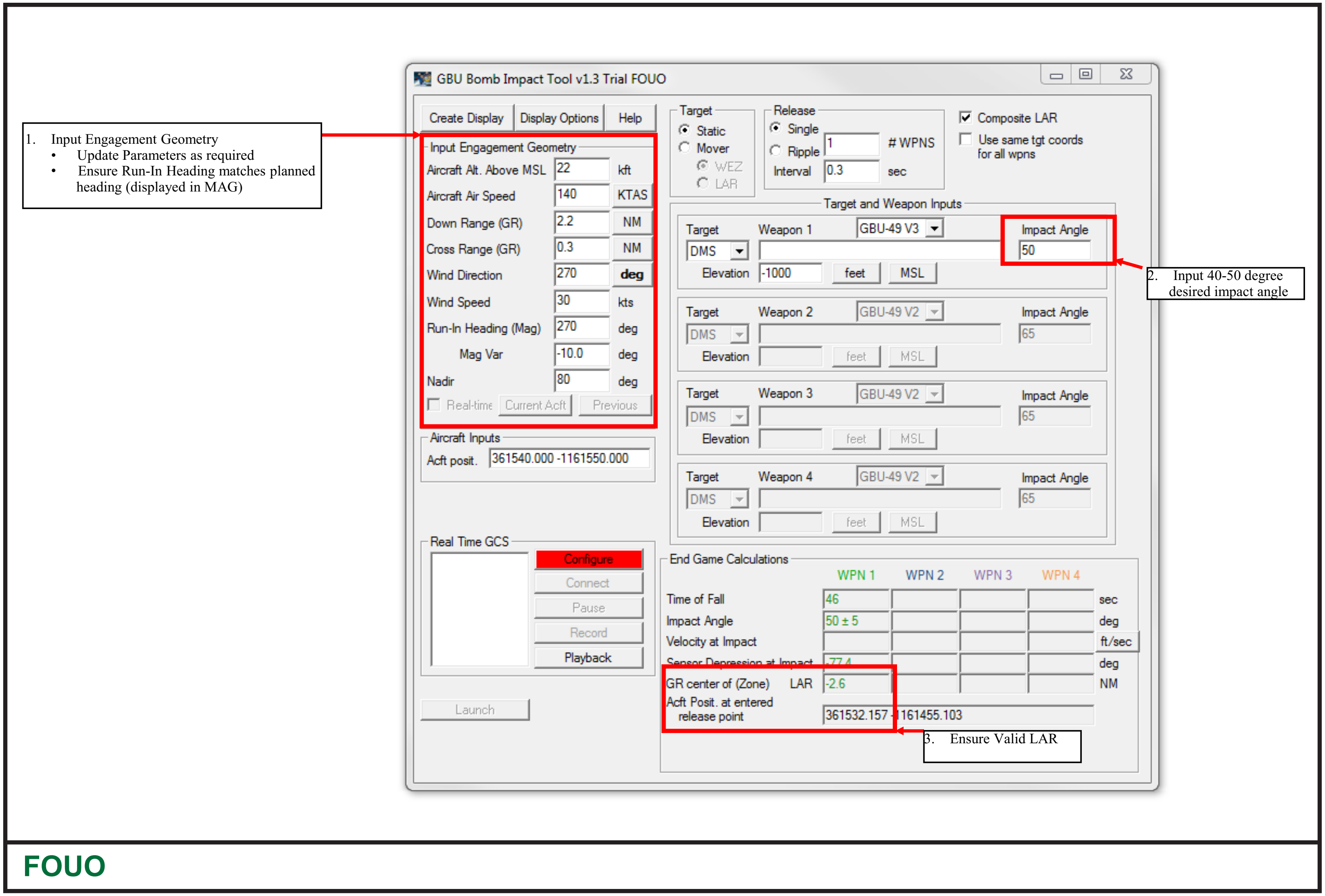


7.5.2.2.1.5 (FOUO) Weapon. In addition to standard items, cover the type of maximum range delivery (i.e., time or range based) at the calculated release point with the specific trigger (e.g., 29 seconds TTR or 2.9 NM ground range).

7.5.2.2.1.6 (FOUO) Target/Track. The pilot briefs the target and the SO briefs the track plan. A GBU-12/49/54 attack against a vertical face presents the SO a significantly different attack than a CCRP delivery. This is due mainly to the release distance of the bomb to meet the desired impact angle and postrelease maneuvering. Create a track that encompasses only the vertical face that the aimpoint is on. This may prevent track shift during the TGP rotation from the aircraft postrelease maneuvering. If a significant point of contrast exists on or around the DPI, a point track may be a viable option to limit the amount of operator input needed.

7.5.2.2.1.7 (FOUO) Aimpoint. Place the aimpoint on the vertical face of desired effects for impact angles greater than 35 degrees. If the GWTS-derived impact angle is less than 35 degrees, the bomb is susceptible to trajectory sag and the aimpoint should be adjusted six feet (two meters) further up the vertical face from the DPI.

Figure 7.20 GBIT Vertical Target Attack Setup.



7.5.2.2.1.8 (FOUO) Shift. Brief a shift cold in accordance with normal attack procedures (as required). Consideration should be given to shifting the weapon short instead of long due to potential target masking and reduced bomb energy.

7.5.2.2.1.9 (FOUO) Egress. Immediately following release expect a 30-degree banked turn across the face of the target, then begin roll out to capture 70 to 75 degrees depression.

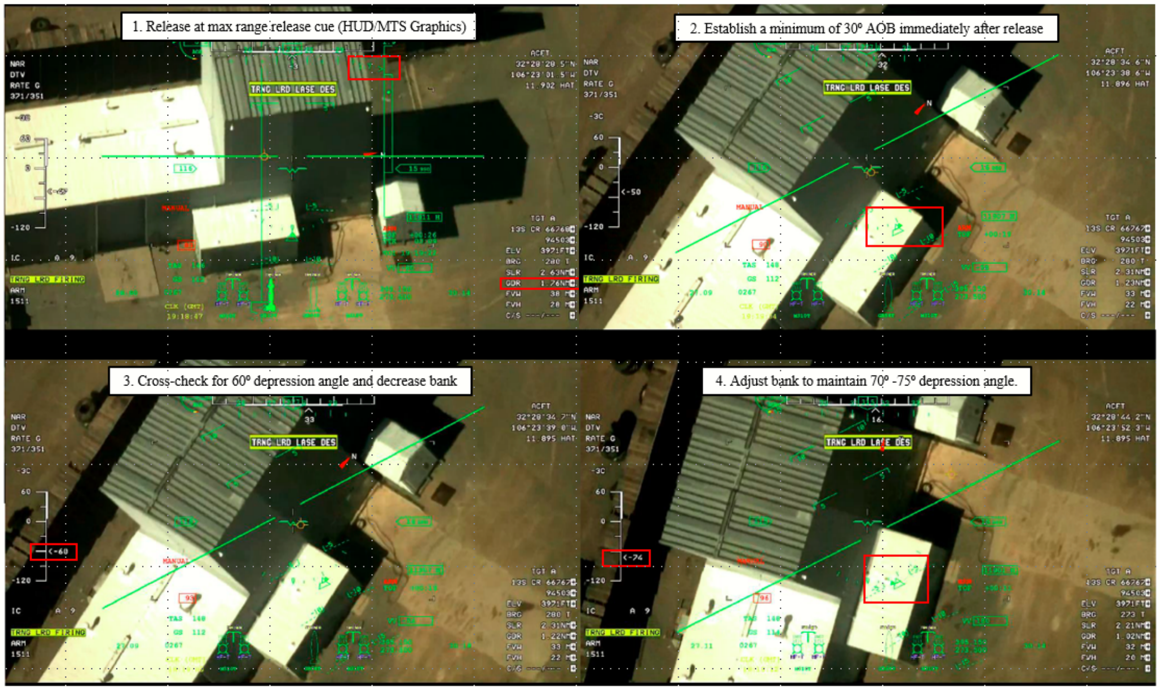
7.5.2.3 (FOUO) Execution. Once weapons checks/briefs are complete and the aircraft is established in position, barring any additional clearances/deconfliction, turn in to execute.

7.5.2.3.1 (FOUO) Turn-In and Final. Verify the aircraft has intercepted the planned offset run-in—failure to do so could result in unintended podium effect, nadir postrelease, and/or ineffective weapons effects. Modify the GBU-12/49/54 attack pacing on final as outlined in **paragraph 7.3.3.3.3.2**, Final, paying specific attention to the changes is release queuing. The pilot executes STAT cross-check and the SO the hub-and-spoke cross-check until the release point; the SO continues through Splash.

7.5.2.3.2 (FOUO) Release to Splash. Pilots remember that in manual release mode the trigger is "hot." At 10 seconds prior to desired release point press the Launch Enable button only; command release at the calculated release point (TTR, ground/slant range) as discussed in the manual delivery, **paragraph 7.3.3.3**, Manual Deliveries. Immediately following release, execute a 30-degree banked turn across the face of the target. Once bank is set, immediately cross-check depression angle; at 60 degrees depression, maintain the nadir cone short of the target by smoothly decreasing bank angle (as required) to capture 70 to 75 degrees depression. If the depression angle increases too rapidly to capture 70 to 75 degrees, the pilot should smoothly roll out to wings level. All bank angle changes must be smooth and deliberate as every degree of change will rotate the TGP. As the TGP azimuth passes 90 degrees, an increase in bank angle away will be necessary to keep the aircraft look angle as perpendicular to the target face as possible and to slow the rate of target rotation in the TGP. However, weigh this additional bank against the TOF remaining to provide the SO a stable platform. At Splash, the SO will accomplish postimpact procedures. See **Figure 7.21**, GBU-12/49/54 Vertical Target Attack Cross-Check Postrelease.

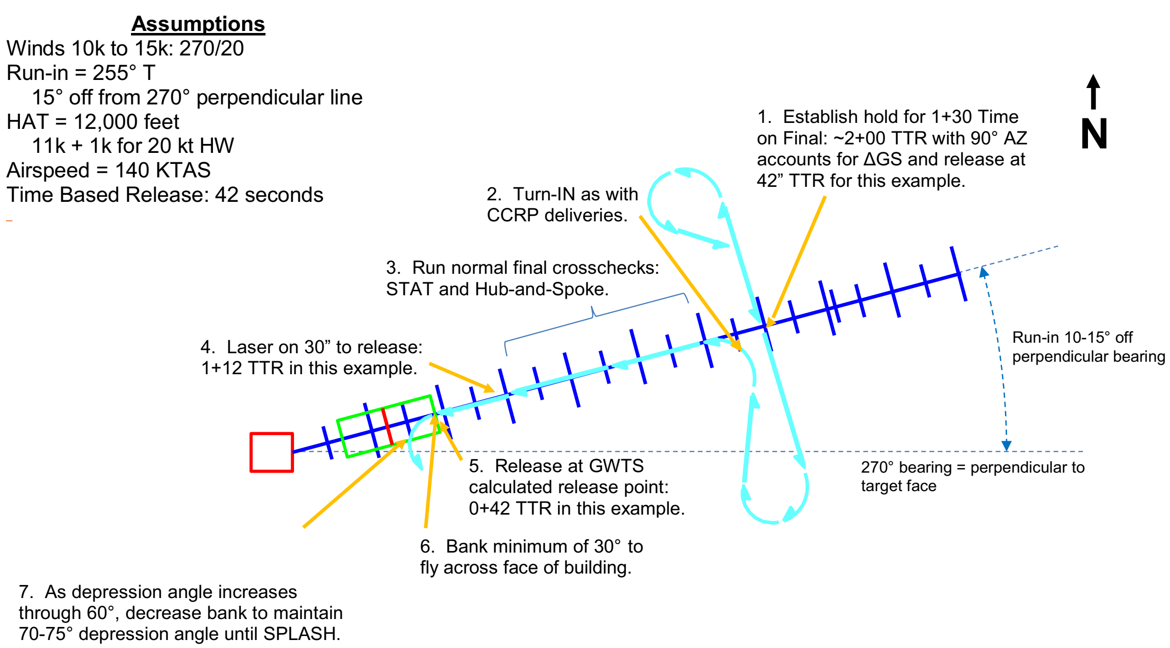
7.5.2.3.3 (FOUO) Egress. At Splash, the aircraft is at a near tail aspect to the target. Continue to maneuver the aircraft to increase range and set up for a possible reattack. **Figure 7.22**, GBU-12/49/54 Vertical Target Attack, depicts the entire GBU-12/49 attack against a vertical target.

Figure 7.21 (FOUO) GBU-12/49/54 Vertical Target Attack Cross-Check Postrelease.



FOUO

Figure 7.22 (FOUO) GBU-12/49/54 Vertical Target Attack.



FOUO

7.6 (FOUO) Low Height Above Target Employment Procedures. Low height above target (Low HAT) procedures are defined as weapons employment below 10,000 feet HAT for AGM-114 and GBU-12. This section will discuss the AGM-114 and GBU-12 TTP Low HAT employment only as the GBU-38 minimum release altitude is 12,000 feet.

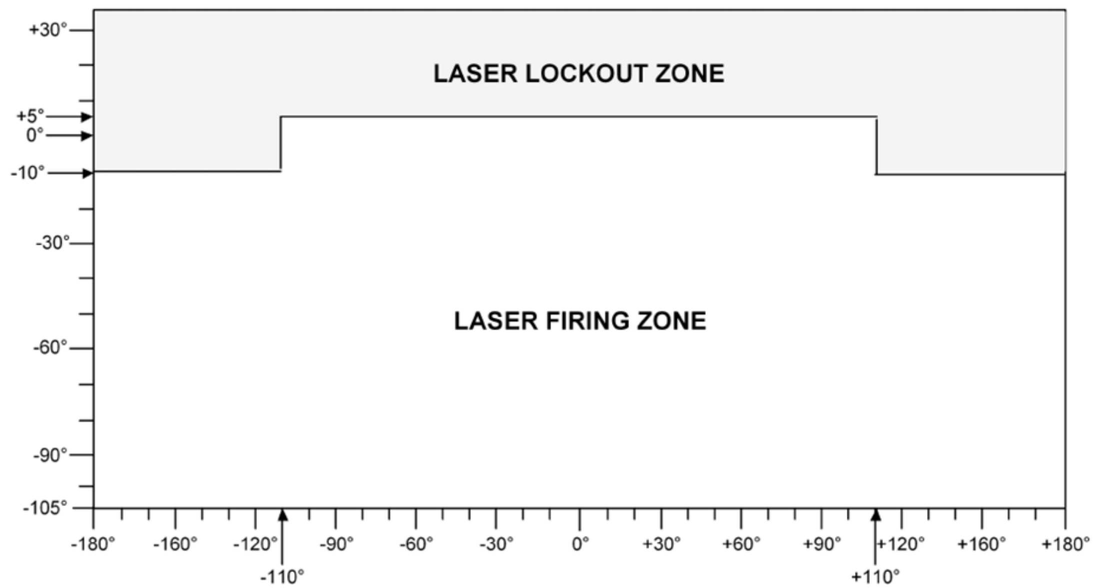
7.6.1 (FOUO) Low HAT vs LOWAT Flying Operations. It is critical crews do not confuse Low HAT employment procedures with LOWAT operations. LOWAT operations for the MQ-9 is defined as operating at or below 5,000 feet AGL. For more detailed information regarding LOWAT, see **Chapter 3**, "Aircraft Fundamentals" and **paragraph 3.5**, Low Altitude.

7.6.2 (FOUO) Low HAT Effects. Low HAT effects provide a different perspective of the target area and increased potential for masking.

7.6.2.1 (FOUO) Different Line of Sight. When compared to medium altitude employments where the LOS to the target almost always includes the tops of targets, the Low HAT environment is predominantly a side LOS view to objects in the target area. During weapons employments, this LOS difference will force the crew to choose an aimpoint on the side of the target or delay selecting/refining an aimpoint until much closer to the target.

7.6.2.2 (FOUO) Masking. Target and aircraft masking are both more of an issue in the Low HAT environment. Buildings and other obstructions that may not be a factor at medium- and high-altitude engagements can become problematic during a Low HAT engagement, especially with Wheel orbits or Shoot-Crank engagements where the bearing to target/aimpoint is changing with a weapon in flight; particularly against vertically developed targets. Before any engagement, crews should analyze the target area to include the look angle at the target throughout the weapons TOF with respect to intended aircraft maneuvering to ensure that laser energy will not be masked by the aircraft. At typical hold ranges to the target, the depression angle is much less than medium altitude, this causes the aircraft to be placed into the laser masking region frequently, specifically during banks. **Figure 7.23**, Laser Masking Region, depicts the MQ-9 laser masking region. Use these regions during planning to determine when to expect aircraft masking, as it will occur as depression angles decrease past the laser masking region. In addition to mission planning, during flight reference the "thicker" portions of the azimuth and depression angle scales on the HUD - these are indications of real-time laser mask regions. While in the hold, the crew must balance the need to maintain track of the target versus the need to manage aircraft positioning. Banking 30 to 40 degrees will mask the TGP from the target, but it minimizes time in masking region and keeps the aircraft ground track minimized while in the hold.

Figure 7.23 Laser Masking Region.



7.6.3 (FOUO) AGM-114 Low HAT. AGM-114 engagements in the Low HAT environment have more restrictive WEZs and do not provide as high of impact angles as shooting from medium altitude HATs. RMIT also does not have data below 2,000 feet HAT. The LOS to the target will remain fairly constant from Rifle to Splash as with medium altitude employments, but the LOS will have a much more horizontal look angle which means aimpoint selection must accommodate the changed perspective. Adaptations might include targeting the wall of a building vice the building roof, or the door of a vehicle vice the top of the vehicle. In the event of an aimpoint on the side of the target/vertical face, it recommended to change the launch mode to a LOAL-D to ensure laser acquisition and minimize spillover. Low HAT engagements should follow the five standard phases of attack as outlined in AGM-114 procedures in paragraph 7.3.2, AGM-114 Attack Procedures, with the following additional Low HAT procedures.

7.6.3.1 (FOUO) Game Plan. Initially vector the aircraft in the direction of the desired run-in for the attack. The crew must focus on vertical obstructions in the target area as they are more of a factor in the Low HAT environment. Crew should also anticipate masking throughout all maneuvering during Low HAT attacks. The refined hold game plan should plan to have an additional 1 to 2 km added to it in order to provide the SO additional time to reacquire the target if masking occurs during the Turn-In. The lower the HAT, the more frequently masking will occur. If the SO has a track established, they must be ready to break the track to keep the crosshairs near the target during masking. At HATs near 10,000 feet, bank can be reduced to mitigate masking while in the hold with a slight increase in turn radius. However, as HAT decreases, the bank angle reduction will cause significant increase in turn radius and the benefit of maintaining a smaller holding ground track will exceed the cost of masking the target. Reducing range to the target can mitigate masking and must be weighed against R_{DL}. As a technique, plan the hold to accommodate an R_{DL} in front one-third of the LOAL-D WEZ with a maximum of 30 degrees off-azimuth.

7.6.3.2 (FOUO) Hold. Once established in, or in transit to the hold, preattack checks should be accomplished IAW **paragraph 7.3.2.1.2**, AGM-114 Preattack Checks, with the following highlights:

7.6.3.2.1 (FOUO) SMS. Set the SMS up in accordance with normal AGM-114 attack procedures. If employing in LOAL-H below a 5,000 feet HAT, the missile may climb above the launch altitude regardless of employment HAT (potentially over 1,000 feet). This is due to the M310 launcher's inherent negative cant and the overcompensation that results with an R-guidance missile attempting to capture the launch aircraft's altitude and trajectory shape. Above 5,000 feet HAT, this peak trajectory can vary from 0 to 100 feet above launch altitude (higher peak trajectories may result from shots in bank). RMIT provides at-a-glance visual reference of the peak trajectory. To ensure adequate deconfliction from any other assets, aircrew should establish lateral deconfliction measures when employing below a 5,000 feet HAT and consider selecting LOAL-D as the flight mode. For employments above 5,000 feet HAT, select LOAL-H or D based on the tactical situation.

7.6.3.2.2 (FOUO) Update. The pilot should consider manual update mode while in the hold to keep the HUD target information accurate in case of TGP masking in the hold. If not a factor, then Auto update mode is preferred.

7.6.3.2.3 (FOUO) Target/Track. Typical AGM-114 track considerations apply to a Low HAT situation with the biggest difference being that the target appears much larger in the typical FOVs during medium altitude employments. This may encourage the use of a point track, as it will grow as the size of the target changes throughout the engagement. It is important to realize that the view of the target may change drastically during both Shoot-Crank and Shoot-Press attacks; therefore, a smaller track that encompasses only the DPI may provide the best results.

7.6.3.2.4 (FOUO) Aimpoint. Select an aimpoint that is appropriate for the weapon impact angle, azimuth, and expected TGP LOS from Rifle to Splash to mitigate podium effect. **paragraph 7.8.4.4.1**, Podium Effect, discusses this in more detail. The DPI for a Low HAT engagement may be a vertical face (i.e., side of the target), rather than a horizontal surface (i.e., top of the target). The weapon effects should be carefully weighed when selecting an aimpoint on a vertical face, as the on-screen view of the target may change throughout the course of the engagement, altering the sensor's ability to guide the weapon to the desired aimpoint for weapon effects. Place aimpoints on the side of vehicles to minimize spillover and the seeker's inherent long last pulse logic (LLPL) that will force the seeker to guide to the furthest return of laser energy.

7.6.3.2.5 (FOUO) Restrictions/Run-In. Brief restrictions and the planned run-in. The crew should check the run-in for possible masking and podium effect based on the aimpoint. The Low HAT environment will typically restrict a shot to be an on-azimuth engagement.

7.6.3.2.6 (FOUO) Shift. The crew should brief a shift as with normal weapons employment procedures. Pay diligence to the shift direction and shift point to ensure vertical obstructions do not exist and the weapon will have LOS with the laser spot.

7.6.3.2.7 (FOUO) Egress. An on-azimuth engagement with a Shoot-Press is preferred as it provides the least potential for laser, aircraft and environmental masking (e.g., vertical obstructions), and podium effect during the TOF. It does however increase the postimpact maneuvering required for reattacks and the potential for nadir/aircraft masking during said maneuvering. A Shoot-Press shot from the wheel or with greater than 90 degrees of azimuth at release has the potential to enter the laser masking region at very Low HATs as the depression angle will decrease as the aircraft continues to fly away from the target. Turning into the target after release will keep the aircraft closer to the target, but also decreases depression angle. It may be necessary to bank away from the target and use opposite rudder and increase the depression angle to maintain desired range to prevent laser and/or aircraft masking. Elect either a Shoot-Press or Shoot-Crank based on situational restrictions. With a Shoot-Crank, anticipate a rapid depression angle increase from an on-azimuth shot to the wheel. As the TGP azimuth approaches 90 degrees, smoothly roll out early to minimize TGP rotation. A Shoot-Crank into the target from the wheel has a high potential for laser and/or aircraft masking in the beginning of the cranking maneuver. The pilot must cross-check the depression angle on the crank inbound to avoid the laser masking region. Cross-check RMIT real time footprint for all engagements looking for the missile run-in and assess the possibility for podium effect if the aimpoint is on the side of the target of the missile if the run-in differs greatly than the TGP bearing to the target.

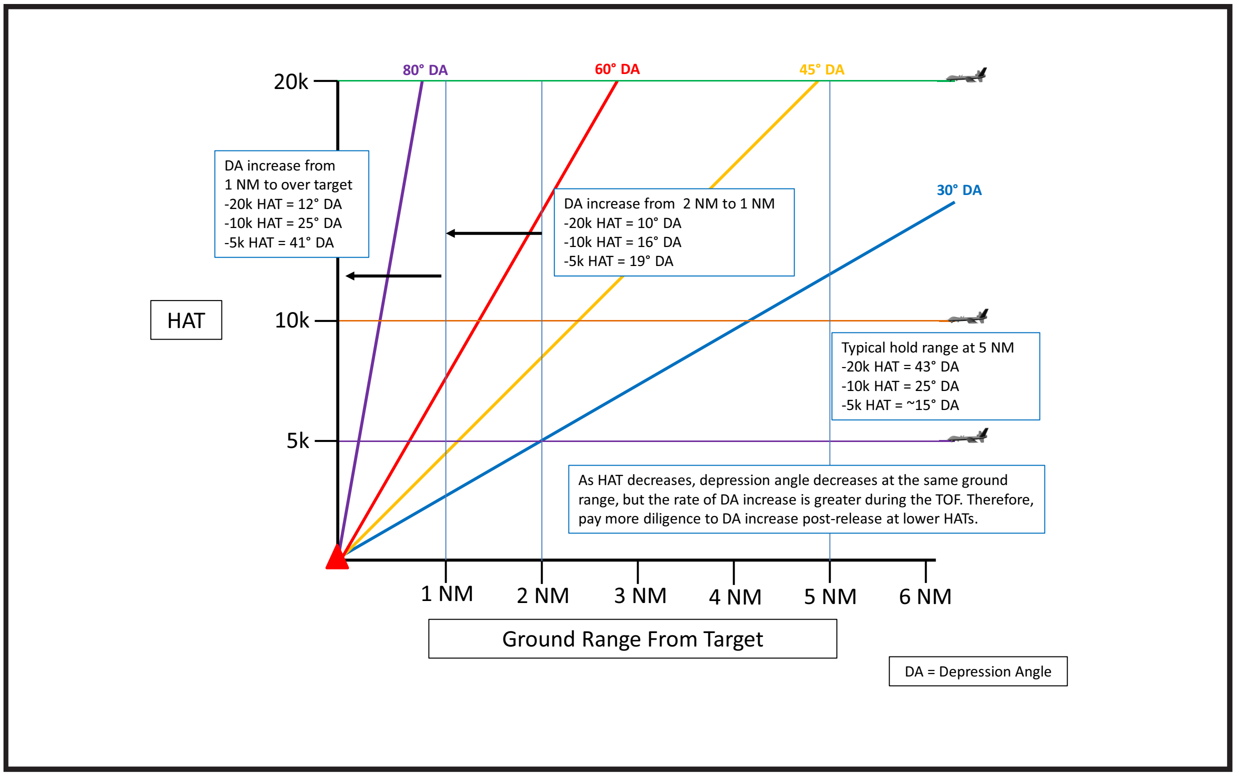
7.6.3.3 (FOUO) Execution. Once the aircraft is in position with the brief complete, execute the attack using normal AGM-114 attack procedures as outlined in **paragraph 7.3.2.1.4** [On Azimuth] Execution, and **paragraph 7.3.2.2.2**, [Off-Azimuth] Execution. The following paragraphs detail the specifics for LOW HAT procedures.

7.6.3.3.1 (FOUO) Turn-In. Execute the Turn-In for on-azimuth engagements with awareness on the depression angle and TGP azimuth to avoid aircraft masking. The SO should ensure the aircraft is out of the laser masking region, prior to firing the laser.

7.6.3.3.2 (FOUO) Final. Once the aircraft is on final, the STAT cross-check remains the same for the pilot. For on-azimuth engagements, as the range decreases towards R_{DL}, the crew should refine the aimpoint if they were unable to determine one from the hold due to image fidelity or lack of LOS to the aimpoint. The SO executes hub-and-spoke cross-check with extra attention to laser masking and picture manipulation for the track plan.

7.6.3.3.3 (FOUO) Egress. After Splash conduct BHA/BDA and determine the need for a reattack. As the aircraft gets closer to the target in the Low HAT environment, it cuts through radials at a faster rate than medium altitude attacks. As a result, the aircraft may be in a nadir situation sooner than expected if using typical medium altitude depression angle cuing, as well as potential masking issues. **Figure 7.24**, Medium Altitude Versus Low HAT Depression Angle, depicts this relationship. Aircrew should be aware of the rapid increase of depression angle the closer the aircraft gets to the target in the Low-HAT environment. Both Shoot-Press and Shoot-Crank egress maneuvers as outlined in **paragraph 7.3.2.1.3**, AGM-114 Egress, are viable options when in LOW HAT. However, the Hellfire WEZ will have less off boresight capability with lower HATs and crews need to factor that into egress/reattack maneuvering.

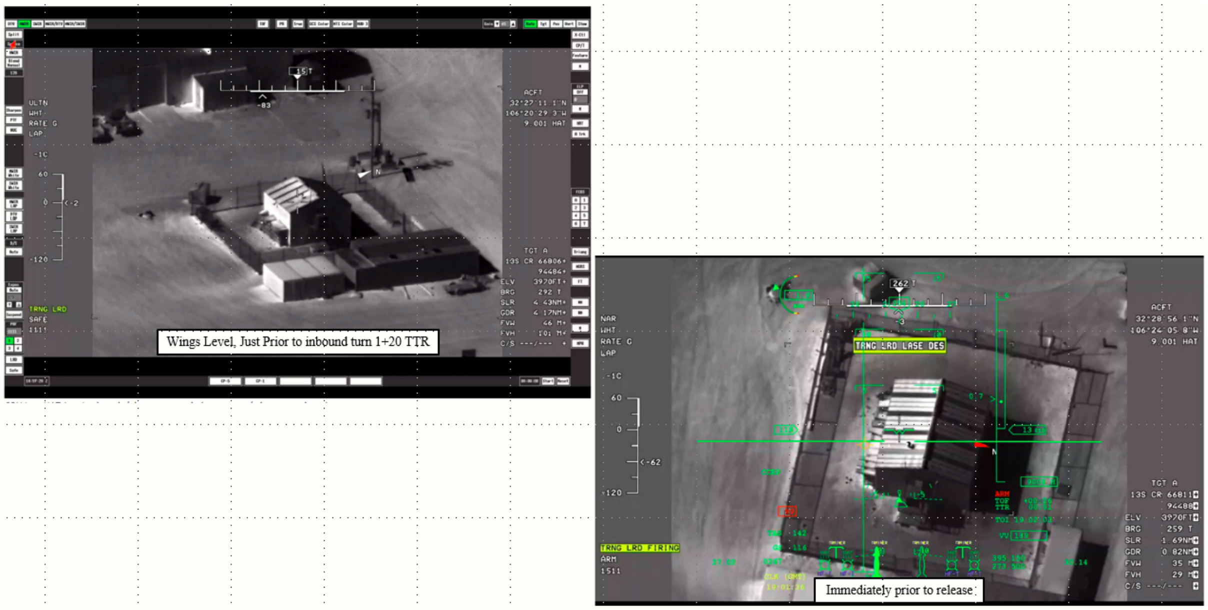
Figure 7.24 Medium Altitude Versus Low HAT Depression Angle.



7.6.4 (FOUO) GBU-12 Low HAT. GBU-12 low HAT employment have the same attack pacing up to release, but with a significantly different sight picture than medium-altitude employments for the SO and a different turning egress maneuver for the pilot. **Figure 7.25**, GBU-12 Low HAT TGP Picture Comparison, depicts the TGP picture initially after Turn-In, as well as prior to release.

7.6.4.1 (FOUO) Game Plan. Initial actions vector the aircraft to the anticipated hold for the attack. If not completed during mission planning and time/conditions permit, crews should run GWTS to determine release solution. Weaponeering must solve for the minimum 608 feet per second impact velocity at the anticipated/planned HAT. If not previously done so and unable to accomplish, recommend restricting execution to tailwind/no-wind engagements. If execution requires a manual release, execute procedures as described in **paragraph 7.3.3.3**, Manual Deliveries. Plan to position the aircraft to allow for 1+00 to 1+30 TTR on final in the low HAT environment; doing so will lead to aircraft masking while holding.

Figure 7.25 (FOUO) GBU-12 Low HAT TGP Picture Comparison.



FOUO

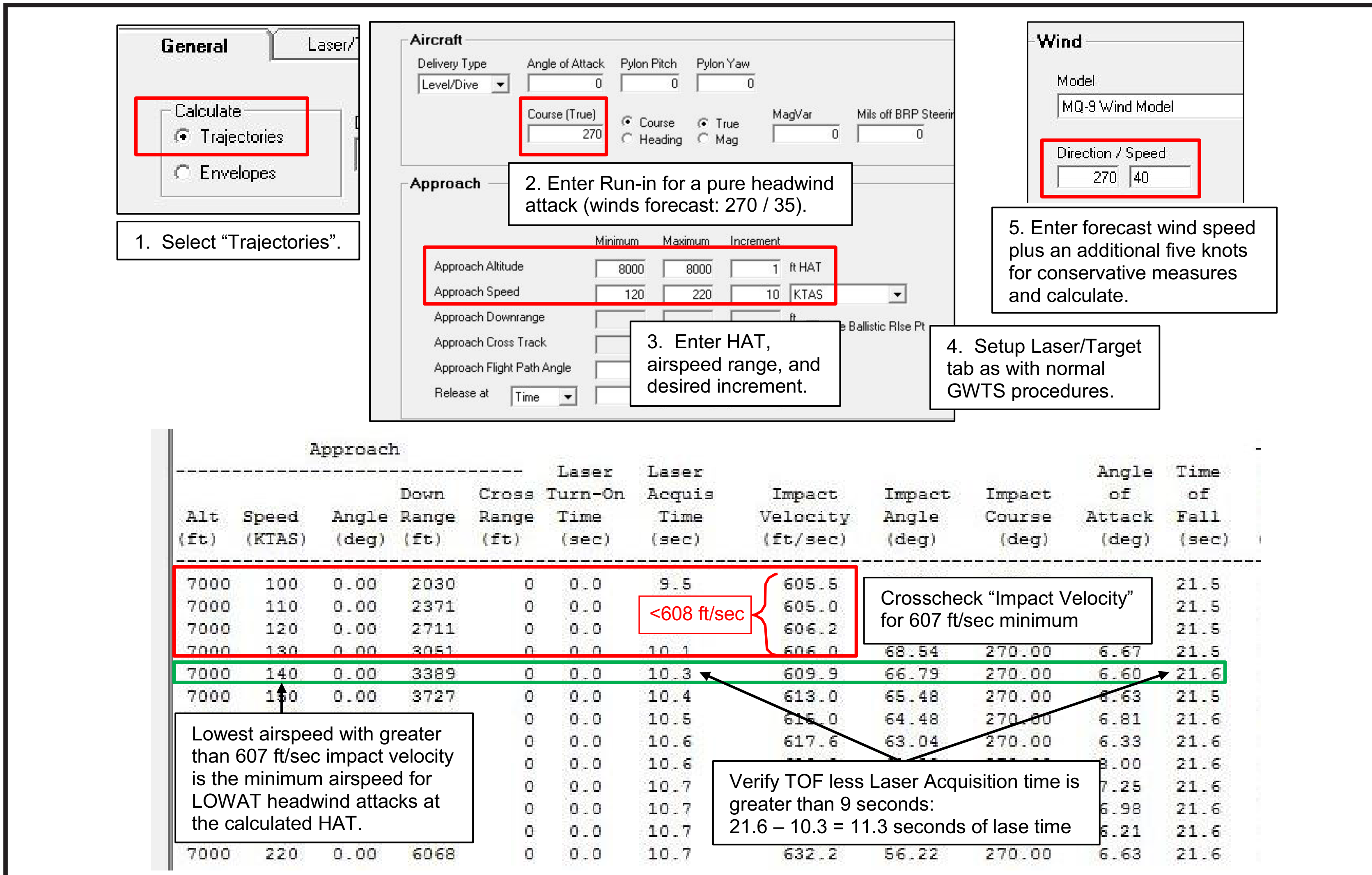
7.6.4.2 (FOUO) Hold. Masking concerns while established in the hold are the same as with an AGM-114 Low HAT engagement, see **paragraph 7.6.3.1**, Game Plan After the aircraft holding game plan is developed and the aircraft is either flying to or established in the hold, accomplish preattack checks.

7.6.4.2.1 (FOUO) Preattack Checks. Run SLAPUM WTARSEC as discussed in **paragraph 7.3.3.1.3**, Preattack Checks, with the following highlights.

7.6.4.2.1.1 (FOUO) Airspeed. Unless weaponeered to ensure impact velocity greater than 607 fps, reference applicable Shot-Kill for minimum release airspeed requirements. If not releasing in CCRP, verify Manual is selected/depicted.

7.6.4.2.1.1.1 (FOUO) **Figure 7.26**, Using GWTS to Determine GBU-12 Headwind Low HAT Minimum Airspeed, provides an example to determine the minimum allowable GBU-12 employment airspeed based on anticipated attack parameters as typical operating altitudes place the MQ-9 well above 10,000 foot HAT.

Figure 7.26 Using GWTS to Determine GBU-12 Headwind Low HAT Minimum Airspeed.



FOUO

7.6.4.2.1.2 (FOUO) Track. Execute additional track management considerations during low HAT GBU-12 attacks. For example, the use of a point track that will grow with the target as it becomes larger in the FOV on the run-in and during the TOF. If a point track is not used, the SO may have to regrow an area track numerous times around new features due to the changing FOV on the run-in. Shadows in and around the target area may negatively affect track stability. The SO should have SA on the bearing of the shadow from the target in relation to the planned run-in line and adjust the track plan to minimize the shadows within the track gates. For area tracks, the sensor should make all attempts to create a track that encompasses the DPI only, with as little of the overall target as practical. This can reduce the amount of scene change within the track gates as the overall scene changes throughout the TOF. Each target is different and the aircrew should discuss the track possibilities if time allows prior to the attack. The constantly changing picture and short GBU-12 TOF in the Low HAT environment should prompt the SO to be prepared to engage the target without a track. Note that due to the smaller slant range, sensor inputs may have an exaggerated effect on crosshair movement when compared to the same inputs on medium altitude attacks.

7.6.4.2.1.3 (FOUO) Aimpoint. Initial aimpoint selection will be difficult due to the horizontal look angle at the target while in the hold and initially on final. DPI breakout will become much easier as the attack progresses and the crew should be prepared to reassess the aimpoint at 30 seconds TTR when the top of the target becomes more visible. Give special consideration to the reduced impact angle of the weapon (at impact) during Low HAT attacks.

7.6.4.2.1.4 (FOUO) Egress. The pilot has two options for postrelease egress maneuvering: Straight-Through or Turning Egress. If the tactical situation allows, the Straight-Through egress is recommended on GBU-12 low HAT deliveries, as it provides the least amount of a TGP rotation during the TOF.

7.6.4.3 (FOUO) Execution. Attack execution follows the same flow and pacing as medium altitude GBU-12 attack procedures as detailed in **paragraph 7.3.3.1.4**, Execution. The following subparagraphs highlight the differences in Low HAT procedures through each step of an attack.

7.6.4.3.1 (FOUO) Turn-In. Increase aircraft masking potential exists at the Turn-In on Low HAT attacks for the initial portion of the turn. Intercept the BSL in the same manner as normal GBU-12 attack procedures outlined in **paragraph 7.3.2.1.4.1**, Turn-In.

7.6.4.3.2 (FOUO) Final. Execute the same final attack pacing and crew specific cross-checks as medium altitude GBU-12 attacks outlined in **paragraph 7.3.3.1.4.2**, Final. At 1+00 TTR to 0+30 TTR, the focus should be on confirming/refining the DPI and the SO should assess the picture for additional features for increased track stability and track survivability.

7.6.4.3.3 (FOUO) Release to Splash. GBU-12 CCRP low HAT release is typically between 35 and 45 degrees depression angle. Immediately after release, the pilot should execute a Turning or Straight-Through egress. The SO should focus on the changes in the picture and the effects on the track and assess any required changes to increase track stability and then focus on crosshair control until Splash. Expect shorter TOF for Low HAT employments, typically between 17 and 26 seconds. Execute postimpact procedures after Splash.

7.6.4.3.3.1 (FOUO) Straight-Through Egress. Execute the straight-through egress in the same manner as in medium altitude attacks as outlined in **paragraph 3.4.3.2**, Straight-Through.

7.6.4.3.3.2 (FOUO) Low HAT Turning Egress. Low HAT turning egress considerations are podium effect, masking, nadir; and higher depression angles than medium altitude employments, plan accordingly. To execute the turning egress on a low HAT engagement, accomplish the following steps immediately after release:

7.6.4.3.3.2.1 (FOUO) At 69 degrees depression angle, bank 20 degrees into azimuth, increasing bank as required to maintain depression angle above 80 degrees until 90 degrees azimuth.

7.6.4.3.3.2.2 (FOUO) Decrease bank once azimuth is greater than 90 degrees to maintain depression angle greater than 60 degrees and minimize TGP rotation.

7.6.4.3.3.2.3 (FOUO) **Figure 7.27**, GBU-12 Low HAT Turning Egress, depicts the cross-check for this maneuver.

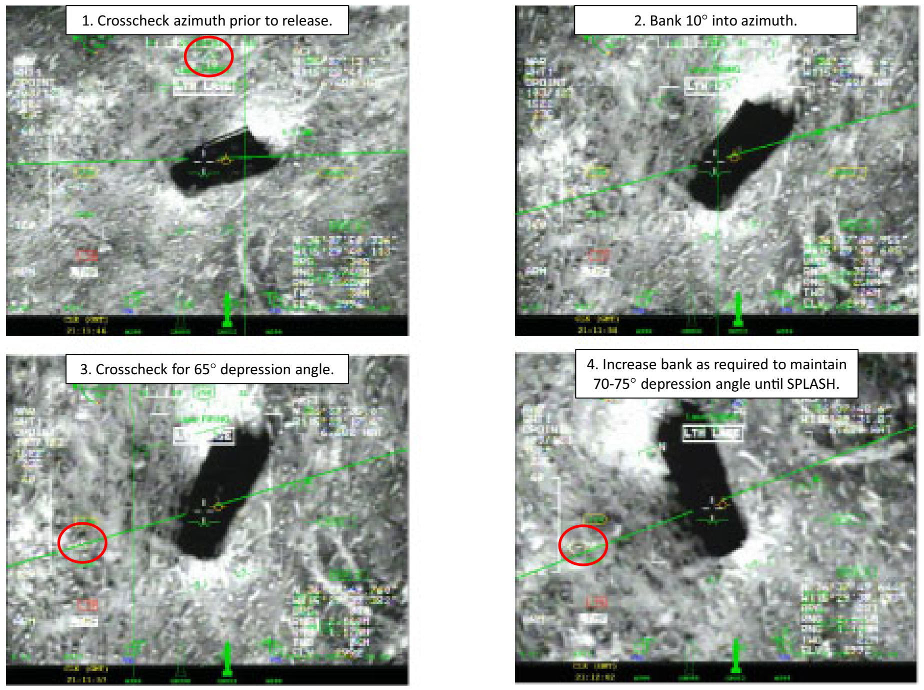
7.6.4.4 (FOUO) Egress. Execute egress procedures in accordance with medium altitude GBU-12 egress procedures from **paragraph 7.3.3.1.5**, Egress.

7.7 (FOUO) Timed Attack Procedures. Timed attack procedures require the crew to achieve weapon effects at a specific time. This can be for a variety of reasons such as in coordinated attacks to achieve simultaneous impacts or providing deconfliction between attack platforms. Additionally, different tactical situations require different levels of timing precision. For instance, a JTAC sequencing in aircraft fires every minute might accept 10 seconds of error; while an attack on two close proximity targets requires exact simultaneous impacts to mitigate potential for Squirters. On all timed attacks, it is critical to vector the aircraft immediately towards the run-in, determine the timing solution and develop the hold plan, prior to executing preattack checks. This provides the crew the ability to determine if they can achieve the timing requirement or if a ROLEX is required. In order to meet timed attack restrictions and determine the timing solution, the crew must use one of three timing methods: time of impact (TOI), planning tool, or control point (CP, GBU-38).

NOTE: As a rule of thumb, on timed attacks that require standard rate turns, use the following equation to determine bank at unplanned airspeeds (i.e., not at 165 KTAS).

(10 percent x TAS) + 7 = Standard Rate Turn Bank Angle (degrees)

Figure 7.27 GBU-12 Low HAT Turning Egress.



FOUO

7.7.1 (FOUO) Timing Methods. There are three types of timing methods: time of impact , planning tool, or control point (CP, GBU-38).

7.7.1.1 (FOUO) Time of Impact Timing. OFP 2407 and beyond incorporates a new timing tool that eliminates the need for the CP timing method under most conditions. TOI works with HF, GBU-12 CCRP, and LJDAM/JDAM LARs with a stationary target. The TOI tool on the HUD calculates the current GMT, TTR, and TOF at R_{DL}. The TOI takes winds into account through a calculated, not measured, wind vector. The TOI works best when transitioning from a crosswind hold to tailwind/headwind final. Under multiple tests of HF/54 TOTs, when executing the XW to TW/HW the TOI was never off by more than 5 seconds. However, when executing TW/HW to XW the delta was anywhere from 10 to 30 seconds with the error increasing with higher azimuths/winds over 20 knots.

7.7.1.1.1 (FOUO) TOI Assumptions and Limitations. Assumptions for TOI calculations include a 3 degree per second heading change (standard rate) during a turn. Additional limitations include TOI accuracy decreasing as winds increase beyond 75 knots. TOI will not display if the aircraft is between the target and R_{DL} and outside of a valid WEZ. Also, in Manual release mode, the pilot must manually enter the TOF. As previous stated, TOI bases its calculations on TTR, TOF, GMT, R_{DL}, and whether or not Manual or WEZ release mode is selected. Testing also revealed that once past 120 degrees azimuth the TOI for all run-ins will start to induce larger errors; recommend staying within 120 degrees of run-in on the final turn.

7.7.1.1.2 (FOUO) TOI GBU-38/49/54 Limitations. Due to TOI not being calculated for GBU-38, GBU-54, and GBU-49 in LAR Release Mode, it is recommended to use the current timing TTP prescribed in this publication. Additional TTP to meet timed attacks include TOI method using Manual Release Mode and Planning Tool method using LAR Release Mode. Both methods require determining a predicted release point and associated TOF prior to execution. Considerations for TTP selection include flying the parameters planned in GBIT for the composite LAR in Manual Release Mode or converting a TOT to a TTT with a countdown timer and Planning Tool. There are tradeoffs for both. Running GBIT takes time and aircrew are restricted on the ability to adjust run-in and airspeed on final resulting in limited timing corrections on final. Planning Tool also takes time and a timer is required to match the TTZ. However, aircrew have the benefit of an auto LAR. The difference between the preferred TTP is the ease of TOI or flexibility of an auto LAR. For LAR Release Mode TTP, see **paragraph 7.7.4**, GBU-38 Timing Attacks.

7.7.1.2 (FOUO) Planning Tool. This method uses the Planning Tool to provide accurate calculations based upon data input which then calculates the Turn-In time and determines the timing solution with the use of a countdown timer. It is possible to accomplish an attack using the Planning Tool Method without a timer by using the GMT clock in the cockpit but it is not recommended as the timer simplifies execution. For attacks with a TTT, start the timer at the HACK. For attacks with a TOT, determine the time remaining until the TOT at the next top of the minute on the GMT clock in the cockpit, enter that time in the timer and start the timer at the top of the next minute. For example, an AGM-114 TOT is at 15:29:00 and the current time is 15:25:35. At 15:26:00 there will be 3 minutes until the TOT. Enter 3+00 into the timer and start the timer when the cockpit GMT time says 15:26:00. The Planning Tool requires the pilot to input the attack and aircraft parameters in order to perform the math calculations necessary to determine the timing solution for when to leave the hold and arrive at the desired release point on time. The majority of work for successful execution with the Planning Tool requires accurate settings and an understanding of the numerous amounts of data presented for AGM-114, GBU-12, GBU-38, and GBU-49 holding and timing solutions. **Figure 6.11**, Planning Tool Features, provides these data points. **Table 6.3**, Planning Tool v11.65 Assumptions and Mitigations, details the assumptions the Planning Tool uses to calculate the timing solution. A significant limitation is that v11.65 assumes an instantaneous bank; meaning that the hold/turn-in data calculated is based on the assumption that the aircraft immediately transitions from wings level in the hold to the planned angle of bank. Recommended execution technique is to turn at planned bank angle mitigating overbank and assess corrections on final (approximately less than 4 seconds of error for a 90 degree turn). Alternative execution technique is to add 5 degrees to the planned AOB for the first half of the turn-in, then reduce bank to the planned AOB for the second half of the turn-in to minimize timing errors. Release triggers using Planning Tool are when the time remaining on the timer equals the displayed TOF (RMIT/TOI) for AGM-114s, and when the timer reaches zero for GBU-12/38/49/54s.

7.7.1.3 (FOUO) Control Point. CP timing uses the CP tool on the Tracker display to provide the aircraft timing solution. Place the CP at the R_{DL} within the zone LAR for GBU-38 timed attacks. The Tracker display provides time to control point (TTCP) and time at control point (TACP) which provide awareness to the aircraft's timing solution. The CP method requires the pilot to place the CP accurately on the Tracker display as well as accomplish basic math to calculate the Turn-In time from the hold and meet the timing solution.

7.7.1.3.1 (FOUO) CP Timing Math and Assumptions. The basic math consists of the Time-to-Turn and the Delta ground speed once on final. The time-to-turn is the time it takes the aircraft to complete a 90 degree turn using standard rate bank angles to intercept final. This equates to approximately 23.5 degrees of bank at 165 KTAS, the timed attack planned airspeed. CP timing assumes a 1:1 ratio between wind speed and the change in ground speed. This assumption is most accurate when holding between 5 and 7 NM from the CP. If the aircraft is closer than 5 NM to the CP, the CP timing math will lead to the aircraft being early once on final. If the aircraft is further than 7 NM from the CP, the CP timing math will lead to the aircraft being late once on final. Delta ground speed calculations are the easiest when the run-in is oriented parallel or perpendicular to the wind direction. **Figure 7.28**, CP Timing Assumptions, depicts the assumptions and application to CP timing.

7.7.2 (FOUO) AGM-114 TIMING. All timing methods can be used on AGM-114 timed attacks to meet a TOT or TTT, the pilot should be proficient with all techniques as the tactical situation might drive one method to be used over others.

7.7.2.1 (FOUO) Intent. There are a number of circumstances why a TOT may be given. The intent can vary between certain impact parameters on a target, synchronizing dissimilar weapons and/or assets, or simply to meet a specific time of weapons impact. The crew must determine the intent prior to executing the attack.

7.7.2.2 (FOUO) AGM-114 Time of Impact (TOI). AGM-114 Time of Impact (TOI). A thorough understanding of the limitations of this technique are critical in assessing if it is the best option for release. See **paragraph 7.7.1.1**, Time of Impact Timing, and **paragraph 7.7.1.1.1**, TOI Assumptions and Limitations, when determining the game plan for execution. See **Table 7.7**, Hellfire Manual Release Mode Calculations, and **Table 7.8**, Hellfire WEZ Release Mode Calculations, for a breakdown of TOI calculations for the AGM-114. There are two options for this method and both require a thorough understanding of the intent.

7.7.2.2.1 (FOUO) Game Plan. The first option is to set an R_{DL} beyond the hold distance of the aircraft relative to the target and use the TOI as a means of instantaneous assessment of when the Hellfire would reach the target (assuming a valid release in AUTO WEZ). In this instance, hold in an unrestricted wheel until TOI equals TOT, and then Rifle. The second option, as seen in **Figure 7.29**, Hellfire TOI with WEZ Release Mode, is to set an R_{DL} that is closer to the target than the aircraft position and initiate a turn towards the target when the TOI equals the TOT. Doing so will enable the aircraft to arrive at the R_{DL} on time in order to Rifle and strike the target at the desired TOT. The following sections will focus on the second option where an R_{DL} is set and the aircraft is holding outside or at the R_{DL}.

Figure 7.28 CP Timing Assumptions.

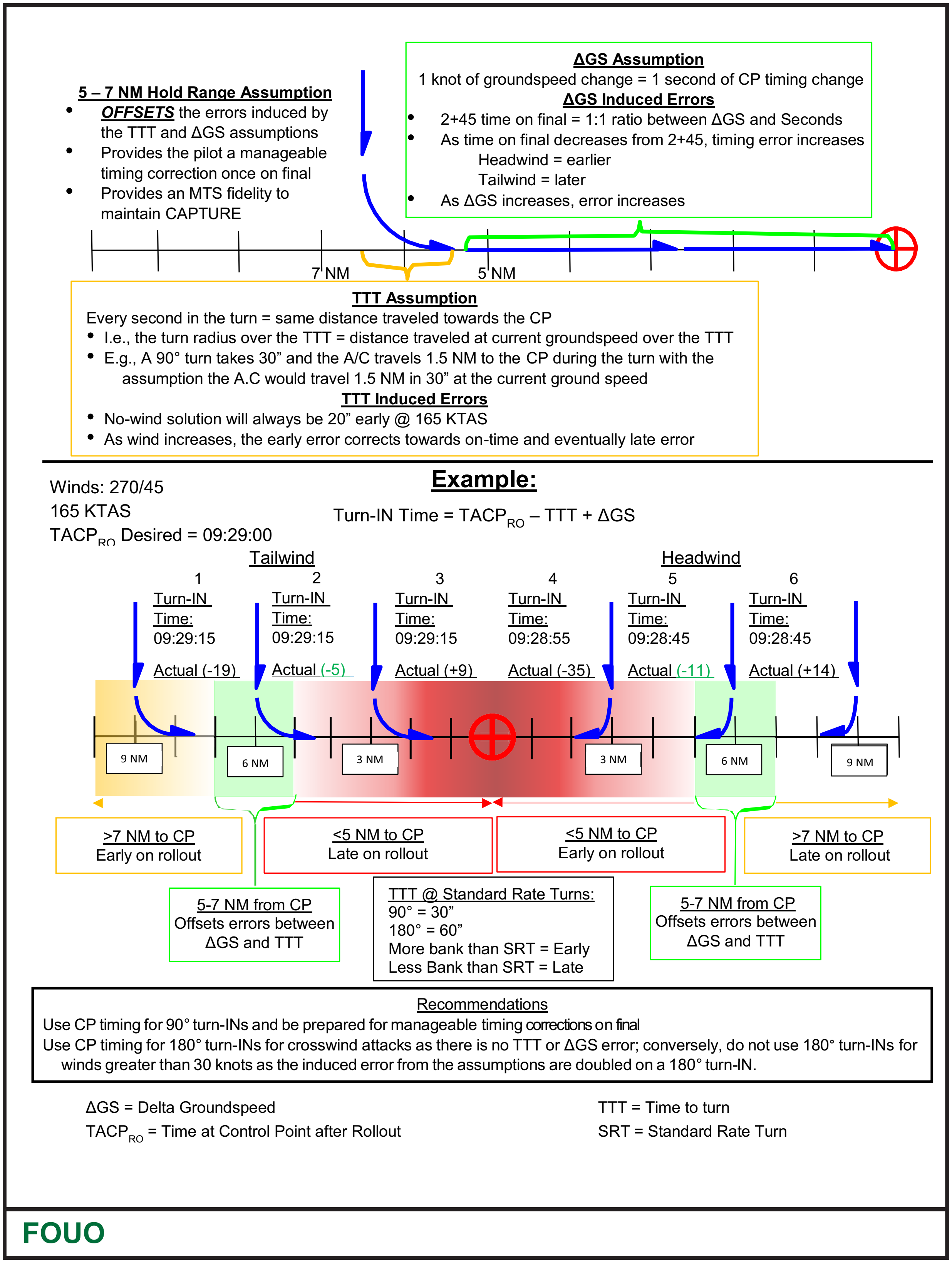


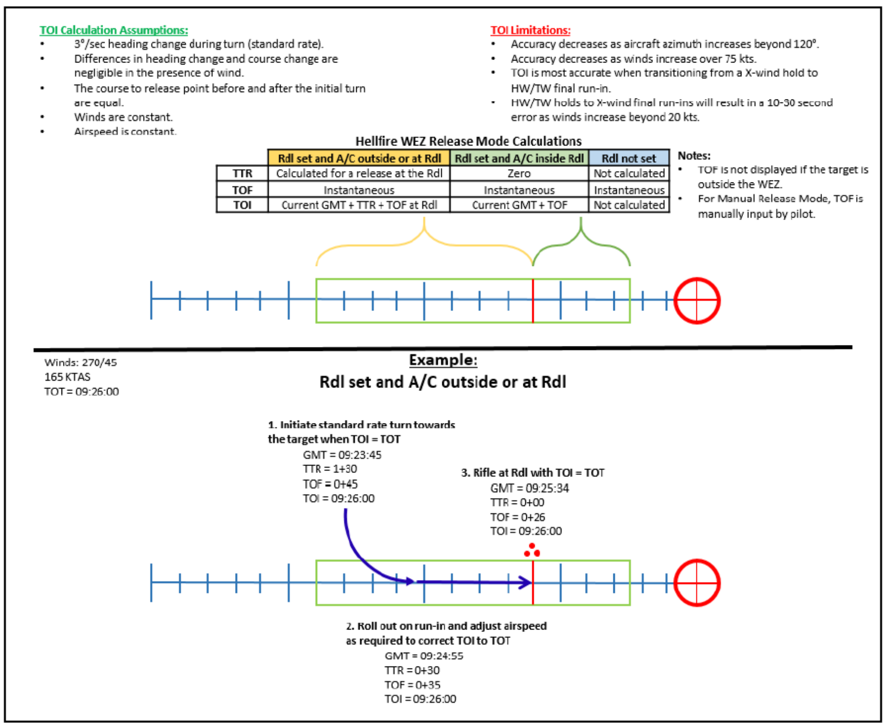
Table 7.7 Hellfire Manual Release Mode Calculations.

	R_{DL} set and A/C outside or at R_{DL}	R_{DL} set and A/C inside R_{DL}
TTR	Calculated for a release at the R_{DL}	Zero
TOF	Instantaneous	Instantaneous
TOI	Current GMT + TTR + TOF at R_{DL}	Current GMT + TOF

Table 7.8 Hellfire WEZ Release Mode Calculations.

	R_{DL} set and A/C outside or at R_{DL}	R_{DL} set and A/C inside R_{DL}	R_{DL} not set
TTR	Calculated for a release at the R_{DL}	Zero	Not calculated
TOF	Instantaneous	Instantaneous	Instantaneous
TOI	Current GMT + TTR + TOF at R_{DL}	Current GMT + TOF	Not calculated

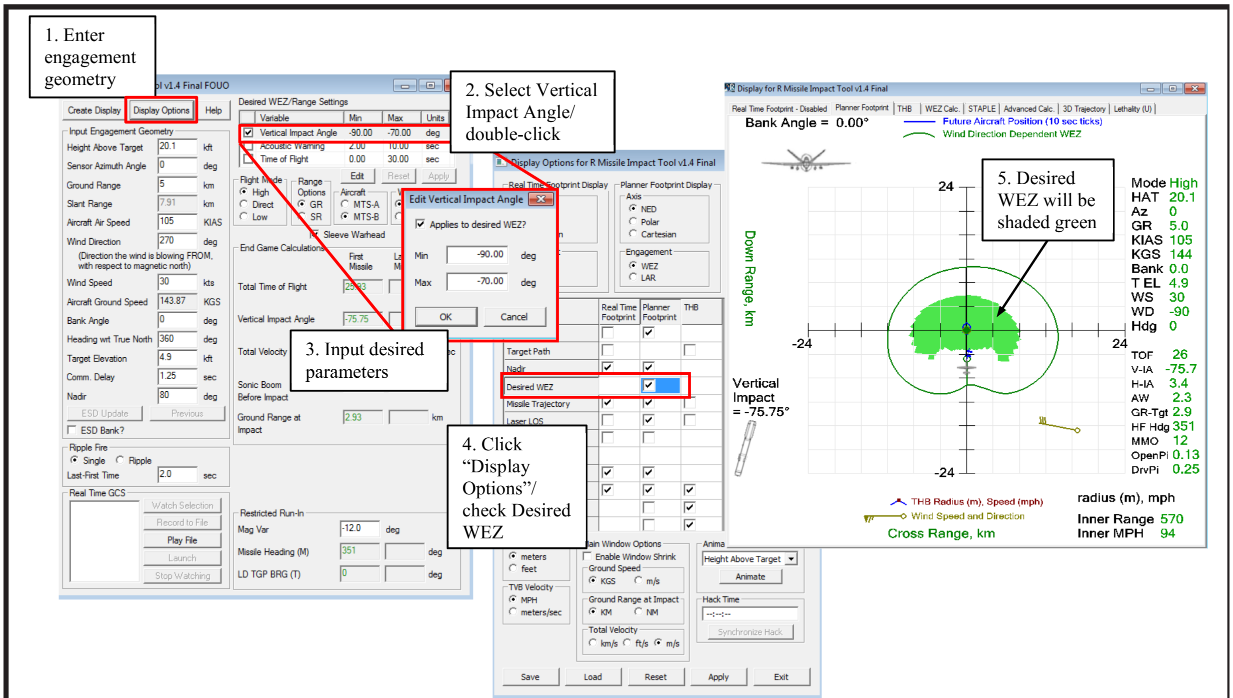
Figure 7.29 Hellfire TOI with WEZ Release Mode.



7.7.2.2.1.1 (FOUO) Developing Holding Game Plan. Assess the run-in, enter it into the SMS (displayed in TRUE or MAG) and direct the aircraft towards the back of the WEZ, as depicted on the Tracker display. While maneuvering the aircraft in the direction of the hold, set airspeed as required, and assess the amount of time the crew has until weapons effects are required in order to determine if executing the

TOT is possible in the allotted time. Next, determine the R_{DL} using RMIT. If a specific minimum impact angle is required, enter the impact angle into the Desired WEZ information on RMIT. **Figure 7.30**, Using RMIT to Determine R_{DL}, depicts this process for a target requiring an impact angle of 70 degrees or more. If the desired impact angle can be achieved throughout the WEZ, simply choose an R_{DL} in the WEZ. To allow for time to correct on final, hold the aircraft 6 to 9 km from the R_{DL}, with wind corrections so that you can complete turns into the target. This will result in increased distance to the target while established in the hold. Holding closer will not decrease the accuracy of TOI, however, if corrections on final are required, a closer hold will limit the options and ability to adjust timing on final. Additionally, maintaining a 90 degree azimuth offset will provide the highest accuracy of the TOI. Accuracy begins to diminish as azimuth increases beyond 120 degrees.

Figure 7.30 Using RMIT to Determine R_{DL}.



FOUO

7.7.2.2.2 (FOUO) Hold. Once the hold plan has been developed and the aircraft is flying en route to the hold, or established in the hold, cross-check TOI to assess time to kill and run preattack checks. To simplify execution and mitigate known limitations inherent in this method, execute a Figure Eight crosswind hold to a headwind or tailwind final.

7.7.2.2.2.1 (FOUO) Determining the Timing Solution. To determine the timing solution, the pilot must assess the aircraft position initially, once established in the hold, and each time the aircraft approaches the Turn-In point that would align the aircraft on final with the desired run-in. When the aircraft is at this point, cross-check TOI on the HUD and determine the Delta between it and the TOT. If the TOI is within 45 seconds, continue the hold and Turn-In on time. If greater than 45 seconds from TOT time, develop a plan to kill time in the hold. Ensure the aircraft is at 90 degrees azimuth to the target when determining the Delta.

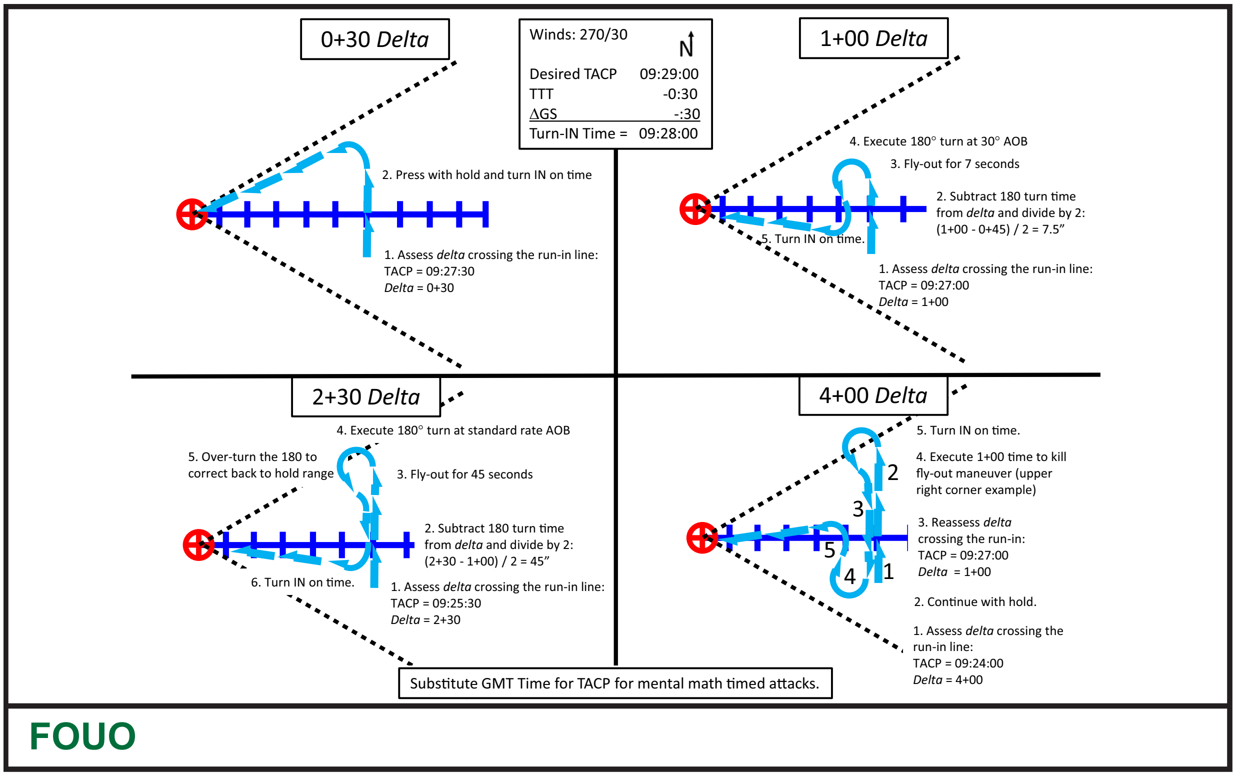
7.7.2.2.2.2 (FOUO) Killing Time-In the Hold. The objective of killing time in the hold is to provide an accurate timing solution while in the hold in order to minimize timing corrections once established on final. Minimal corrections on final equate to more time dedicated to effectively employing the weapon. To kill time in the hold, calculate the Delta as discussed in the previous paragraph and execute one of the following rules of thumb to kill time in the hold based on the Delta:

- (FOUO) TOI less than 45 seconds to the TOT time, continue hold and turn in on time.
- (FOUO) TOI between 0+45 and 3+00 to the TOT time, execute a timed fly-out maneuver to kill the exact amount of time remaining in the hold.
- (FOUO) TOI greater than 3+00 to the TOT time, continue the hold plan and turn at the hold boundary.
- (FOUO) These numbers provide rough decision criteria for the pilot to execute the hold and kill the appropriate amount of time prior to Turn-In.

7.7.2.2.2.3 (FOUO) Fly-Out Maneuver. The purpose of a fly-out maneuver is to position the aircraft to have it arrive back at the desired run-in restriction on time. To execute a Fly-Out maneuver, take the Delta and subtract out the time it takes for a 180-degree turn (typically executed at standard rate). Take the remaining time and divide it in half. Using this result, cross-check the GMT clock time and fly perpendicular to the hold away from the run-in for the duration of the time calculated. Once the timed Fly-Out is complete, execute a 180-degree turn at the planned bank angle and head back to the run-in. A turn more than 180 degrees will be required to get the aircraft back to the same range when the Delta was calculated. Another option is to fly the outbound leg of the Fly-Out maneuver offset from the line perpendicular to the hold to create turning room so that the aircraft arrives at the desired range once rolled out on the inbound leg back to the Turn-In point. Once at the desired hold range and approximately 90 degrees of azimuth to the target, cross-check TOI and assess the Delta for the calculated TOT. If executed properly, as the aircraft approaches the run-in, the displayed TOI will be at the calculated TOT time; the crew should then turn-in and execute the attack. If the Delta to the TOT time is large, then repeat this process to kill the remaining time in the hold. If the Turn-In time has already passed, then immediately Turn-In and execute the attack. **Figure 7.31**, Killing Time-In the Hold for CP Timed Attacks, depicts examples of the Fly-Out maneuver and holding decision criteria.

7.7.2.2.2.4 (FOUO) Preattack Checks. Recommend solving for the timing solution prior to beginning SLAPUM WTARSEC, perform AGM-114 attack procedures as outlined in **paragraph 7.3.2.1.2**, AGM-114 Preattack Checks.

Figure 7.31 Killing Time-In the Hold for CP Timed Attacks.



7.7.2.2.3 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.2.1.4**, Execution, for on-azimuth attacks with the following highlights; note the timing solution is the trigger that drives the Turn-In and attack pacing.

7.7.2.2.3.1 (FOUO) Turn-In. Cross-checking the TOI on the HUD, the pilot turns-in when the TOI matches the TOT time; execute this turn at standard rate and intercept final. On the turn-in, the pilot should assess if they are early or late. If the TOI is greater than the TOT, then they are late. If the TOI is less than TOT, then they are early. If they are early, the pilot can reduce bank angle as required (staying within desired restriction) to match the TOI to TOT time. If they are late, they can increase bank angle as required to match the TOI to TOT time.

7.7.2.2.3.1.1 (FOUO) Turn Time Adjustment. For more accurate turn-in time corrections see **Table 7.9**, Turn Time Adjustment Relative to AoB Change, which provides rules of thumb for the effect increasing or decreasing bank can have on time in the turn. Based on a 90 degrees standard rate turn taking 30 seconds, the times in the table reflect the increase or decrease in time throughout the turn. Positive times indicates the time in seconds you will make up in the turn if initiated 90 degrees off azimuth (i.e., increasing AoB from standard rate to 30 degrees at 145 KTAS will reduce the turn time by 10 seconds from 30 seconds to 20 seconds). Negative times indicate the time in seconds you will lose in the turn if initiated 90 degrees off azimuth (i.e., decreasing AoB from a standard rate turn to 15 degrees at 165 KTAS will increase the turn time by 21.4 seconds from 30 seconds to 51.4 seconds).

Furthermore, the inverse of the AoB change will correlate to the same time adjustment (i.e., decreasing AoB from 30 degrees to 25 degrees at 185 KTAS will increase the turn time by 6.5 seconds from 26 seconds to 32.5 seconds). The best application of this information is to know that, at 165 KTAS, the turn can be initiated 8 seconds late and still roll-out on final on time as long as AoB is increased from a standard rate turn to 30 degrees.

7.7.2.2.3.2 (FOUO) Final. Once on final, run the STAT cross-check as outlined in **paragraph 7.3.1.4.2.1**, STAT Check, and assess the timing solution to determine if the aircraft is early or late. Cross-check TOI and make corrections to meet the TOT time.

7.7.2.2.3.2.1 (FOUO) Late Timing Correction. If the TOI on the HUD is later than the TOT time, the aircraft is late. Determine the Delta and speed up by commanding an airspeed increase that corresponds to the number of seconds late (e.g., 14 seconds late, increase airspeed hold by 14 knots from the current value). As the airspeed increases, cross-check TOI and assess the Delta between it and release time. Once the Delta is within 10 seconds, cross-check the current airspeed in the HUD and set its value into airspeed hold. As a rule of thumb, the aircraft can typically make-up about 10 seconds per minute on final. Based on the tolerance for the TOT and desired weapons effects, ABORT the attack if the TOI is outside the TOT tolerance or impact conditions will not meet desired weapons effects from the extended shot range.

Table 7.9 Turn Time Adjustment Relative to AoB Change.

AoB Change	145 KTAS	165 KTAS	185 KTAS
Std-10	-37	-49.6	-51.6
Std-15	-14.7	-21.4	-25.2
Std-30	10	8.3	5.7
Std-35	13.7	12.5	10.4
Std-40	16.4	15.6	13.8
15-15	22.2	28.2	26.4
15-20	12.1	14.7	14.9
20-25	7.5	9	9.5
25-30	5.1	6	6.5
30-35	3.6	4.2	4.7
35-40	2.7	3.1	3.5
FOUO			

7.7.2.2.3.2.2 (FOUO) Early Timing Corrections. If the TOI on the HUD is earlier than the TOT time, the aircraft is early. Determine the Delta and slow down by commanding an airspeed decrease that corresponds to the number of seconds early, not to exceed stall plus 5 knots (e.g., 22 seconds early, decrease airspeed hold by 22 knots from the current value, but not slower than 97 KIAS if stall speed is 92 knots). Beyond 10 seconds of error, geometry is another option to correct an early timing error if recognized early and at the beginning of the run-in. It is not recommended to use simultaneous airspeed and geometry corrections to fix early timing errors. Execute the applicable geometric maneuver to correct the timing solution and put the aircraft on time, initially turning the aircraft to better align with the desired run-in. However, geometric timing corrections may position the aircraft outside of planned employment parameters. Once geometric corrections are used, it is imperative that the aircraft is pointed back towards the CP, or else the TOI will be inaccurate. This may result in an off azimuth shot depending on how much geometry was used. See **Table 7.10** Geometric Timing Corrections, to see common geometric maneuvers to fix various timing errors. Refer to the current aircraft heading and use that to determine the heading changes for geometric error corrections.

7.7.2.2.3.2.3 (FOUO) Rifle to Splash. Rifle at desired R_{DL}, or the range that will meet the TOT, whichever has priority. As the actual Rifle time approaches and is within 10 seconds, the pilot should depress and hold the Launch Enable button and squeeze the trigger at Rifle time. Execute standard AGM-114 procedures from Rifle to Splash. After Splash, the SO accomplishes post impact procedures.

Table 7.10 Geometric Timing Corrections.

Geometric Maneuver	Time Killed	Actions
60-60	10 seconds	Cross-check heading, turn at standard rate for 60 degrees of heading change and then reverse turn back to steering.
90-90	20 seconds	Cross-check heading, turn at standard rate for 90 degrees of heading change and then reverse turn back to steering.
90-10-90	30 seconds	Cross-check heading, turn at standard rate for 90 degrees of heading change, roll out and drive wings level for 10 seconds, and then turn back to steering.
90- X -90	20 + X seconds	Cross-check heading, turn at standard rate for 90 degrees of heading change, roll out and drive wings level for X seconds, and then turn back to steering.
FOUO		

7.7.2.2.4 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.2.1.3**, AGM-114 Egress.

7.7.2.3 (FOUO) AGM-114 Planning Tool. Execute standard on-azimuth AGM-114 attack procedures in accordance with **paragraph 7.3.2.1.4**, [On-Azimuth] Execution, and the following procedures specific to AGM-114 timed attacks using the Planning Tool throughout the five phases of attack. Intent phase remains unchanged.

7.7.2.3.1 (FOUO) Time Based Planning Tool Attack. Recommend use when aircraft can establish the hold with greater than 3+00 TTT.

7.7.2.3.1.1 (FOUO) Game Plan. Choosing a HACK time and hold range that are a balance of minimizing potential holding errors, cross-check breakdowns, and options for turn time solutions is critical to effective execution.

7.7.2.3.1.1.1 (FOUO) Determining the HACK. When determining a HACK time, execute Time Based Planning Tool attacks with a minimum HACK of 3+00.

7.7.2.3.1.1.2 (FOUO) Holding Game Plan. Assess the run-in (direction and range), and direct the aircraft towards the back one-third of the WEZ, as depicted on the Tracker display. Immediately after maneuvering the aircraft in the direction of the hold, update the Planning Tool "9-Pack" at the top with attack parameters. For all attacks, run RMIT to determine the TOF for planned release parameters; **Figure 7.30**, Using RMIT to Determine R_{DL}, illustrates this process. Once the R_{DL} has been determined, input planned release range into "R_{DL}." Input the planned TOF and minimum seconds on final, then cross-check the "SMS Input" range and set it into the Desired Range in the SMS. Next determine a hold range to stake the aircraft at leading up to the attack.

7.7.2.3.1.1.2.1 (FOUO) Determining Hold. On the right side of the Planning Tool, use the desired hold distance container to select a hold range that provides a 180-In/Out time closest to 2+30 (rounding up or down as required), depending on HW/TW attack with turns into the wind. Once the hold range is determined, plan to execute a Modified Figure Eight hold within 30 degrees of the run-in at that range, regardless of restriction. Set the hack in the timer and start when the hack is called for a TTT, or start at the top of the corresponding minute for a TOT as discussed in **paragraph 7.7.1.2**, Planning Tool.

7.7.2.3.1.2 (FOUO) Hold. Enter and maintain a Modified Figure Eight hold at planned range, complete preattack checks, and assess position at a timer reading of 3+00.

7.7.2.3.1.2.1 (FOUO) Calculating Turn-In Time. The Planning Tool calculates numerous Turn-In times and the previously stated process to establish the hold identifies the specific Turn-In time for the attack. Execute the hold at the planned hold range to use these numbers. If the hold range changes due to poor aircraft positioning in the hold, then the Turn-In time will have to be updated real-time using the data on the right side of the Planning Tool for the new range.

7.7.2.3.1.2.2 (FOUO) Determining the Timing Solution. Fly the aircraft within 30 degrees of the run-in and at the planned range and airspeed, the Delta between the timer and 3+00 will give situational awareness to how much time to kill in the hold.

7.7.2.3.1.2.3 (FOUO) Killing Time in the Hold. Killing time in the hold can be accomplished using the Planning Tool's Turn-In time and 180-In and 180-Out times, The following procedures outline maneuvers for killing time in the hold.

7.7.2.3.1.2.3.1 (FOUO) Planning Tool Data Only. The aircraft needs to remain within 30 degrees of the desired run-in while in the hold. Position the aircraft to maintain the planned hold range at 90 degree azimuth, or adjusted for wind, when approaching the run-in line. See **Figure 6.11**, Planning Tool Features, for a description of Holding Crab Angle calculations.

7.7.2.3.1.2.4 (FOUO) Preattack Checks. Once the hold plan has been developed, and the timing solution has been solved, run SLAPUM WTARSEC in accordance with standard AGM-114 attack procedures as outlined in **paragraph 7.3.1.3.2**, Preattack Checks.

7.7.2.3.1.3 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.2.1.4**, Execution, for on-azimuth attacks, or from **paragraph 7.3.2.2.2**, Off-Azimuth Execution, for off-azimuth attacks, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.2.3.1.3.1 (FOUO) Turn-In Decisions. Regardless of when HACK is called (i.e., 3+00 or 10+00 HACK), assess aircraft position at a timer reading of 3+00 and execute one of the following 3 situations. These are based on current aircraft position in relation to a ± 10 degree decision zone. Execute the turn to final with the planned bank angle in the Planning Tool. Turn-In when the timer matches the Planning Tool's Turn-In time for the current range to the target and intercept final. Adjust this time 3 seconds early or late for every 10 degrees off of 90 Azimuth.

7.7.2.3.1.3.1.1 (FOUO) CASE 1—Inside of 10 degrees of run in: Fly straight for 15 seconds, then execute a 180-In/Out into the wind, then fly towards the run-in until the Turn-In time (approximately 15 seconds) and turn in on time as depicted in **Figure 7.32**, Time Based Planning Tool—Case 1: Within 10 degrees of Run-In. Technique: If inside 10 degrees but not at the run-in yet, fly out for 20 seconds, execute the 180 degree turn, then fly in for 10 seconds. This will position the aircraft closer to the run-in line for the turn-in.

7.7.2.3.1.3.1.2 (FOUO) CASE 2—Driving away from R_{DL} outside of 10 degrees of run-in: Execute an immediate 180-In/Out into the wind. Once established at the new ground range, turn in on time as depicted in **Figure 7.33**, Time Based Planning Tool—Case 2: Past the Run-In.

7.7.2.3.1.3.1.3 (FOUO) CASE 3—In or after the holding turn, and aircraft is not within 10 degrees of Run-In: Execute one of the two following events.

7.7.2.3.1.3.1.3.1 CASE 3A. If <45 seconds to Turn-In time, arc at nearest 0.5 km increment from the target, then turn in on time as depicted in **Figure 7.34**, Time Based Planning Tool—Case 3: During or After Holding Turn.

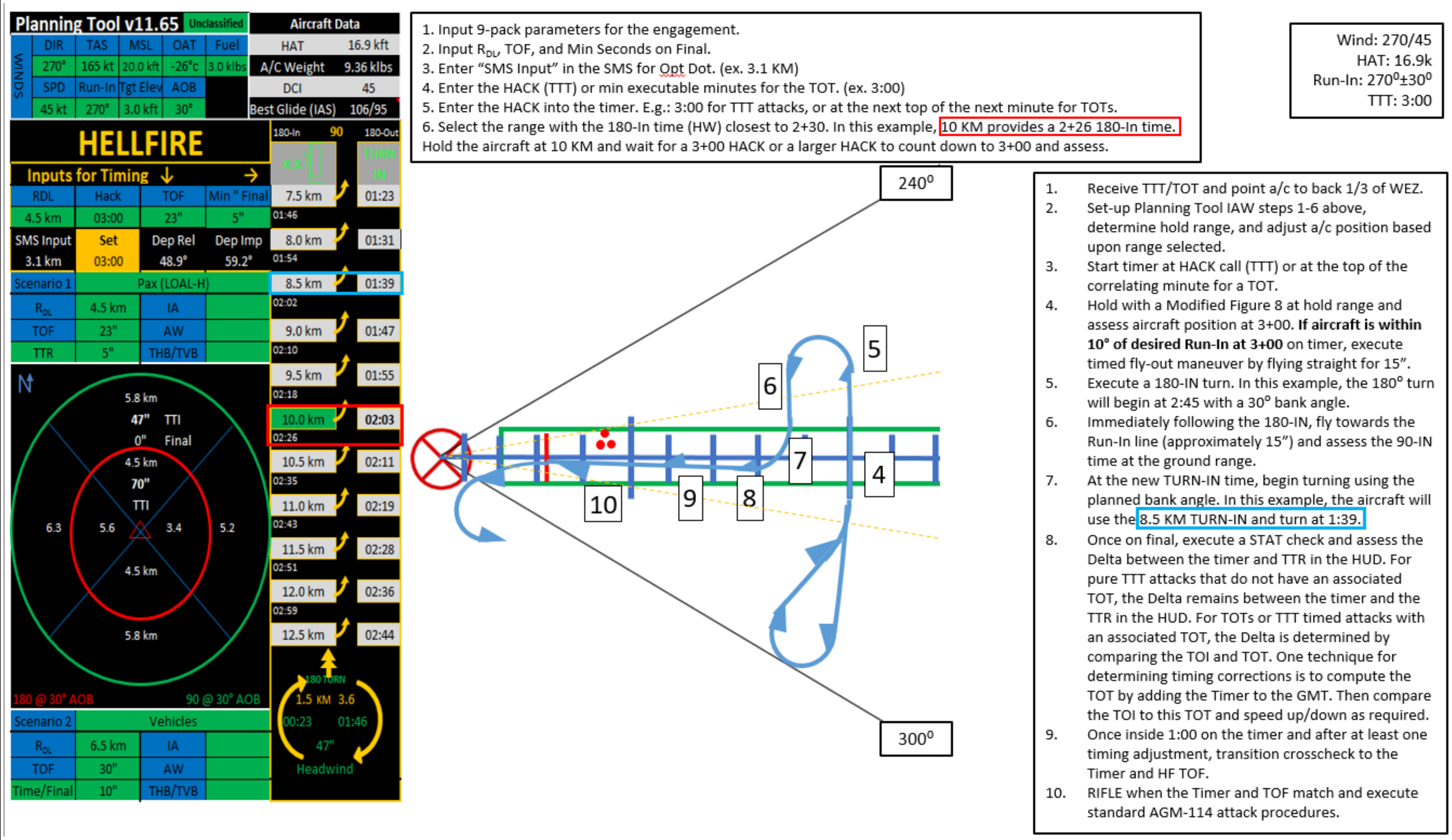
7.7.2.3.1.3.1.3.2 CASE 3B. If >45 seconds to Turn-In time, continue back to the original hold range, then turn in on time as depicted in **Figure 7.34** Time Based Planning Tool—Case 3: During or After Holding Turn.

7.7.2.3.1.3.1.4 (FOUO) Crosswind Contingency. If in a crosswind, the 10 degrees decision zone shifts into the wind 10 degrees per 30 knots of wind (e.g., if the aircraft has a 30 knot/45 degree quartering headwind, shift the ± 10 degree decision zone 5 degrees into the wind).

7.7.2.3.1.3.2 (FOUO) Final. Once on final, execute a STAT check, as outlined in **paragraph 7.3.1.4.2.1**, STAT Check, and calculate the Delta between the timer and the TTR to determine if the aircraft is early or late. For pure TTT attacks that do not have an associated TOT (i.e., a Hack is called without corresponding TOT) the Delta remains between the timer and the TTR in the HUD. For TOTs or TTT timed attacks with an associated TOT, the Delta is determined by comparing the time of impact on the Real Time Footprint tab in the RMIT display to the actual TOT.

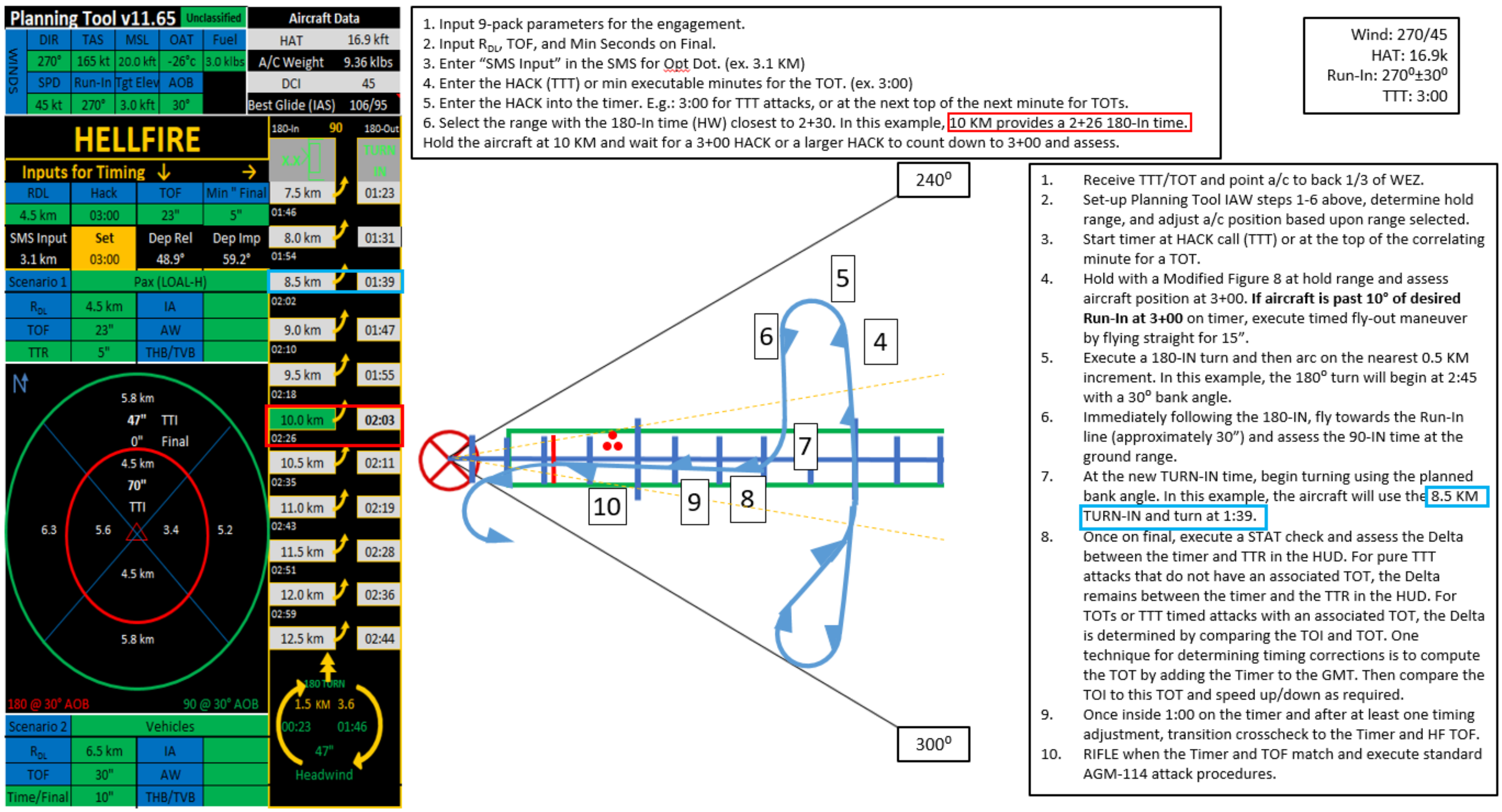
7.7.2.3.1.3.2.1 (FOUO) Timing Corrections. Use airspeed corrections if the Delta is less than 10 seconds. Airspeed corrections are executed by pushing or pulling the control stick to the larger number. This is easy to visualize if the timer is set in front of the HUD. Push or pull the control stick forward or aft and trim in one KTAS for every second of the delta. (i.e., If the TTR is greater by 6 seconds, push the stick forward and trim in 6 knots of airspeed). Once the TTR and timer match, cross-check the current KIAS on the HUD and trim in that speed. If the Delta is greater than 10 seconds when on final, use Geometry corrections in accordance with **Table 7.10**, Geometric Timing Corrections. Then continue with the STAT check down final.

Figure 7.32 (FOUO) Time Based Planning Tool—Case 1: Within 10 degrees of Run-In.



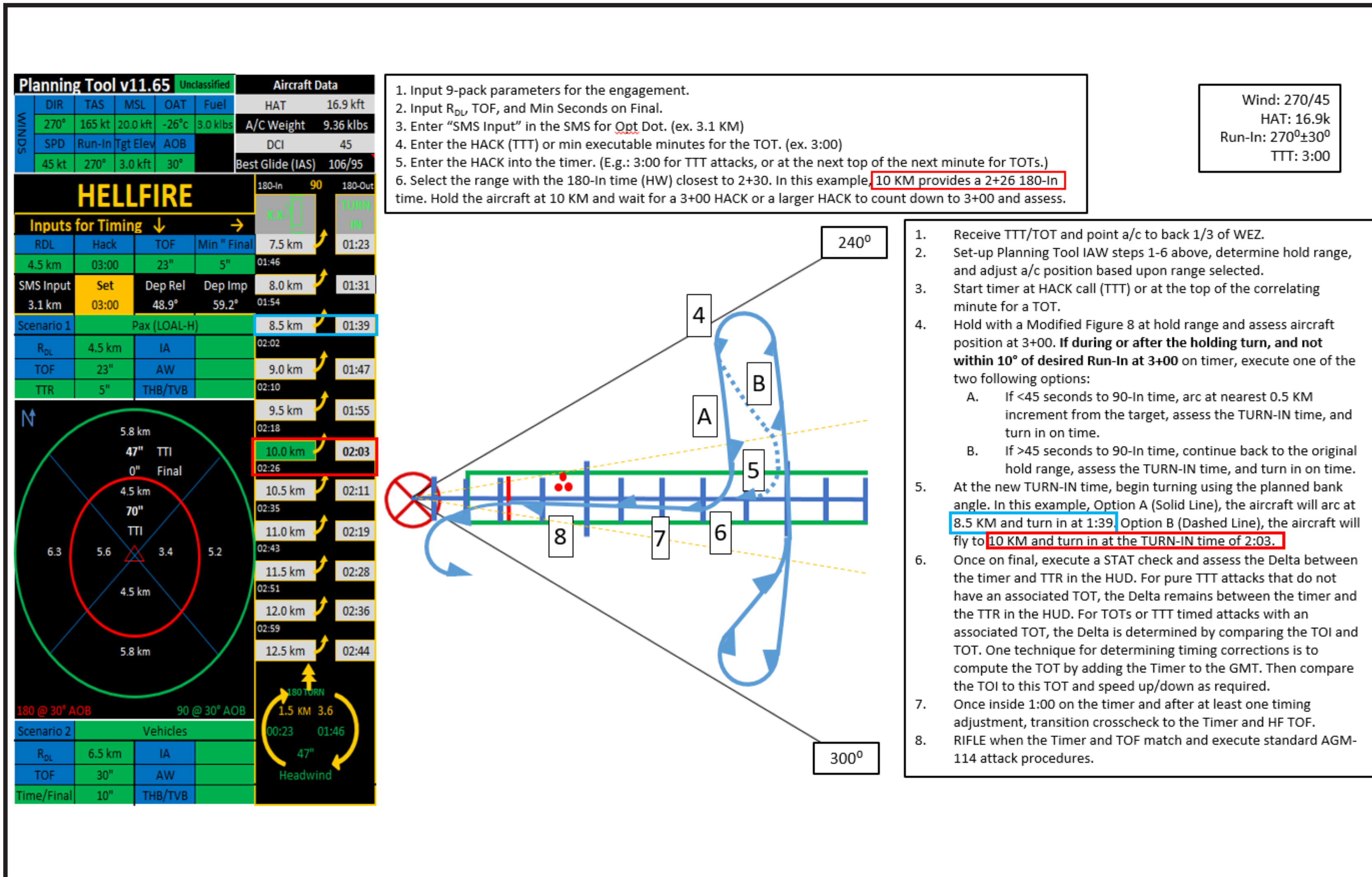
FOUO

Figure 7.33 (FOUO) Time Based Planning Tool—Case 2: Past the Run-In.



FOUO

Figure 7.34 (FOUO) Time Based Planning Tool—Case 3: During or After Holding Turn.



FOUO

7.7.2.3.1.3.3 (FOUO) Rifle to Splash. For pure TTT attacks, Rifle when the time in the timer matches the displayed TOF in the HUD. For TOT attacks, Rifle when the Time of Impact in the Real Time Footprint or displayed TOF on HUD matches the TOT. Execute standard AGM-114 procedures from Rifle to Splash. After Splash, SO accomplish postimpact procedures.

7.7.2.3.1.4 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.2.1.3**, AGM-114 Egress.

7.7.2.3.2 (FOUO) Distance Based Planning Tool Attack. Recommend use when unable to execute a Time Based Attack, as described in **paragraph 7.7.2.3.1**, Time Based Planning Tool Attack, due to time restriction or when hold range is forced by tactical scenario.

7.7.2.3.2.1 (FOUO) Game Plan. Execute as described in the AGM-114 Planning Tool **paragraph 7.3.3.1.1**, Game Plan.

7.7.2.3.2.1.1 (FOUO) Determining the HACK. When determining a HACK time, a good technique is to execute Planning Tool attacks with the smallest HACK available (i.e., 3+00 versus 6+00). Using the smallest HACK time available will minimize potential holding errors and cross-check breakdowns.

7.7.2.3.2.1.2 (FOUO) Holding Game Plan. Execute as described in the AGM-114 Planning Tool **paragraph 7.3.1.2.4**, Holding Game Plan.

7.7.2.3.2.1.2.1 (FOUO) Determining Hold. On the right side of the Planning Tool, use the desired hold distance container to select a hold range. For headwinds, select the closest range that provides a 180-In time. This allows the aircraft to make a 180 degree turn into the wind/target and still have a Turn-In option at the new ground range. For tailwind attacks, use the closest range that provides a Turn-In time as the hold range. Once the hold range is determined, plan to execute a Modified Figure Eight hold within 30 degrees of the run-in at that range. Set the HACK in the timer and start when the HACK is called for a TTT, or start at the top of the corresponding minute for a TOT as discussed in **paragraph 7.7.1.2**, Planning Tool.

7.7.2.3.2.2 (FOUO) Hold. Enter and maintain a Modified Figure Eight hold, complete preattack checks, and assess turn-in time when crossing the Run-In.

7.7.2.3.2.2.1 (FOUO) Calculating Turn-In Time. Execute as described in the AGM-114 Planning Tool **paragraph 7.7.2.3.1.2.1**, Calculating Turn-In Time.

7.7.2.3.2.2.2 (FOUO) Determining the Timing Solution. When flying the aircraft within 30 degrees of the run-in and at the planned range and airspeed, the required aircraft maneuvering has already been determined and the Delta between the timer and the 180-In/180-Out and Turn-In time provides awareness on the timing solution and the amount of time to kill in the hold.

7.7.2.3.2.2.3 (FOUO) Killing Time in the Hold. Killing time in the hold can be accomplished using the Planning Tool's Turn-In time and 180-In and 180-Out times, The following procedures outline maneuvers for killing time in the hold.

7.7.2.3.2.2.3.1 (FOUO) Planning Tool Data Only. The aircraft needs to remain within 30 degrees of the desired run-in while in the hold. Position the aircraft to maintain the planned hold range at 90 degrees azimuth, or adjusted for wind, when approaching the run-in line and cross-check the timer to determine the Delta between the timer and the Turn-In time. If the Delta is less than 30 seconds, anticipate reaching the Turn-In time prior to the 30-degree line. If the Delta is more than 30 seconds, continue the hold and execute a 180-degree turn into the wind at the 180-In (headwind)/180-Out (tailwind) time on the timer, or when the aircraft reaches the lead turnpoint to stay within 30 degrees of the run-in, whichever occurs first. Contingency—if more than 30 seconds and already past the 180-Out time, set 135 degrees azimuth until within 20 seconds of the Turn-In time at the current range. Cross-check the next range and Turn-In time passing each 0.5 km. Turn to capture 90 degrees AZ once at the desired range prior to turning in. As the aircraft finishes the 180-degree turn, cross-check the timer and calculate the Delta between it and the Turn-In time for the new range to the target. If the Delta is less than 30 seconds, maintain the current range to the target and Turn-In at the new Turn-In time. If the Delta is greater than 30 seconds, continue the turn past 180 degrees and maneuver the aircraft back to the planned hold range. Repeat this process until reaching the Turn-In time.

7.7.2.3.2.2.3.2 (FOUO) Fly-Out Maneuver and Planning Tool Data. If there is a restricted run-in that requires less than 30 degrees of tolerance, the timing solution requires a Fly-Out maneuver to be executed in conjunction with the Planning Tool data. As the aircraft approaches the run-in line, calculate the Delta between the timer and the 180-In (headwind)/180-Out (tailwind) time. (e.g., the timer shows 3+30 and the 180-In turn time is 2+04 (3+30 - 2+04 = 1+26 Delta).

7.7.2.3.2.2.3.2.1 (FOUO) For Deltas greater than 3+00, continue the hold and reassess the next time crossing the run-in line.

7.7.2.3.2.2.3.2.1.2 (FOUO) For Deltas less than 3+00, take the Delta and fly-out for half of that time using the GMT clock or timer as a reference (e.g., 1+26/2= 43, fly out for 0+43). While executing the Fly-Out maneuver, maintain the planned hold range. Once the time on the outbound leg of the Fly-Out maneuver is complete, turn 180 degrees into the wind using the planned bank angle in the Planning Tool, roll out, and arc the target at the new range after the 180 while cross-checking the timer and Turn-In time for the Delta. When the Delta is zero, the aircraft is at the Turn-In time and should turn in using the planned bank angle in the Planning Tool. For headwind attacks, the Fly-Out maneuver will lead to a slight overshoot of the run-in due to the decreased range to the target after the 180 Turn-In. Consider increasing the outbound leg of the Fly-Out maneuver to mitigate this. For tailwind attacks, the opposite is true and the Fly-Out maneuver's outbound leg should be decreased due to the increased range after the 180 Turn Out.

7.7.2.3.2.2.4 (FOUO) Preattack Checks. Once the hold plan has been developed, and the timing solution has been solved, run SLAPUM WTARSEC in accordance with standard AGM-114 attack procedures as outlined in **paragraph 7.3.2.3.2**, Preattack Checks.

7.7.2.3.2.3 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.2.1.4**, Execution, for on-azimuth attacks, or from **paragraph 7.3.2.2.2**, Off-Azimuth Execution, for off-azimuth attacks, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.2.3.2.3.1 (FOUO) Turn-In Decisions at HACK. Execute the turn to final with planned bank angle in the Planning Tool. Turn-In when the timer matches the Planning Tool's Turn-In time for the current range to the target and intercept final. Adjust this time 3 seconds early or late for every 10 degrees off of 90 Azimuth. If the HACK is 4+00 or less, depending on the aircraft position relative to the Run-In line, there are typically three standard decisions that can be made. If HACK is greater than 4+00, then accomplish additional killing time in the hold per **paragraph 7.7.3.3.5.4.1**, Fly-Out Maneuver and Planning Tool Data. As a good rule of thumb, in all situations crews should reference timer and time to turn executing the appropriate fly-out maneuver, as required, in accordance with the previously referenced paragraph.

7.7.2.3.2.3.1.1 (FOUO) HACK called approaching the Run-In line. If the aircraft has not reached the Run-In line when HACK is called, typically the aircraft should be able to continue flying until the Turn-In time. When the timer reaches the Turn-In time, begin the turn to final. See **Figure 7.35**, AGM-114 Planning Tool Timed Attack Approaching the Run-In Line at HACK (Headwind).

7.7.2.3.2.3.1.2 (FOUO) HACK called past the Run-In line. If the aircraft is past the Run-In line when HACK is called, the pilot has two options.

7.7.2.3.2.3.1.2.1 (FOUO) Option 1 (recommended). The pilot begins an immediate 180 degrees max perform turn into the wind back into the run-in line. Using this option will allow the pilot additional time to roll wings level and assess new ground range and Turn-In time.

7.7.2.3.2.3.1.2.2 (FOUO) Option 2. The pilot delays turn until the 180-IN/OUT time (headwind/tailwind dependent). At the 180-IN/OUT time, the pilot will execute the bank angle which was input in the 9-pack, and after rollout, assess new ground range and Turn-In time. If executed in this capacity, the Turn-In should be simultaneous/immediate after completing the 180-in/out; it is recommended to begin bank 6 to 9 seconds prior to the timer displayed 180 in/out time to provide crews time to roll out at the new range and assess the new 90 IN time. See **Figure 7.36**, AGM-114 Planning Tool Timed Attack Past the Run-In Line at HACK (Headwind).

7.7.2.3.2.3.1.3 (FOUO) HACK called while in a Turn. If the aircraft is in the middle of a turn when HACK is called, continue the turn and rollout once 90 degrees azimuth is displayed in the TGP. After wings level, immediately assess the new ground range and the Turn-In time. Once the new Turn-In time matches the timer, begin the turn to final. See **Figure 7.37**, AGM-114 Planning Tool Timed Attack While in a Turn at HACK (Headwind).

7.7.2.3.2.3.2 (FOUO) Additional Example with a Tailwind. For a tailwind example, see **Figure 7.38**, GBU-12 Planning Tool Attack Past the Run-In at HACK (Tailwind). Although that figure is a GBU-12 example, the overall execution remains the same.

7.7.2.3.2.3.3 (FOUO) Final. Execute as described in the AGM-114 Planning Tool in **paragraph 7.7.2.3.1.3.2**, Final.

7.7.2.3.2.3.3.1 (FOUO) Timing Corrections. Execute timing corrections as outlined in **paragraph 7.7.2.3.1.3.2.1**, Timing Corrections.

7.7.2.3.2.3.4 (FOUO) Rifle to Splash. Execute as described in the AGM-114 Planning Tool in **paragraph 7.7.2.3.1.3.3**, Rifle to Splash.

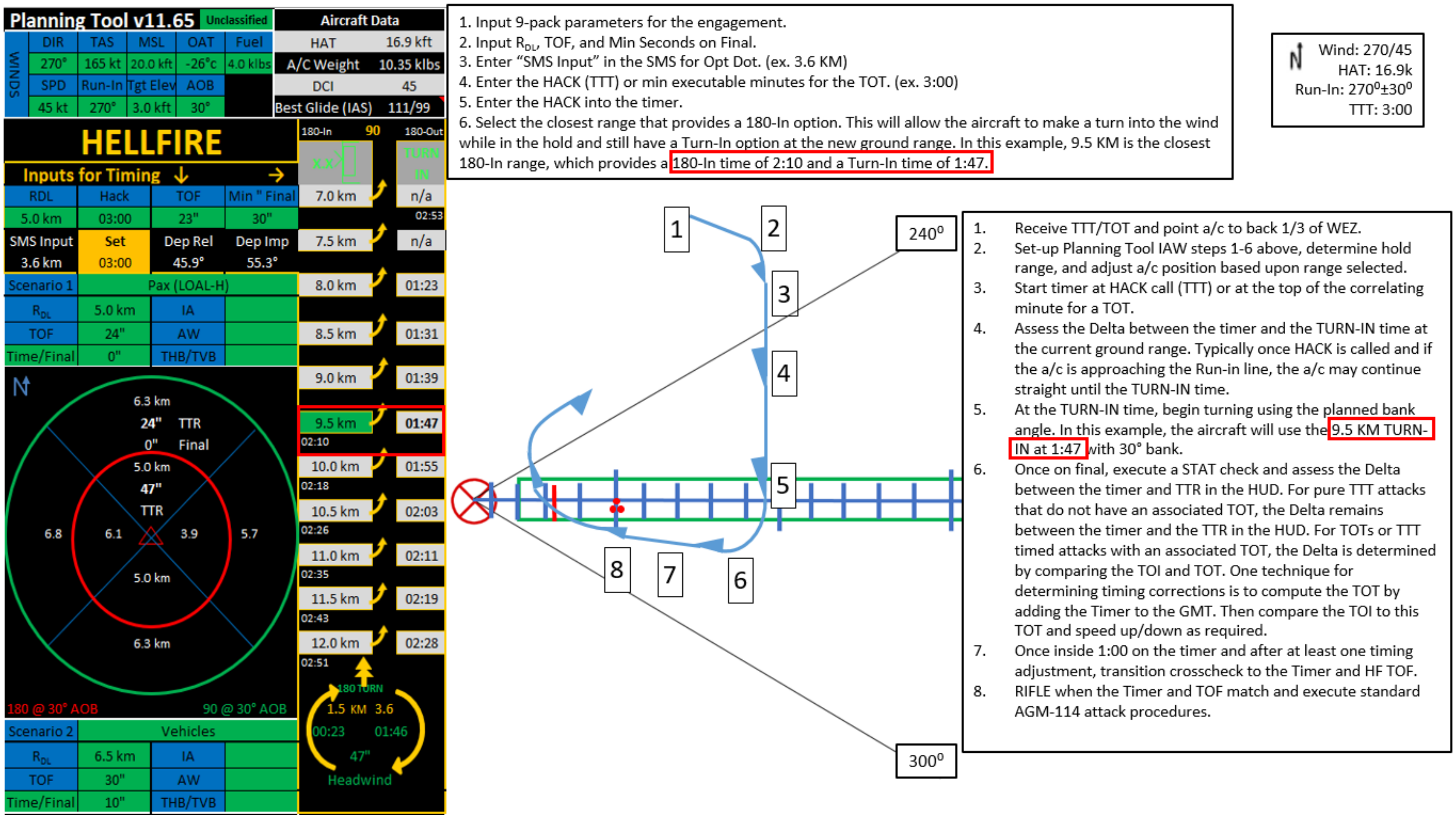
7.7.2.3.2.4 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.2.1.3**, AGM-114 Egress.

7.7.3 (FOUO) GBU-12 Timing Attacks. The two primary types of GBU-12 timing attacks are the TOI and Planning Tool. GBU-12 timing attacks still follow the five phases of an attack as outlined in **paragraph 7.3.1** Attack Phases; determine type of attack following intent during game plan development.

7.7.3.1 (FOUO) Intent. GBU-12 TOT considerations are similar to that of the AGM-114 as discussed in **paragraph 7.7.2.1**, Intent.

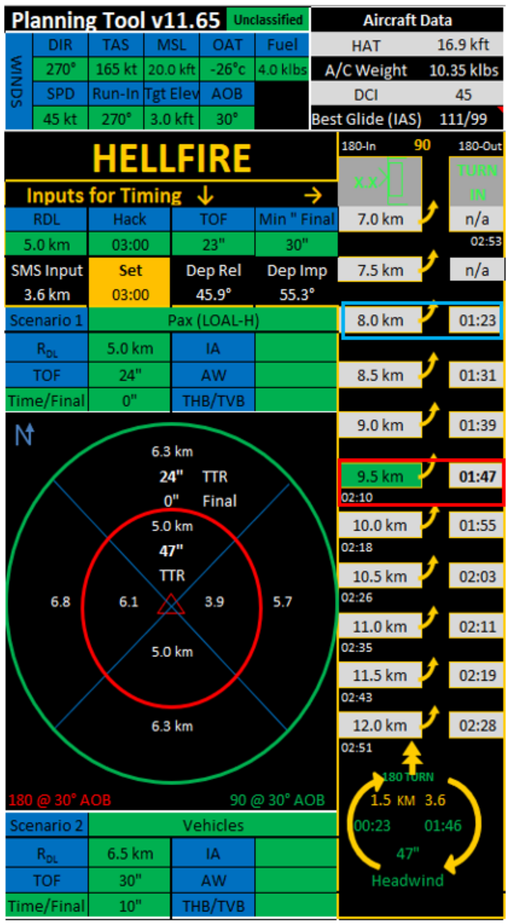
7.7.3.2 (FOUO) GBU-12 Time of Impact Timing. TOI calculations, assumptions, and limitations for GBU-12s are similar to those for AGM-114s. This section will focus on execution for GBU-12s. Calculations for the GBU-12 is listed in **Table 7.11**, GBU-12 Manual Release Mode, and **Table 7.12**, GBU-12 CCRP Release Mode. ***Note:*** CCRP uses the BRP as the R_{DL}. The following guidance is specifically for CCRP TOI, not Manual delivery. For Manual deliveries, the TOF must be input by the pilot and the TOI will simply be the current GMT, TTR, plus the TOF.

Figure 7.35 (FOUO) AGM-114 Planning Tool Timed Attack Approaching the Run-In Line at HACK (Headwind).



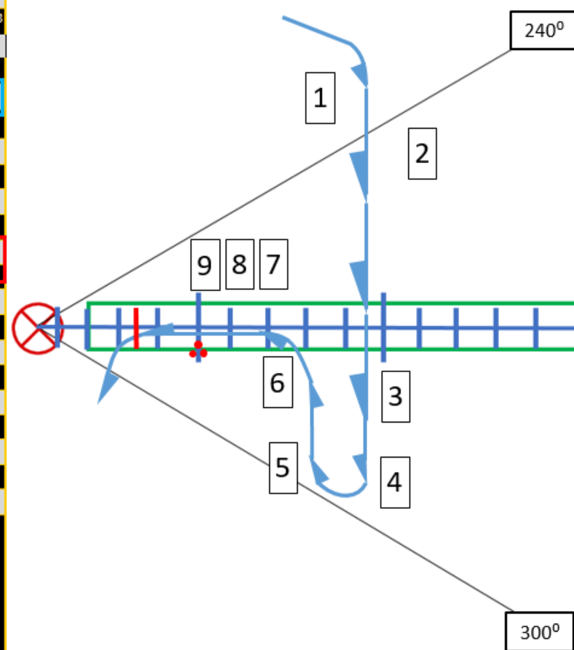
FOUO

Figure 7.36 (FOUO) AGM-114 Planning Tool Timed Attack Past the Run-In Line at HACK (Headwind).



1. Input 9-pack parameters for the engagement.
2. Input R_{DL}, TOF, and Min Seconds on Final.
3. Enter "SMS Input" in the SMS for Opt Dot. (ex. 3.6 KM)
4. Enter the HACK (TTT) or min executable minutes for the TOT. (ex. 3:00)
5. Enter the HACK into the timer.
6. Select the closest range that provides a 180-In option. This will allow the aircraft to make a turn into the wind while in the hold and still have a Turn-In option at the new ground range. In this example, 9.5 KM is the closest 180-In range, which provides a 180-In time of 2:10 and a 8 KM Turn-In time of 1:23

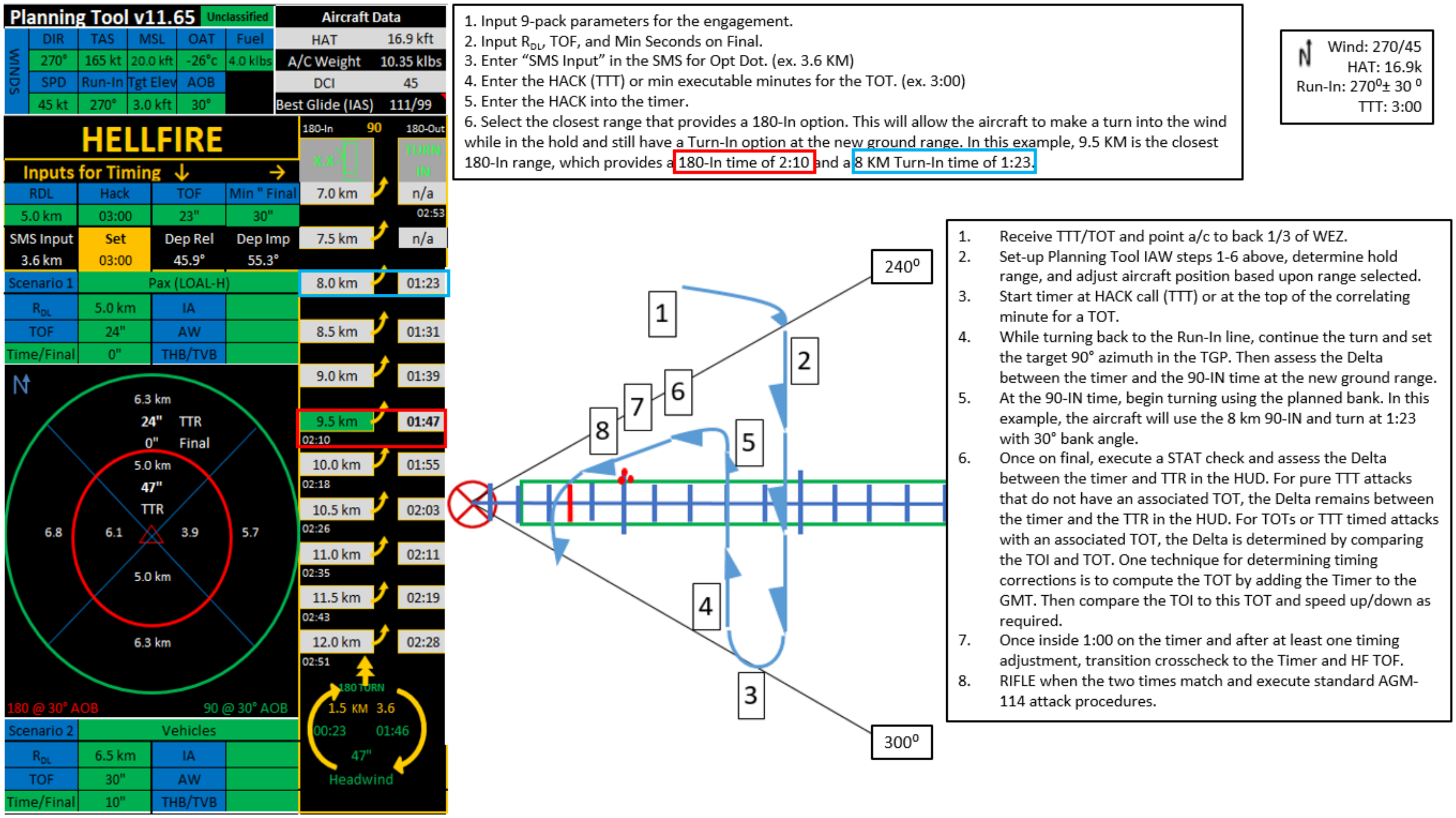
N
Wind: 270/45
HAT: 16.9k
Run-In: 270°±30°
TTT: 3:00



1. Receive TTT/TOT and point a/c to back 1/3 of WEZ.
2. Set-up Planning Tool IAW steps 1-6 above, determine hold range, and adjust a/c position based upon range selected.
3. Start timer at HACK call (TTT) or at the top of the correlating minute for a TOT.
4. If past the Run-In line, you have two options: **Option 1:** (recommended) begin an immediate max perform turn into the wind. Using this technique will allow additional time to assess new ground range and TURN-IN Delta. **Option 2:** wait to turn until the 180-IN time, then begin the turn using the planned bank angle. In this example, the 180° turn will begin at 2:10 with 30° bank.
5. Immediately following the 180-IN, assess the Delta between the timer and the 90-IN time at the new ground range.
6. At the new 90-IN time, begin turning using the planned bank angle. In this example, the aircraft will use the 8 km TURN-IN and turn at 1:23 with 30° bank.
7. Once on final, execute a STAT check and assess the Delta between the timer and TTR in the HUD. For pure TTT attacks that do not have an associated TOT, the Delta remains between the timer and the TTR in the HUD. For TOTs or TTT timed attacks with an associated TOT, the Delta is determined by comparing the TOI and TOT. One technique for determining timing corrections is to compute the TOT by adding the Timer to the GMT. Then compare the TOI to this TOT and speed up/down as required.
8. Once inside 1:00 on the timer and after at least one timing adjustment, transition crosscheck to the Timer and HF TOF.
9. RIFLE when the Timer and TOF match and execute standard AGM-114 attack procedures.

FOUO

Figure 7.37 (FOUO) AGM-114 Planning Tool Timed Attack While in a Turn at HACK (Headwind).



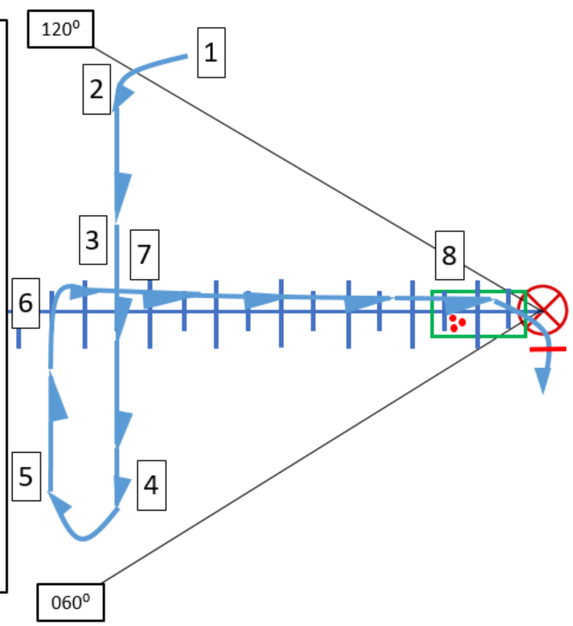
FOUO

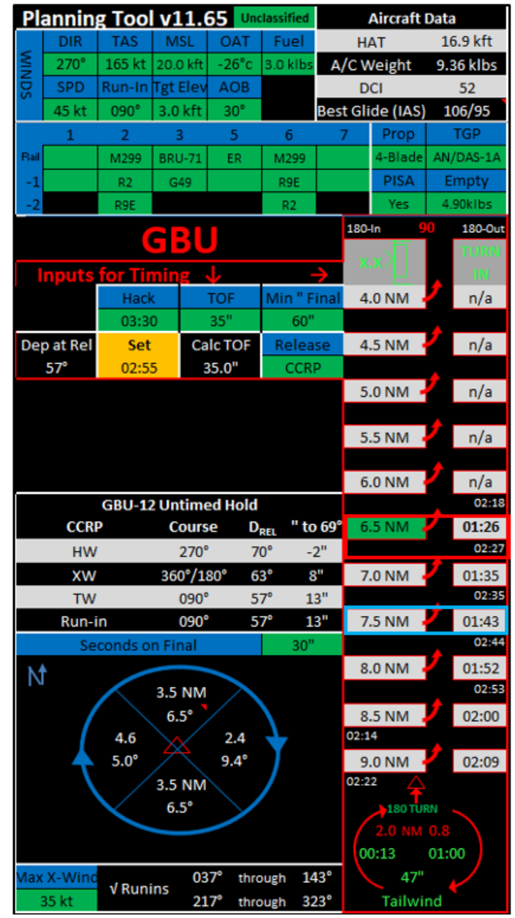
Figure 7.38 (FOUO) GBU-12 Planning Tool Attack Past the Run-In at HACK (Tailwind).

Wind: 270/45
HAT: 16.9k
Run-In: 090°±30°
TTT: 3:30

1. Input 9-pack parameters for the engagement.
2. Enter the HACK (TTT) or remaining minutes to the TOT at the next top of the minute. (ex. 3:00)
3. Enter the Bomb TOF and minimum seconds desired on final.
4. Enter the HACK into the timer. (ex. 2:55)
5. Select the closest range that provides a TURN-IN time as the hold range. Holding ground range is 6.5 NM in this example which provides a 180-OUT time of 2:27 and a 90-IN time of 1:26.

1. Receive TTT/TOT and point aircraft to 5-6 NM point.
2. Set-up Planning Tool IAW steps 1-5 above, determine the hold range and adjust hold A/R based upon selected hold range. 6.5 NM for this example.
3. Start timer at HACK call (TTT) or at the top of the correlating minute for a TOT.
4. If past the Run-IN line, you have two options: **Option 1:** (recommended) begin an immediate max perform turn into the wind. Using this technique will allow additional time to assess new ground range and 90-IN Delta. **Option 2:** wait to turn until the 180-IN/OUT time, then begin the turn using the planned bank angle. In this example, the 180-OUT turn will begin at the 3:30 HACK with a 30° bank angle.
5. Immediately after the 180-OUT turn is complete, assess the Delta between the timer and the TURN-IN time at the new ground range.
6. At the new TURN-IN time, begin turning using the planned AOB. In this example, the aircraft will use the 7.5 NM TURN-IN and turn at 1:43 with 30° bank angle.
7. On final, transition to the STAT check and assess the delta between the timer and the TTR in the HUD. Adjust airspeed 1 KTAS for every second early or late. Push/Pull to the larger number between the two times. (E.g. Timer displays 1:06 and TTR displays 1:11, KTAS will speed up 5 kts)
8. Execute standard GBU-12 CCRP delivery procedures.





FOUO

Table 7.11 GBU-12 Manual Release Mode.

	A/C Outside or at R_{DL}	A/C Inside R_{DL}
TTR	Calculated for a release at the BRP	Zero
TOF	Calculated using a ballistic trajectory	Calculated using a ballistic trajectory
TOI	Current GMT + TTR + TOF	Current GMT + TOF

Table 7.12 GBU-12 CCRP Release Mode.

	A/C Outside or at R_{DL}	A/C Inside R_{DL}
TTR	Calculated for a release at the BRP	Zero
TOF	Calculated using a ballistic trajectory	Calculated using a ballistic trajectory
TOI	Current GMT + TTR + TOF	Current GMT + TOF

7.7.3.2.1 (FOUO) Game Plan. Assess the run-in, enter it into the SMS (displayed in TRUE) and point the aircraft towards 5 to 7 NM, as depicted on the Tracker display. While maneuvering the aircraft in the direction of the hold, set airspeed as required, and assess the amount of time the crew has until weapons effects are required in order to determine if executing the TOT is possible in the allotted time. Once CCRP is displayed on the HUD, bound the hold to stay within required restrictions of the run-in. To allow for time to correct on final, the holding game plan should aim to hold the aircraft 5 to 7 NM from the target, with wind corrections so that turns can be completed into the target. This will result in increased distance to the target while established in the hold.

7.7.3.2.2 (FOUO) Hold. Once the hold plan has been developed and the aircraft is flying en route to the hold, or established in the hold, cross-check TOI to assess time to kill and run preattack checks. To simplify execution and mitigate known limitations inherent in this method, execute a Figure Eight crosswind hold to a headwind or tailwind final.

7.7.3.2.2.1 (FOUO) Preattack Checks. Run SLAPUM WTARSEC in accordance with standard GBU-12 CCRP delivery attack procedures as outlined in **paragraph 7.3.2.3.2**, Preattack Checks.

7.7.3.2.3 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.5.1.2.2**, Execution, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.3.2.3.1 (FOUO) Turn-In. Execute a standard GBU-12 CCRP turn-in as described in **paragraph 7.3.3.1.4.1**, Turn-In, with the following differences. Cross-checking the TOI on the HUD, the pilot turns-in when the TOI matches the TOT time with a standard rate turn and intercepts final. On the turn-in, the pilot should assess if they are early or late. If they are early, the pilot can reduce bank angle as required (staying within desired restriction) to match the TOI to TOT time.

If they are late, they can increase bank angle as required to match the TOI to TOT time. See **paragraph 7.7.2.2.3.1.1**, Turn Time Adjustment, and **Table 7.9**, Turn Time Adjustment Relative to AoB Change, for specific turn time corrections.

7.7.3.2.3.2 (FOUO) Final. Once on final, run the STAT cross-check as outlined in **paragraph 7.3.1.4.2.1**, STAT Check, and assess the timing solution to determine if the aircraft is early or late. Cross-check TOI and make corrections to meet the TOT time. If within 10 seconds, continue on final. If the aircraft is going to be greater than 10 seconds early or late, execute the appropriate timing correction as described in **paragraph 7.7.2.2.3.2.1**, Late Timing Correction, and **paragraph 7.7.2.2.3.2.2**, Early Timing Corrections.

7.7.3.2.3.3 (FOUO) RELEASE to Splash. Release at CCRP. As the Time to Release time counts down to 10 seconds, the pilot should depress and hold the Launch Enable button and squeeze the trigger until weapons release. Execute standard GBU-12 procedures (e.g., track employment TTP, postrelease maneuver) from **paragraph 7.3.3.1.4.3**, Release to Splash. After Splash, the SO accomplishes postimpact procedures.

7.7.3.2.4 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.3.1.5**, Egress.

7.7.3.3 (FOUO) GBU-12 Planning Tool. Execute standard GBU-12 CCRP delivery attack procedures in accordance with **paragraph 7.3.3.1**, CCRP Deliveries, and the following procedures specific to GBU-12 timed attacks using the Planning Tool throughout the five phases of the attack.

7.7.3.3.1 (FOUO) GBU-12 Time Based Planning Tool Attack. Recommend use when aircraft can establish the hold with greater than 4+00 TTT.

7.7.3.3.1.1 (FOUO) Game Plan. Choosing a HACK time and hold range that are a balance of minimizing potential holding errors, cross-check breakdowns, and options for turn time solutions is critical to effective execution.

7.7.3.3.1.1.1 (FOUO) Determining the HACK. When determining a HACK time, execute Time Based Planning Tool attacks with a minimum HACK of 4+00.

7.7.3.3.1.1.2 (FOUO) Holding Game Plan. Assess the run-in, enter it into the SMS, and point the aircraft towards the point 5 to 6 NM from the target on the run-in line, as depicted on the tracker display. While maneuvering the aircraft in the direction of the hold, immediately update the 9-Pack with planned attack parameters, perform a target update (if required), enter the HUD displayed TOF and the minimum desired time on final.

7.7.3.3.1.1.2.1 (FOUO) Determining Hold. On the right side of the Planning Tool, use the desired hold distance container to select a hold range that provides a 180-In/Out time of 2+30, depending on HW/TW attack. Once the hold range is determined, plan to execute a Modified Figure Eight hold within 30 degrees of the run-in at that range, regardless of restriction.

7.7.3.3.1.1.3 (FOUO) Setting the HACK. Once there is sufficient time for the timed attack using the Planning Tool, enter the "Set X:XX" (orange box) time into the timer for a TTT and HACK, as it automatically subtracts the GBU-12 TOF from the timer. For a TOT or a TTT called at a specific time, determine the time remaining until the TOT at the next top of the minute, subtract the TOF, and enter that time into the timer (e.g., at 16:21:09 for a 16:29:00 TOT, plan to start the timer at 16:22:00 and set 6+25 in the timer for a 35 second TOF). Once the hack is set, continue to the hold and start the timer when the hack is called for a TTT, or on the top of the corresponding minute for a TOT as just discussed. Fly a Modified Figure Eight hold at the planned range and within 30 degrees of the run-in.

7.7.3.3.1.2 (FOUO) Hold. Enter and maintain a Modified Figure Eight hold as discussed in **paragraph 3.4.2.4.1**, Entering Holding and Maintaining Standoff, and assess turn-in time.

7.7.3.3.1.2.1 (FOUO) Calculating Turn-In Time. Execute as described in the AGM-114 Planning Tool, **paragraph 7.7.3.3.5.1**, Calculating Turn-In Time.

7.7.3.3.1.2.2 (FOUO) Determining the Timing Solution. Execute as described in the AGM-114 Planning Tool, **paragraph 7.7.2.2.2.1**, Determining the Timing Solution.

7.7.3.3.1.2.3 (FOUO) Killing Time in the Hold. Execute as described in **paragraph 7.7.2.2.2.2**, Killing Time in the Hold.

7.7.3.3.1.2.3.1 (FOUO) Planning Tool Data Only. Execute as described in the AGM-114 Planning Tool, **paragraph 7.7.3.3.5.4**, Planning Tool Data.

7.7.3.3.1.2.3.2 (FOUO) Fly-Out Maneuver and Planning Tool Data. Execute as described in **paragraph 7.7.3.3.5.4.1**, Fly-Out Maneuver and Planning Tool Data.

7.7.3.3.1.3 (FOUO) Preattack Checks. Once the hold plan is developed and the timing solution solved, run SLAPUM WTARSEC in accordance with standard GBU-12 CCRP delivery attack procedures as described in **paragraph 7.3.3.1.3**, Preattack Checks.

7.7.3.3.2 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.3.3.3**, Execution, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.3.3.2.1 (FOUO) Turn-In Decisions at HACK. Execution uses the same procedures from **paragraph 7.7.2.3.2.3.1**, Turn-In Decisions at HACK. The examples are AGM-114 based; however, the overall execution remains the same.

7.7.3.3.2.2 (FOUO) Final. Once on final, calculate the Delta between the timer and the TTR to determine if the aircraft is early or late while maintaining standard GBU-12 CCRP delivery attack pacing and cross-checks.

7.7.3.3.2.2.1 (FOUO) Timing Corrections. Execute timing corrections as outlined in **paragraph 7.7.2.3.1.3.2.1**, Timing Corrections.

7.7.3.3.2.3 (FOUO) Release to Splash. Command release at 10 seconds TTR and execute standard GBU-12 CCRP delivery procedures postrelease (e.g., SO track plan, turning egress, straight-through egress). After Splash, the SO accomplishes postimpact procedures.

7.7.3.3.3 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 3.4.3.2**, Straight Through, or **paragraph 7.3.3.1.4.3.2**, Turning Egress Execution.

7.7.3.3.4 GBU-12 Distance Based Planning Tool Attack. Recommend use when unable to execute a Time Based Attack, as described in **paragraph 7.7.3.3.1**, GBU-12 Time Based Planning Tool Attack, due to time restriction or when hold range is forced by tactical scenario.

7.7.3.3.4.1 (FOUO) Game Plan. Execute as described in **paragraph 7.3.3.1.1**, Game Plan.

7.7.3.3.4.1.1 (FOUO) Determining the HACK. Execute as described in **paragraph 7.7.2.3.1.1.1**, Determining the HACK.

7.7.3.3.4.1.2 (FOUO) Holding Game Plan. Execute as described in **paragraph 7.7.2.3.1.1.2**, Holding Game Plan.

7.7.3.3.4.1.2.1 (FOUO) Determining Hold. Execute as described in **paragraph 7.7.2.3.2.1.2.1**, Determining Hold.

7.7.3.3.4.1.3 (FOUO) Setting the HACK. Execute as described in **paragraph 7.7.3.3.1.1.3**, Setting the HACK.

7.7.3.3.5 (FOUO) Hold. Enter and maintain a Modified Figure Eight hold as discussed in **paragraph 3.4.2.5.1**, Entering Holding and Maintaining Standoff, and assess turn-in time.

7.7.3.3.5.1 (FOUO) Calculating Turn-In Time. Execute as described in the AGM-114 Planning Tool, **paragraph 7.7.3.3.5.1**, Calculating Turn-In Time.

7.7.3.3.5.2 (FOUO) Determining the Timing Solution. Execute as described in the AGM-114 Planning Tool, **paragraph 7.7.3.3.5.2**, Determining the Timing Solution.

7.7.3.3.5.3 (FOUO) Killing Time in the Hold. Killing time in the hold can be accomplished using the Planning Tool's Turn-In time and 180-In and 180-Out times as previously discussed in **paragraph 7.7.2.2.2.2**, Killing Time in the Hold.

7.7.3.3.5.4 (FOUO) Planning Tool Data Only. Execute as outlined in the AGM-114 Planning Tool, **paragraph 7.7.3.3.5.4**, Planning Tool Data.

7.7.3.3.5.4.1 (FOUO) Fly-Out Maneuver and Planning Tool Data. Execute as outlined in **paragraph 7.7.3.3.5.4.1**, Fly-Out Maneuver and Planning Tool Data.

7.7.3.3.5.5 (FOUO) Preattack Checks. Once the hold plan is developed and the timing solution solved, run SLAPUM WTARSEC in accordance with standard GBU-12 CCRP delivery attack procedures as outlined in **paragraph 7.3.3.1.3**, Preattack Checks.

7.7.3.3.6 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.5.1.2.2**, Execution, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.3.3.6.1 (FOUO) Turn-In. Execute the turn to final at the planned bank angle set in the Planning Tool. Turn-In when the timer matches the Planning Tool's Turn-In time for the current range to the target and intercept final.

7.7.3.3.6.1.1 See **paragraph 7.7.2.3.2.3.1**, Turn-In Decisions at HACK, for execution decisions due to the aircraft position relative to the Run-In line. The examples are AGM-114 based; however, the overall execution remains the same.

7.7.3.3.6.2 (FOUO) Final. Once on final, calculate the Delta between the timer and the TTR to determine if the aircraft is early or late while maintaining standard GBU-12 CCRP delivery attack pacing and cross-checks.

7.7.3.3.6.2.1 (FOUO) Timing Corrections. Execute timing corrections as outlined in **paragraph 7.7.2.3.1.3.2.1**, Timing Corrections.

7.7.3.3.6.3 (FOUO) Release to Splash. Execute release procedures as described in **paragraph 7.3.2.2.2.3**, Release to Splash.

7.7.3.3.7 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 3.4.3.2**, Straight Through, or **paragraph 7.3.3.1.4.3.2**, Turning Egress Execution.

7.7.4 (FOUO) GBU-38 Timing Attacks. The GBU-38 LAR provides some flexibility like the AGM-114 WEZ for release, as opposed to the CCRP on a GBU-12 delivery. GBU-38 timing attacks still follow the five phases of an attack as outlined in **paragraph 7.3.1**, Attack Phases; determine type of attack following intent during game plan development.

7.7.4.1 (FOUO) Intent. GBU-38 TOT considerations are similar to that of the AGM-114 as discussed in **paragraph 7.3.1.1**, Intent.

7.7.4.2 (FOUO) GBU-38 Time of Impact Timing. TOI calculations, assumptions, and limitations for GBU-38s are similar to those for AGM-114s. GBU-38 TOI execution is similar to GBU-12 with the exception of a LAR versus CCRP release. Calculations for the GBU-38, 49, and 54 are listed in **Table 7.13**, GBU-38, GBU-54, and GBU-49 Manual Release Mode, and **Table 7.14**, GBU-38, GBU-54, and GBU-49 LAR Release Mode.

Table 7.13 GBU-38, GBU-54, and GBU-49 Manual Release Mode.

	A/C Outside or at R_{DL}	A/C Inside R_{DL}
TTR	Calculated for a release at the BRP	Zero
TOF	Manually input by pilot	Manually input by pilot
TOI	Current GMT + TTR + TOF	Current GMT + TOF

Table 7.14 GBU-38, GBU-54, and GBU-49 LAR Release Mode.

	A/C Outside or at LAR	A/C Inside LAR
TTR	Not calculated	Not calculated
TOF	Not calculated	Instantaneous
TOI	Not calculated	Not calculated
TTM	Calculated	Calculated
TTZ	Calculated	"RANGE" or "ZONE"

7.7.4.2.1 (FOUO) Game Plan. Assess the run-in, enter it into the SMS (displayed in TRUE) and point the aircraft towards 5 to 7 NM, as depicted on the Tracker display. While maneuvering the aircraft in the direction of the hold, set airspeed as required, and assess the amount of time the crew has until weapons effects are required in order to determine if executing the TOT is possible in the allotted time. To allow for time to correct on final, the holding game plan should aim to hold the aircraft 5 to 7 NM from the target, with wind corrections so that turns can be completed into the target. This will result in increased distance to the target while established in the hold.

7.7.4.2.1.1 (FOUO) Determining Release Parameters. Use GBIT to determine min, max, desired release range, and TOF; see **Figure 6.10**, GBIT Setup and Display. If unable to use GBIT, the range and TOF may be determined by executing a simulated attack. First input the desired impact angle and azimuth into the SMS. Next, execute a simulated attack in accordance with **paragraph 7.3.4.7**, Execution. When on final, choose a point in the middle of the applicable LAR (e.g., range or zone; zone recommended) as depicted on the Tracker display and HUD. Cross-check and note the ground range and TOF, as well as grids and elevation as required. Regardless of which method is used, select Manual Release Mode and input this data into a Manual LAR in the SMS. Once complete, the TOI will appear on the HUD, and the R_{DL} will appear on the HUD and tracker.

7.7.4.2.2 (FOUO) Hold. Once the hold plan has been developed and the aircraft is flying en route to the hold, or established in the hold, cross-check TOI to assess time to kill and run preattack checks. To simplify execution and mitigate known limitations inherent in this method, execute a Figure Eight crosswind hold to a headwind or tailwind final.

7.7.4.2.2.1 (FOUO) Preattack Checks. Run SLAPUM WTARSEC in accordance with standard GBU-38 attack procedures as outlined in **paragraph 7.3.4.6.1**, Preattack Checks.

7.7.4.2.3 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.4.7**, Execution, with the additional restriction of the timing solution driving the Turn-In and attack pacing as described below.

7.7.4.2.3.1 (FOUO) Turn-In. Execute a standard GBU-38 turn-in as described in **paragraph 7.3.3.1.4.1**, Turn-In, with the following differences. Cross-checking the TOI on the HUD, the pilot turns-in when the TOI matches the TOT time with a standard rate turn and intercepts final. On the turn-in, the pilot should assess if they are early or late. If they are early, the pilot can reduce bank angle as required (staying within desired restriction) to match the TOI to TOT time. If they are late, they can increase bank angle as required to match the TOI to TOT time. See **paragraph 7.7.2.2.3.1.1**, Turn Time Adjustment, and **Table 7.9**, Turn Time Adjustment Relative to AoB Change, for specific turn time corrections.

7.7.4.2.3.2 (FOUO) Final. Once on final, run the STAT cross-check as outlined in **paragraph 7.3.1.4.2.1**, STAT Check, and assess the timing solution to determine if the aircraft is early or late. Cross-check TOI and make one timing correction to meet the TOT time. If within 10 seconds, continue on final. If the aircraft is going to be greater than 10 seconds early or late, execute the appropriate timing correction as described in **paragraph 7.7.2.2.3.2.1**, Late Timing Corrections, and **paragraph 7.7.2.2.3.2.2**, Early Timing Corrections.

7.7.4.2.3.3 (FOUO) RELEASE to Splash. In Manual Release, the trigger is a hot trigger. Release when TOI equals TOT and established within generated LAR. Once the aircraft is established in the LAR, the weapon will release when the trigger is pulled. Execute standard GBU-38 procedures (e.g., track employment TTP, postrelease maneuver) from **paragraph 7.3.4.7.3**, Release to Splash.

7.7.4.2.4 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.4.8**, Egress.

7.7.4.3 (FOUO) GBU-38 Planning Tool. The GBU-38 Time Based and Distance Based Planning Tool attacks are executed in the same manner as the GBU-12 procedures as outlined in **paragraph 7.7.3.3**, GBU-12 Planning Tool. The main difference is that Manual Release mode is selected in the Planning Tool, which enables the R_{DL} to be input. Run GBIT to determine desired release range and TOF; then input those numbers into the SMS and Planning Tool to generate associated holding data. Also, when on final, command release once inside the LAR when the Timer reaches 0+00.

7.7.4.4 (FOUO) GBU-38 Control Point. The mechanics on final are similar to a GBU-12 attack, however, a GBU-38 CP timed attack requires significant time to conduct due to the set up required.

7.7.4.4.1 (FOUO) Game Plan. Unlike a GBU-12 where the TOF is constant during a CCRP delivery, the GBU-38 TOF changes on final like an AGM-114. Currently however, the GBU-38 does not have mission execution software available in the cockpit for real-time release and TOF parameters visible from the hold. In order to accurately accomplish a TOT, the release point and the associated TOF must be determined prior to executing the attack phases.

7.7.4.4.1.1 (FOUO) Determining the Release Parameters. Use GBIT to determine release range and TOF, see **Figure 6.10**, GBIT Setup and Display. If unable to use GBIT, the range and TOF may be determined by executing a simulated attack. First input the desired impact angle and azimuth into the SMS. Then choose a point in the middle of the applicable LAR (e.g., range or zone; zone recommended) as depicted on the Tracker display. Next, place the CP inside the desired LAR on the Tracker display once on final for the simulated attack. When the aircraft arrives at the CP while on final for the simulated attack, cross-check and note the ground range and TOF. The CP represents the desired release range and the TOF used to calculate the Turn-In time. Both data points will determine the hold plan.

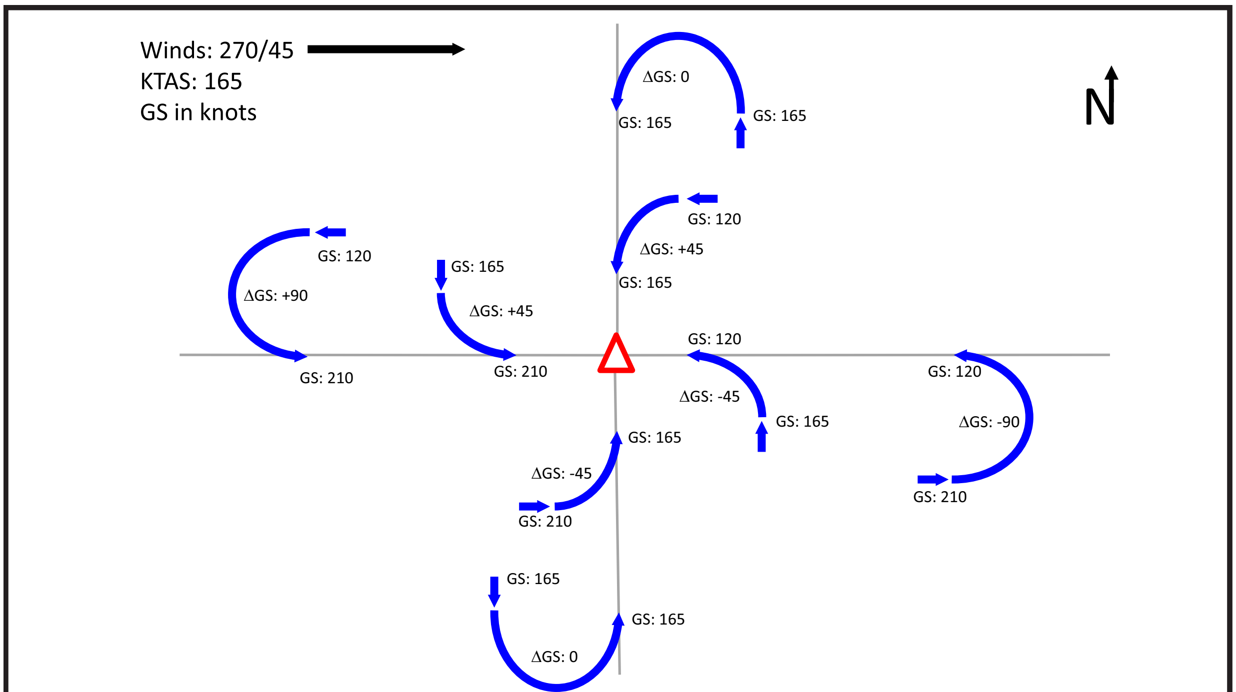
7.7.4.4.1.2 (FOUO) Calculating Turn-In Time. Calculate the Turn-In time in order to determine the timing solution; the timing solution accounts for the time to Turn, flight to release point, and release of the weapon to meet the TOT. Whether using GBIT or by executing a simulated attack, weapons TOF must be determined. Subtract the TOF from the TOT to determine the release time. Since the CP is at the release point, the release time equates to the time at control point (TACP), which the aircraft must be at to achieve both desired effects and meet the TOT. The TACP also serves as the reference point to determine if the aircraft is early or late once on final. From the release time (TACP) subtract the Time to Turn, typically 90 degrees from the Figure Eight hold; then add or subtract winds to account for the Delta ground speed changes. **Table 7.15**, Calculating GBU-38 CP Timing Turn-In Times, has example calculations for a headwind, tailwind, crosswind, and quartering crosswind attacks. This method assumes one knot of ground speed change for every one knot of wind. **Figure 7.39**, Determining Delta Ground Speed, depicts the Delta ground speed changes for typical Turn-Ins for headwind, tailwind, crosswind, and quartering crosswind attacks. Once the Turn-In time is calculated, the crew must determine the timing solution.

7.7.4.4.2 (FOUO) Determining the Timing Solution. To determine the timing solution, the pilot must assess the aircraft position initially once established in the hold, and each time the aircraft approaches the run-in line on the Tracker display. The most valid assessments of TACP are when the aircraft is either pointed at the CP or 90 degrees off. Since the calculated Turn-In time is based off of a 90 degree turn from the hold to final, when at 90 degrees azimuth in the hold, cross-check the TACP on the Tracker display and determine the Delta between it and the calculated Turn-In time.

Table 7.15 Calculating GBU-38 CP Timing Turn-In Times.

Headwind TOT: 09:09:00 TOF: -:40 Release Time: 09:28:20 TTT: -:30 ΔGS: -:25 Turn-In Time: 09:27:25	Tailwind TOT: 09:09:00 TOF: -:40 Release Time: 09:28:20 TTT: -:30 ΔGS: +:25 Turn-In Time: 09:28:15	Crosswind TOT: 09:09:00 TOF: -:40 Release Time: 09:28:20 TTT: -:30 ΔGS: -:25 Turn-In Time: 09:27:25 (-ΔGS) TOT: 09:29:00 TOF: -:40 Release Time: 09:28:20 TTT: -:30 ΔGS: +:25 Turn-In Time: 09:28:15 (+ΔGS)	Crosswind 180 TOT: 09:09:00 TOF: -:40 Release Time: 09:28:20 TTT: -1:00 ΔGS: -:00 Turn-In Time: 09:27:30
Release Time = TOT – TOF Turn-In Time = Release Time—Time to Turn + Delta GS **ASSUMPTIONS:** * Winds 270/25, TOT 09:29:00, CP placed on release point.			
FOUO			

Figure 7.39 Determining Delta Ground Speed.



FOUO

7.7.4.4.3 (FOUO) Hold. Hold the aircraft in a Figure Eight hold with turns into the wind 5 to 7 NM from the CP. Once established in the hold, cross-check TACP against the calculated turn time to determine time required to kill in the hold in addition to running preattack checks.

7.7.4.4.3.1 (FOUO) Killing Time-In the Hold. The objective of killing time in the hold is the same as outlined in **paragraph 7.7.3.3.5.3**, Killing Time in the Hold. To kill time in the hold, determine the Delta between the current TACP and calculated Turn-In time. Execute the same fly-out timing considerations as listed in the previously mentioned paragraph with the main difference of cross-checking TACP instead of TOI.

7.7.4.4.3.2 (FOUO) Fly-Out Maneuver. The purpose of a Fly-Out maneuver is to maneuver the aircraft to have it arrive back at the desired run-in at the Turn-In time. To make the Fly-Out maneuver calculations easier, a pure headwind or tailwind run-in makes the Figure Eight hold have the same ground speed as the aircraft flies perpendicular to the run-in. To execute a Fly-Out maneuver, take the Delta and subtract out the time it takes for a 180-degree turn. Take the remaining time and divide it in half. Using this result, cross-check the GMT clock time and fly perpendicular to the hold away from the run-in for the duration of the time calculated. Once the timed Fly-Out is complete, execute a 180-degree turn at the planned bank angle and head back to the run-in. A turn more than 180 degrees will be required to get the aircraft back to the same range when the Delta was calculated, or as the aircraft flies the outbound leg of the Fly-Out maneuver, fly offset from the line perpendicular to the hold to create turning room so that the aircraft is at the desired range once on the inbound leg to the Turn-In point. Once at the desired hold range and approximately 90 degrees of azimuth to the CP, cross-check TACP and assess the Delta for the calculated Turn-In time. As the aircraft approaches the run-in, it will be at the calculated Turn-In time if the Fly-Out maneuver was executed properly and the crew should Turn-In and execute the attack. If the Delta to the Turn-In time is large, then repeat this process to kill the remaining time in the hold. If the Turn-In time has already passed, then immediately Turn-In and execute the attack. **Figure 7.31**, Killing Time-In the Hold for CP Timed Attacks, depicts examples of the Fly-Out maneuver and holding decision criteria.

7.7.4.4.3.3 (FOUO) Preattack Checks. Once the hold plan has been developed and the timing solution has been solved, run SLAPUM WTARSEC in accordance with standard GBU-38 attack procedures as outlined in **paragraph 7.3.2.2.1.1**, Preattack Checks.

7.7.4.5 (FOUO) Execution. Execution uses the same procedures from **paragraph 7.3.2.3.3**, Execution, for standard GBU-38 attacks, with the additional restriction of the timing solution driving the Turn-In and attack pacing.

7.7.4.5.1 (FOUO) Turn-In. Execute the turn to final with a standard rate turn at the calculated Turn-In as discussed at the end of **paragraph 7.7**, Timed Attack Procedures.

7.7.4.5.2 (FOUO) Final. Once on final, run the STAT cross-check and assess the timing solution to determine if the aircraft is early or late. Cross-check TACP to assess the Delta between it and calculated release time. If within 10 seconds, continue on final. If the aircraft is going to be greater than 10 seconds early or late, execute the appropriate timing correction.

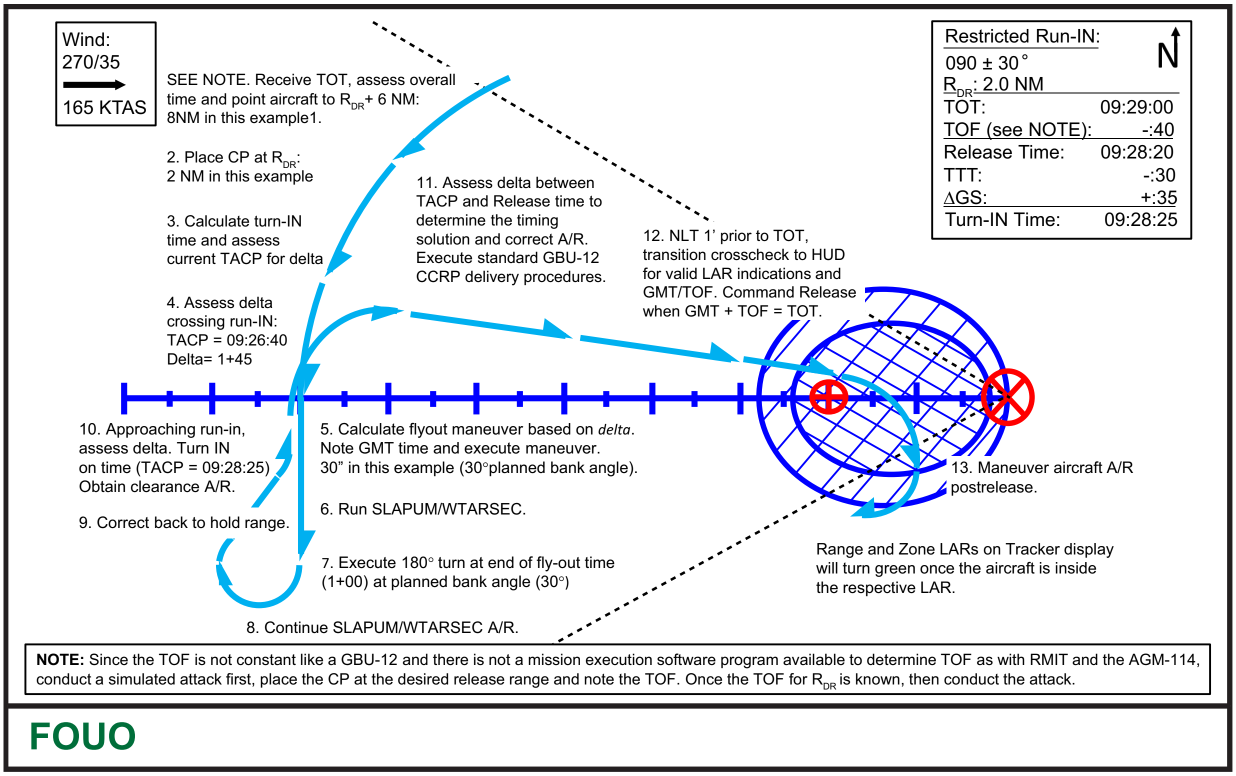
7.7.4.5.2.1 (FOUO) Late Timing Correction. If the TACP on the Tracker display is later than the calculated release time, the aircraft is late. Determine the Delta and speed up by commanding an airspeed increase that corresponds to the number of seconds late (1:1 ratio). As the airspeed increases, cross-check TACP and assess the Delta between it and release time. Once the Delta is within 10 seconds, cross-check the current airspeed in the HUD and set its value into airspeed hold. As a rule of thumb, the aircraft can typically make-up about 10 seconds per minute on final. Based on the tolerance for the TOT and desired weapons effects, ABORT the attack if the TOI is outside the TOT tolerance or impact conditions will not meet desired weapons effects from the extended release range (i.e., range versus zone).

7.7.4.5.2.2 (FOUO) Early Timing Corrections. If the TACP on the Tracker display is earlier than the calculated release time, the aircraft is early. Determine the Delta and slow down by commanding an airspeed decrease that corresponds to the number of seconds early, not to exceed stall plus 5 knots (e.g., 22 seconds early, decrease airspeed hold by 22 knots from the current value, but not slower than 97 KIAS if stall speed is 92 knots). Beyond 10 seconds of error, geometry is another option to correct an early timing error if recognized early and at the beginning of the run-in. It is not recommended to use simultaneous airspeed and geometry corrections to fix early timing errors. Execute the applicable geometric maneuver to correct the timing solution and put the aircraft on time, initially turning the aircraft to better align with the desired run-in. However, geometric timing corrections may position the aircraft outside of planned employment parameters. Once geometric corrections are used, it is imperative that the aircraft is pointed back towards the CP, or else the TACP will be inaccurate. This may result in an off azimuth shot depending on how much geometry was used. See **Table 7.10**, Geometric Timing Corrections, to see common geometric maneuvers to fix various timing errors. Refer to the current aircraft heading and use that to determine the heading changes for geometric error corrections.

7.7.4.5.3 (FOUO) Release to Splash. At one minute prior to the TOT transition the cross-check to the HUD and TOF and away from the TACP on the Tracker display and calculated release time. Command release when the TOF in the HUD added to the GMT clock time in the HUD equals the TOT. As the aircraft approaches this release point, verify the aircraft is in the appropriate LAR for desired impact parameters. If the TOT tolerance allows and the aircraft is past the desired release point (i.e., early), release the weapon prior to minimum range and accept the Delta between the TOT and actual TOI. Execute standard GBU-38 procedures from release to Splash In accordance with **paragraph 7.3.1.4.2.3**, Release to Splash. After Splash, the SO accomplishes post impact procedures.

7.7.4.6 (FOUO) Egress. Execute standard egress procedures as outlined in **paragraph 7.3.4.6.1.8**, Egress. **Figure 7.40**, GBU-38 CP Timing, depicts an example of a CP Timing Attack.

Figure 7.40 GBU-38 CP Timing.



7.7.4.7 (FOUO) Quartering Crosswind CP TOT. Conducting a quartering crosswind CP timing attack is the most difficult timing solution with winds greater than 30 knots. Recommended selecting another attack run-in aspect if available, or conduct a Planning Tool Attack after determining the release range and TOF.

7.7.5 (FOUO) GBU-49/54 Timing. The primary method for conducting GBU-49/54 timed attacks is the TOI, secondary is the Planning Tool method.

7.7.5.1 (FOUO) GBU-49/54 TOI. Execute TOI as outlined in **paragraph 7.7.4.2**, GBU-38 Time of Impact, with the notable difference of selecting Stationary Target mode versus Moving Target.

7.7.5.2 (FOUO) GBU-49/54 Planning Tool. The GBU-49/54 Time Based and Distance Based Planning Tool attacks are executed in the same manner as the GBU-12 procedures as outlined in **paragraph 7.7.3.3**, GBU-12 Planning Tool. The only exceptions are that Manual Release is selected in the Planning Tool, which enables the R_{DL} and TOF to be input. Run GWTS to determine R_{DL} and TOF then input the numbers into the Planning Tool and SMS Also, when on final, command release inside the LAR when the TOF equals zero.

7.8 (FOUO) Contingencies. There are multiple contingencies that prevent or hinder weapons employment. They fit into the following categories: weather, release malfunctions, weapons malfunctions, laser malfunctions, TGP malfunctions, and terminal guidance.

7.8.1 (FOUO) Employment Through the Clouds.

7.8.1.1 (FOUO) GBU-12 Employment Through the Cloud. See **Table 7.16**, Minimum Cloud Deck (AGL) for 9 Seconds of Lase Time for MQ-9 GBU-12. GBU-12 deliveries may still be possible assuming the following conditions can be met:

7.8.1.1.1 (FOUO) Accurate coordinates (to the degree that the terminal guidance laser falls within the LAR for the coordinates used) for the target can be generated and loaded into the SMS (BOC delivery).

7.8.1.1.2 (FOUO) The bottom of the cloud deck is high enough to allow for 8.8-second lase time on GBU-12 (9,000 feet ROT).

7.8.1.1.3 (FOUO) Second asset available to provide laser energy on target below cloud deck.

7.8.1.2 (FOUO) GBU-38. GBU-38 deliveries may still be possible assuming the following condition can be met:

7.8.1.2.1 (FOUO) Accurate coordinates for the target can be generated and loaded into the SMS. **Table 7.16**, Minimum Cloud Deck (AGL) for 9 Seconds of Lase Time for MQ- 9 GBU-12.

7.8.1.3 (FOUO) AGM-114R Employment Through the Clouds. The following TTP solves situations where AGM-114R variant are required to employ through the clouds. Due to the complicated nature of these TTP, only attempt employing through a cloud deck when the tactical situation requires it.

7.8.1.3.1 (FOUO) GBU-12 employment through the weather requires a minimum ceiling of 9,000 feet. AGM-114 employments from normal MQ-9 operating altitudes of approximately 20,000 HAT, requires the same minimum ceiling. This ROT also assumes employments <60 degrees off-azimuth and ground ranges between 4 km and 8 km. When the tactical situation drives employment with lower ceilings, follow the ROT in the next paragraphs:

7.8.1.3.2 (FOUO) Based on the trajectory shaping of LOAL-H versus LOAL-D, the rules of thumb for minimum cloud ceilings vary. Also note that these ROT only apply to missiles with R guidance, as no testing has been accomplished for P guidance.

7.8.1.3.2.1 (FOUO) LOAL-D. For LOAL-D engagements, the minimum ceiling (the lowest level cloud obscuring the target) is 5,000 feet AGL with a 10,000 HAT. For every 5,000 feet HAT increase, the minimum ceiling increases by 1,000 feet. The exception to this rule is that an employment at 5,000 HAT requires a minimum ceiling of 3,000 feet. See **Table 7.17**, Hellfire Lowest Ceiling ROT for a visual representation.

Table 7.16 Minimum Cloud Deck (AGL) for 9 Seconds of Lase Time for MQ-9 GBU-12.

Aircraft TAS at Release	Target Altitude (Feet MSL)	Aircraft Altitude at Release (Feet MSL)				
		10,000	15,000	20,000	25,000	30,000
140	0	5,479	6,128	7,182	8,529	8,513
	5,000	N/C	5,465	6,785	7,931	8,406
	10,000	N/C	N/C	5,451	6,749	7,862
160	0	4,952	6,142	7,201	8,554	8,550
	5,000	N/C	5,471	6,796	7,946	8,428
	10,000	N/C	N/C	5,457	6,759	7,876
180	0	4,961	6,457	7,221	8,580	8,590
	5,000	N/C	5,477	6,808	7,963	8,453
	10,000	N/C	N/C	5,462	6,769	7,890
200	0	4,970	6,172	7,243	8,609	8,636
	5,000	N/C	5,484	6,820	7,981	8,480
	10,000	N/C	N/C	5,468	6,780	7,906

OVERALL NOTES:

* GWTS set with 35 degrees latitude for target and no winds.

* Unless otherwise noted, all altitudes are AGL.

EXAMPLE: If dropping at 160 TAS from 15,000 feet MSL on a target that was at 5,000 feet MSL, the cloud deck would need to be at least 5,471 feet above the target.

LEGEND:

N/C—not calculated

Table 7.17 Hellfire Lowest Ceiling ROT.

Launch Altitude (Feet HAT)	Lowest Cloud Ceiling (Feet AGL)	
	LOAL-Direct	LOAL-High
25,000	8,000	9,000
20,000	7,000	8,000
15,000	6,000	7,000
10,000	5,000	6,000
5,000	3,000	4,000

Assumptions:

* At Rifle, <±60 degrees azimuth and 4 km to 8 km ground range.

7.8.1.3.2.2 (FOUO) LOAL-L. There is no recommended employment through the clouds TTP for LOAL-L due to lack of simulation/testing.

7.8.1.3.2.3 (FOUO) LOAL-H. For LOAL-H engagements, the minimum ceiling is 6,000 feet AGL with a 10,000 HAT. Just like for LOAL-D, for every 5,000 HAT increase, the minimum ceiling increases by 1,000 feet. Again, the exception for LOAL-H is a 5,000 HAT employment requires a 4,000 feet ceiling. See **Table 7.17**, Hellfire Lowest Ceiling ROT, for a visual representation.

7.8.1.4 (FOUO) General Considerations.

7.8.1.4.1 (FOUO) Target Location Error. Due to the employment parameters in the above ROT, TLE between the provided coordinates and the accuracy of the TGP will keep the pointing vector of the HF within the Target Handover Boundary. This assumes that the passed coordinates are TLE IV or better.

7.8.1.4.2 (FOUO) Laser Acquisition. The three-dimensional pointing vector in the R09 is based on where the TGP is "looking" at Rifle. When the laser is not firing, the solution is based on DTED, which is less accurate than a laser solution in normal cases. Due to the target being obscured, firing the laser into the clouds may result in erroneous slant range data, which will impact the reliability of the HF to reach the target. Therefore, shooters should NOT fire the laser at Rifle. Although DTED is less accurate, the two different location solutions have proven to be equally effective in operational employments.

7.8.1.4.2.1 (FOUO) Buddy Lase. The shooter above the weather and designating asset below the clouds must coordinate to ensure the laser spot is visible to the missile seeker once it passes through the clouds. Due to look angles experienced by airborne assets at low altitude, and the wide range of Hellfire impact angles, ineffective engagements have occurred in combat due to crews failing to communicate laser to target line, and expected impact angles. For LOAL-H employments in the heart of the WEZ expected impact angles are approximately 70 degrees or more and desired points of impact (DPI) should be placed on the top of targets. For LOAL-D employments in the heart of the WEZ expected impact angles are approximately 45 degrees, and DPI should be placed on the side of targets.

7.8.1.4.2.2 (FOUO) Target Handover Boundary. The THB displayed by RMIT assume laser acquisition at lock-on enable. Due to the potential for lock-on enable to occur prior to the missile clearing the clouds, the RMIT THB may not be representative of the actual missile FOV, when employing through the clouds. To maximize the handover boundary for through-the-clouds employment, input the most accurate coordinates available and employ using LOAL-D.

7.8.1.4.2.2.1 (FOUO) THB Considerations. Due to decreased THB, and target-tracking limitations, crews should not engage moving targets with AGM-114s through the clouds until further testing can quantify the THB and target escape velocity, with delayed laser acquisition.

7.8.1.4.3 (FOUO) Close Air Support and Bomb-on-Coordinate Employment. Per JP 3-09.3, *Close Air Support*, any attack where the aircraft is never required to be TALLY/CAPTURED the target, or CONTACT the mark, is a BOC attack. Therefore, an AGM-114 through-the-clouds engagement is a BOC engagement. Also from JP 3-09.3, *Close Air Support*: "For BOC missions, all aircraft delivering ordnance must read back Line 4, and Line 6 from the system or weapon, as appropriate, in conjunction with other required restrictions." A readback of the target elevation, and coordinates from the TGP graphics should be close to, but likely will not match the exact coordinates passed in the 9-Line. The crew should create a manual target in the SMS, and use target lock to slave the TGP to those coordinates. Then verify TGP-indicated target coordinates, and elevation nearly match the information passed in the 9-Line. Pilots should read back Lines 4, and 6 from the bottom of the launch status page on the SMS. For aircrew to correlate the target, and coordinates, they can use a combination of SMS target coordinates, TGP target coordinates, tracker target, and sensor point-of-interest (SPI), Zeus SPI, as well as SAR imagery, and SPI from the CLAW display.

7.8.1.5 (FOUO) Employment Procedures. Below are step-by-step procedures for an AGM-114 employment through the clouds.

7.8.1.5.1 (FOUO) Release Solution. Determine an acceptable release solution, factoring in both weather, and desired weapons effects (DWE). To do this, assess the current cloud ceiling in feet AGL by requesting a PIREP from an asset below the weather. Compare the current conditions to the information in **Table 7.17**, Hellfire Lowest Ceiling ROT.

7.8.1.5.2 (FOUO) SMS. Create a SMS target using the target's coordinates and elevation.

7.8.1.5.2.1 (FOUO) Select this target as the active target on the SMS Select Target page.

7.8.1.5.3 (FOUO) SO Duties. The sensor operator checks "target lock" in the targeting mode window. The TGP will slave to the location of the currently selected SMS target.

7.8.1.5.4 (FOUO) Game Plan. Position the aircraft (to include changing altitudes) as required to achieve an acceptable ceiling clearance from **Table 7.17**, Hellfire Lowest Ceiling ROT.

7.8.1.5.5 (FOUO) Verify that the target coordinates in the TGP graphics match the actual target coordinates. The SAR is an additional source to use for correlation.

7.8.1.5.6 (FOUO) Coordination. Coordinate with the lasing platform IAW **paragraph 8.9.1**, Buddy Lase Procedures.

7.8.1.5.7 Rifle the hellfire with the laser off.

CAUTION: To prevent fratricide with the designator, adhere to laser safety zones and Hellfire designator exclusion zones outlined in JP 3-09, *Joint Fire Support*, Appendix B.

7.8.2 (FOUO) Release Malfunctions. Release malfunctions are contingencies at weapons release where the weapon does not leave the aircraft, even though release is commanded (e.g., Master Arm-ARMED, Launch Enable pressed and then trigger squeezed). Switch errors are not considered a release malfunction and the pilot must identify when one has occurred and, if still in a position to employ, continue lasing and re-command release.

7.8.2.1 (FOUO) Combat. In the event of a release malfunction in combat, as a technique, step to the next weapon, continue lasing, and complete the engagement (assuming same weapon type is available, aircraft still in position to employ, and same PRF). Once the engagement is complete, run the appropriate release malfunction checklist in the -34. Apply caution when executing this TTP as unless the crew can verify the initial intended ordnance has not released from the aircraft (e.g., no plume observed following an on-boresight hellfire shot, or no wing rock following GBU release), there is no guarantee it has not been released.

7.8.2.2 (FOUO) Training Environment. For release malfunctions in a training environment (simulated ordnance), execute in the same manner as in combat. For release malfunctions in a training environment (live ordnance), call KNOCK IT OFF if required, complete no-spot procedures, notify appropriate agencies, and run the appropriate -34 checklist.

7.8.2.3 (FOUO) Procedures. In any situation, if the decision is made not to step to the next weapon, execute no-spot procedures first, and then run the applicable -34 checklist. The possible release malfunctions types are hung store, misfire, or hangfire. Reference Section 3 in -34 checklist for release malfunction checklists.

7.8.3 (FOUO) Weapons Malfunctions. Weapons malfunctions are contingencies where a successful release occurs but no Splash is observed, or Splash is observed without the weapon fuzing (Dud).

7.8.3.1 (FOUO) No-Spot. A no-spot malfunction occurs when the weapon TOF expires with no Splash observed. The reason for the no-spot may vary (e.g., seeker failure, weapon control system failure, etc.), but the procedures remain the same:

7.8.3.1.1 (FOUO) Crews will continue lasing 15 seconds after the expected time of impact.

7.8.3.1.2 (FOUO) After 15 seconds, sensors will CEASE LASER, select IR, zoom-out as required, and conduct a rolling box search pattern to search for the weapons impact point.

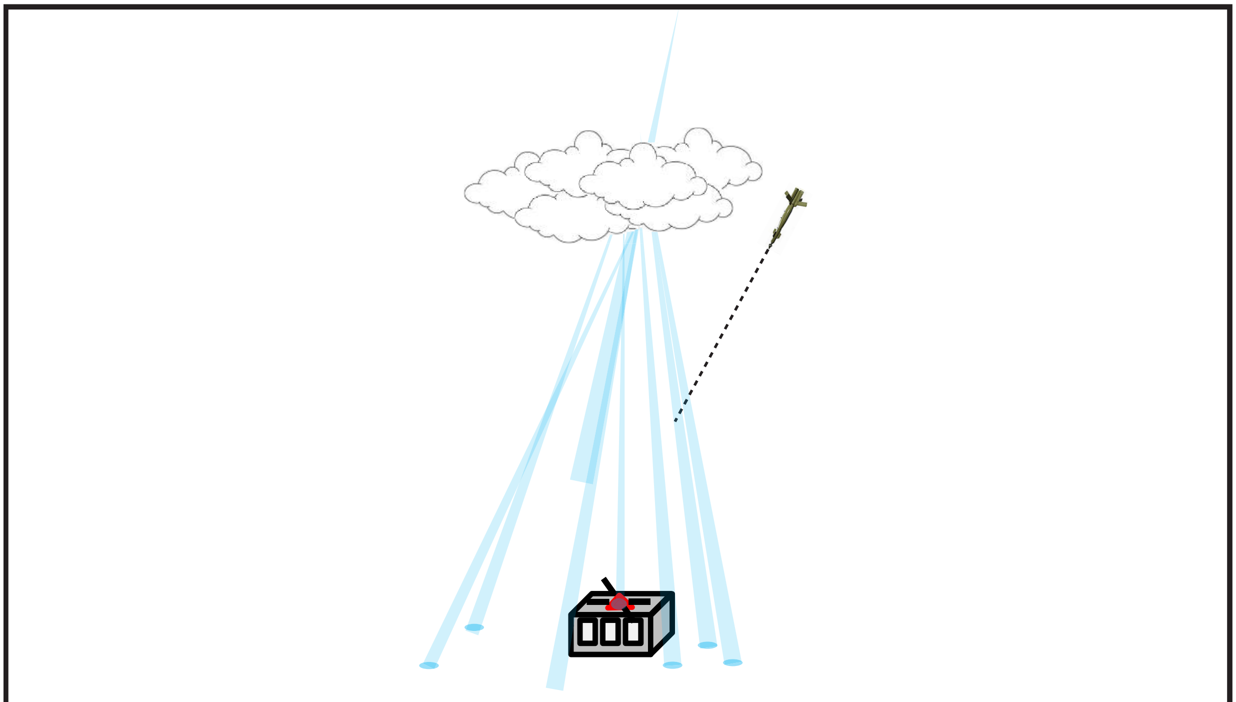
7.8.3.1.2.1 (FOUO) If crew elects to step to the next missile (AGM-114 only) due to possible release malfunction, consideration should be given to executing no-spot procedures after the second missile impacts since the impact observed could have potentially been the first missile.

7.8.3.2 (FOUO) Dud. A dud malfunction occurs when the crew observes Splash, but without expected weapons effects. When a weapon duds, the fuze fails to fire. It is possible the weapon may dud due to the release settings in the SMS not being setup properly, and/or the weapon is unarmed at release.

7.8.4 (FOUO) Terminal Guidance (Laser) Contingencies. Terminal guidance begins when the laser-guided munition (LGM) acquires the properly PRF coded laser energy. There are several situations which may cause terminal guidance problems for LGMs.

7.8.4.1 (FOUO) Backscatter. Laser backscatter occurs when laser energy is reflected due to suspended matter in the atmosphere (e.g., smoke, haze, clouds). See **Figure 7.41**, Backscatter Effect. The SO should cross-check elevation when the LRD is firing to determine if laser backscatter is a concern (i.e., there is a significant change in elevation upon lasing). The reflected laser energy can cause the seeker to lock-on and guide to the false target, increasing the chances for missing the intended target. Avoid using LGMs in an environment where backscatter is a concern.

Figure 7.41 Backscatter Effect.

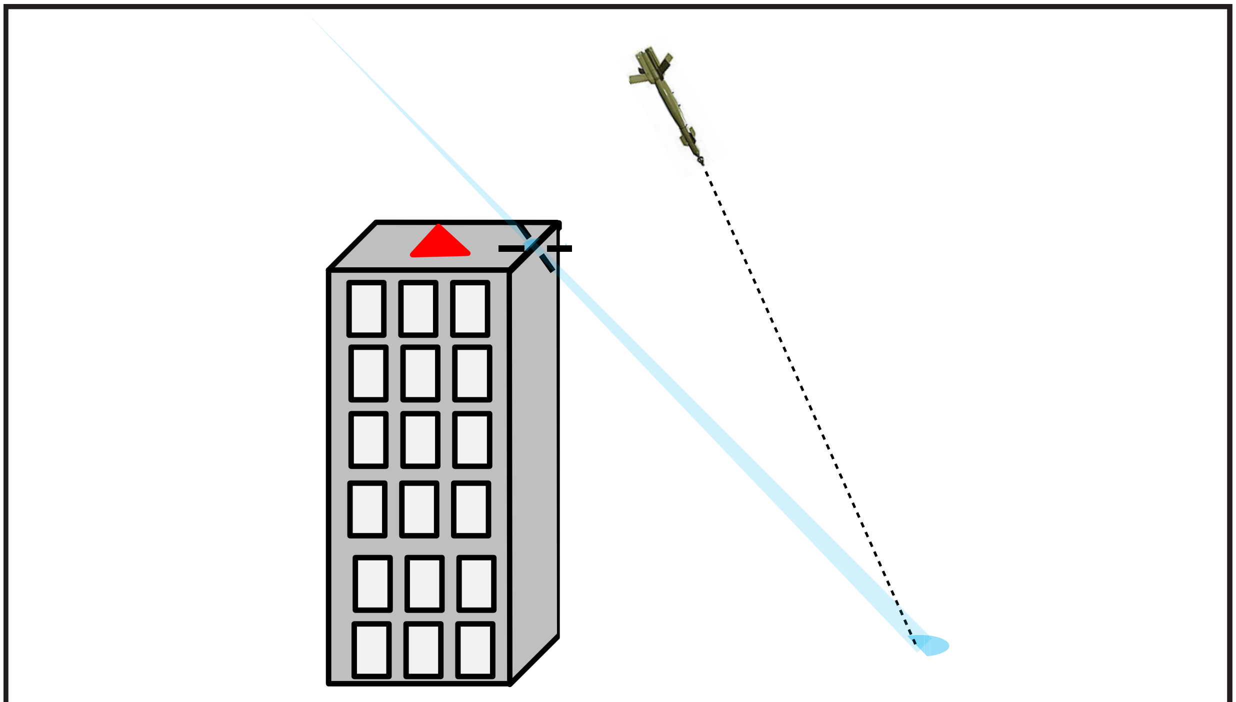


FOUO

7.8.4.2 (FOUO) Laser Spillover. Spillover effect is caused when the diameter of the laser beam is larger than the target being illuminated. See **Figure 7.42**, Spillover Effect. When laser energy spills over the target, objects around or behind the target can be illuminated.

7.8.4.2.1 (FOUO) Spillover Effects. The LGM may guide on one of these secondary objects rather than the intended target. Depending on the target type, there are several ways to overcome the spillover effect. For small targets, employ as close as possible to minimize the laser beam divergence. For vertical targets, designate below the top of the target so the laser beam does not spill over on the top. For most other targets, designate the center of mass to minimize the amount of laser spillover. The AN/DAS-1 laser spot size is very small which helps minimize the spillover effect. Refer to AFTTP 3-1.MQ-9, Chapter 2, for specifics regarding the MQ-9 LRD spot.

Figure 7.42 Spillover Effect.



FOUO

7.8.4.3 (FOUO) Flashlight. Flashlight effect is caused by a low graze angle. See **Figure 7.43**, Flashlight Effect. The lower the graze angle, the more the laser energy can be spread over an area larger than the target. Keeping the graze angle steep maximizes the strength of the target return. Flashlight effect is not typically a factor at the medium altitudes the MQ-9 usually employs from. It is also not a factor on large targets such as buildings or groups of personnel. At low altitudes, consideration should be given to employing as close as possible to minimize flashlight effect or targeting the flat side of the target if possible in order to mitigate flashlight.

7.8.4.4 (FOUO) Laser Masking. Laser masking occurs when an object obstructs the laser LOS from the TGP to the target. See **Figure 7.44**, Laser Masking Region. There are three common types of masking: Podium effect, aircraft, and environmental.

7.8.4.4.1 (FOUO) Podium Effect. Podium effect occurs when the movement of the aircraft during the weapon time of flight induces masking because the laser spot is unable to be positioned at a location where the weapon's seeker has LOS to it. See **Figure 7.45**, Podium Effect. Without laser energy, the LGM will not guide, and the P_H is significantly reduced. Podium effect may occur with either self-designation or buddy lasing. There is a greater risk of podium effect at low altitudes or against vertical targets. For the MQ-9, self-lasing at medium altitude with steep depression angles reduces the chance of podium effect against horizontal targets with the DPI on the top.

Figure 7.43 Flashlight Effect.

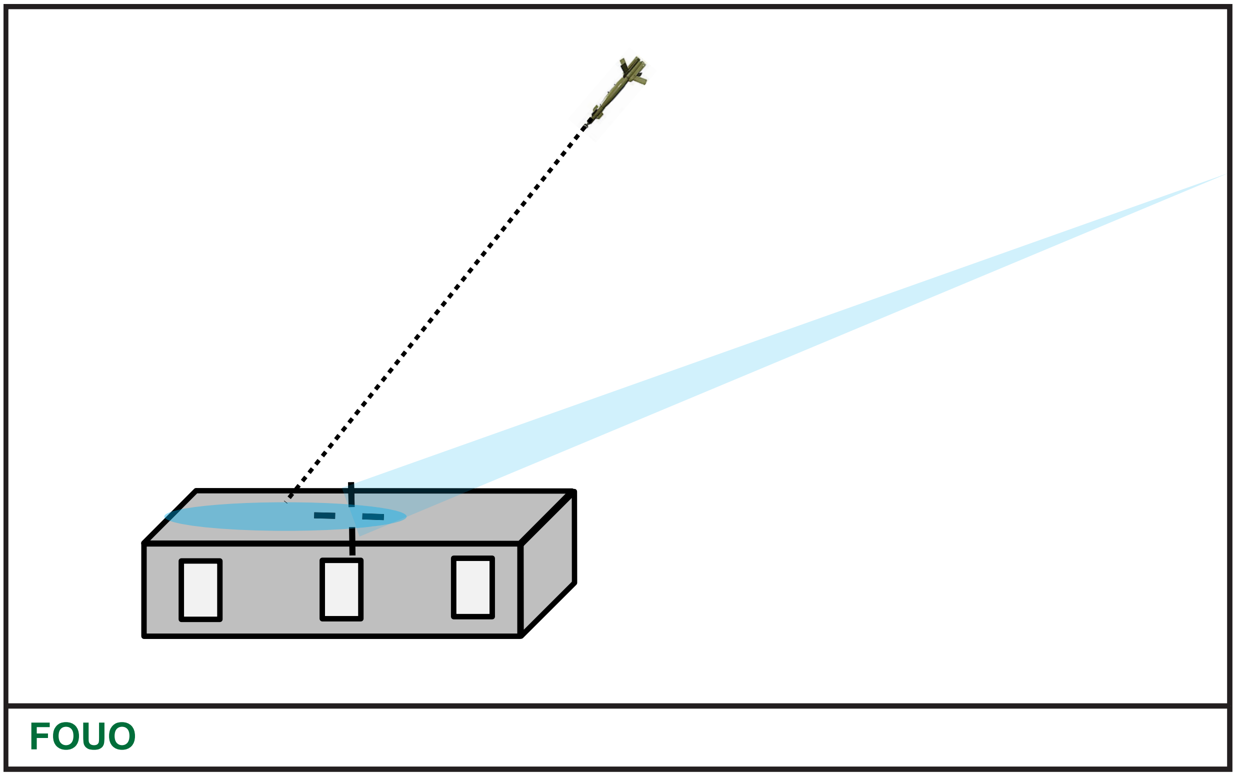


Figure 7.44 Laser Masking Region.

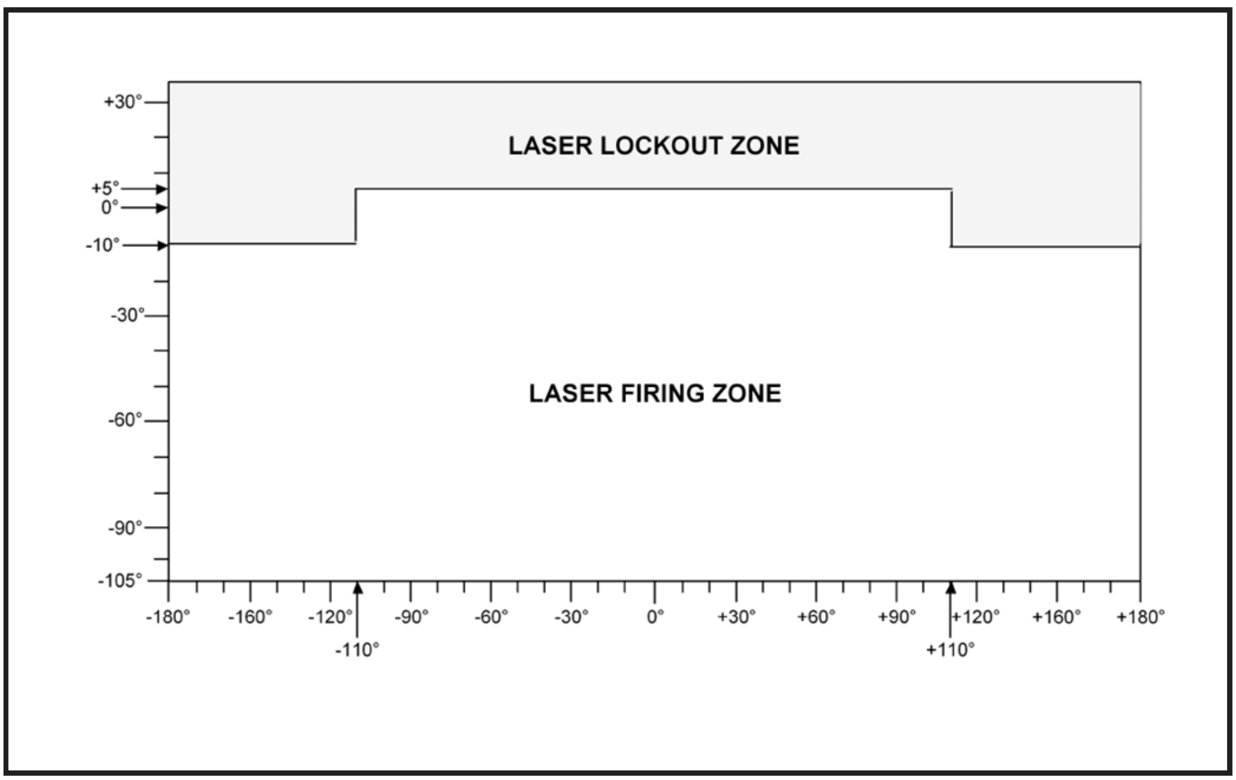
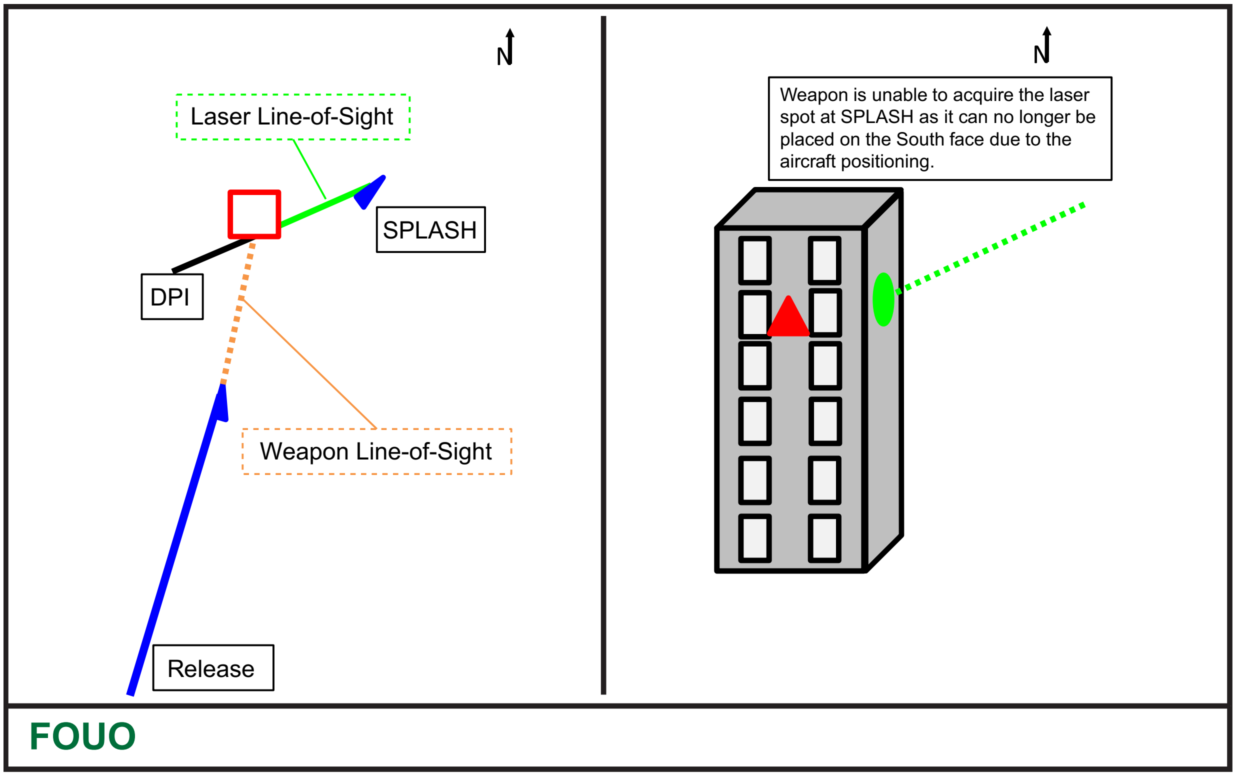


Figure 7.45 Podium Effect.



7.8.4.4.2 (FOUO) Aircraft Masking. Aircraft masking occurs when the laser LOS to the target is obstructed by the aircraft and/or its weapons. See **Figure 7.46**, Aircraft Masking. The laser lock-out region prevents blocking or deflecting of the beam, as well as prevents damage to the TGP LRD receiver and to the IR seekers of onboard LGMs, by inhibiting the laser from firing in the region. See **Figure 7.44**, Laser Masking Region. IMPENDING MASK message appears when the TGP is within 5 degrees of the laser mask region. When the TGP is in the lockout region, the LASER MASKED message appears in the HUD display. When the laser is clear of the masked area, it will automatically resume firing provided the SO does not turn off the laser during the masking event.

7.8.4.4.3 (FOUO) Environmental Masking. Environmental masking occurs when objects in the target area, or clouds, obstruct laser LOS to the target. Environmental masking should be mitigated prior to release. The SO should scan for vertically developed objects in the target area that could obstruct the laser LOS if the aircraft is flown with the same bearing to the target as the obstacle. The obstacles should be made aware to the crew and the pilot should adjust the run-in and postrelease maneuvering as required to avoid the masking. If lower-level clouds are present in the target, the SO must zoom-out to WIDE or ULTW FOV and assess the clouds over the target. The crew should identify gaps in cloud coverage and position the aircraft to that side of the target. Once on final and prior to release, the SO can zoom-out once more, slew up slightly and verify the run-in is free from clouds. In the event of questionable masking, the crew should coordinate for a GOALIE option to mitigate cloud masking.

Figure 7.46 Aircraft Masking.

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CHAPTER 8

MQ-9 FORMATION AND MULTISHIP

8.1 Overview. Employing MQ-9s in formation exponentially increases mission efficiency and effectiveness. An MQ-9 formation efficiently maximizes its effects through effective flight leadership and contract adherence. An important distinction is the definition of "traditional formation" (a preplanned, dedicated, and formal flight relationship) versus "multiship" (an ad hoc formation of similar and/or dissimilar aircraft relying on real-time direction from a tactical lead for a specified time or until desired effects are achieved). This chapter establishes common terms, administration, briefing, execution, and debriefing of a formation, as well as other multiship considerations. Additionally, differences between formation and multiship are distinguished in separate sections. Relevant and proven formation TTP in individual mission sets are discussed in the applicable chapters in the AFTTP 3-1.MQ-9.

8.1.1 Maximize Formation Capabilities. The following paragraphs outline specific efficiencies that flight leads, mission commanders, and supported squadrons can capitalize on when employing the MQ-9 in formation.

8.1.1.1 Aircraft. Multiple aircraft allow for equipment redundancies between the flight. Additionally, formation contracts enable search plan and attack execution to be massed with significantly less coordination.

8.1.1.2 Sensor. Multiple sensors provide different look angles of a target or target area, as well as the ability to simultaneously search within a target area. Coordinated find/fix/track plans between all sensors (e.g., SAR, TGP, AIRHANDLER, etc.) quickly bring comprehensive situational awareness (SA) to any wide area search (WAS). Although counter intuitive, two MQ-9s working as a flight can search a larger area in less time with greater shared SA than two MQ-9s operating independently.

8.1.1.3 Weapons. Formation attacks can increase weapon efficiencies through flight buddy-lase TTP (also known as shooter-buddy TTP). They decrease the time between attacks as well as increase flexibility with the numbers and types of weapons carried across the formation.

8.1.1.4 Communications. The flight communications plan allows the formation to monitor multiple frequencies and increase SA. Some MQ-9 squadrons have configurable radio monitoring that allows cockpits to monitor the airborne radios of another MQ-9, effectively giving the flight real-time SA on up to four radios.

8.1.2 Traditional Formation Versus Ad Hoc Multiship.

8.1.2.1 Traditional Formations. Preplanned formations, henceforth referred to as "formations" are "traditional" in the sense they plan, brief, fly and debrief together with defined flight lead and wingman roles. Formations can be listed on the ATO, with named flights, e.g., SAVAGE 11 and 12. MQ-9 formations are likely two-ships, but allow for four or more given crew proficiency and mission requirements.

8.1.2.2 Ad Hoc Multiship. Ad hoc formations, henceforth referred to as "multiship," may consist of MQ-9s as well as dissimilar aircraft that join for a specific task under the control of a tactical lead to provide specific effects. This multiship is temporary and individual aircraft will effectively "clear off" once the effects are achieved or the task is complete. By definition, multiships have limited prior coordination, and rely on leadership akin to tactical lead via coordinated attacks.

8.2 Formation Roles. Formations are divided into two roles with specific responsibilities: flight lead and wingman. Shooter, buddy, goalie, and cover are all roles associated with strike execution and are assigned by the flight lead to the members of the flight.

8.2.1 Flight Lead. The flight lead is the PIC of the lead aircraft. The flight lead is responsible for the entire formation's effectiveness and must manage many tasks during all phases of a mission. Squadrons should build and execute a flight lead upgrade (FLUG) program and selectively enter experienced and proficient pilots into the upgrade. Reference Capt Christopher Gausepohl's USAFWS paper, *Two-Ship Flight Lead Upgrade Training Plan: A Road Map for MQ-1/-9 Pilots*, for further details.

8.2.1.1 Determination of Flight Lead. Within a formation of multiple qualified flight leads, the most experienced flight lead will typically be that formation's flight lead, unless proficiency or SA dictate otherwise.

8.2.1.2 Responsibilities. The flight lead has several responsibilities for the safe and effective execution of the formation.

8.2.1.2.1 Mission Planning. The flight lead develops a plan that best fulfills the mission objectives based on available resources and Intel assessment.

8.2.1.2.2 Communication. The flight lead sets the formation communication plan to maximize information exchange while minimizing comm requirements.

8.2.1.2.3 Contracts. The flight lead sets formation contracts to provide direction to the formation in all phases of the sortie. Contracts manage expectations within the formation and enable all flight members to accomplish tasks in concert with each other while reducing interflight communication.

8.2.1.2.4 Deconfliction. The flight lead is responsible for safe deconfliction of formation and other assets. This pertains to both aircraft and weapons. Although the flight lead is responsible for deconfliction, this does not alleviate the wingmen of the responsibility to identify and communicate unsafe situations.

8.2.1.2.5 Formation Management. The flight lead manages the formation during execution to continually put the formation in the best position for mission success.

8.2.1.3 Multiship Flight Lead. Sometimes flight lead responsibilities are accomplished by a mission commander (MCC) in a blended flight lead/Top 3 role when all aircraft come from the same squadron or operation. If not, the aircraft with the most SA or first to employ weapons in the ad hoc multiship should assume the multiship tactical lead role.

8.2.2 Element Lead. For formations with four or more aircraft, one of the wingmen should be declared the element lead. Normally, the element lead retains normal wingman roles. As required, the flight lead may delegate specific flight lead responsibilities to the element flight lead. If the flight lead falls out, the element lead will become the flight lead.

8.2.2.1 Determination of Element Lead. The same ROE in choosing a flight lead should be used as a baseline for determining the element lead.

8.2.2.2 Element Lead Number. Normally, the deputy flight lead is numbered at the halfway point for the formation. For example, the element lead would be Number Three in a four-ship.

8.2.3 Wingman. All other formation members who report directly to the flight lead or the element lead are considered wingmen. For two-ship formations, the wingman will be referred to as "Two" and the flight lead can be referred to as "One" or "Lead."

8.2.3.1 Responsibilities. Wingmen are required to execute IAW flight lead plans, tasks, contracts, and direction. If unable to adhere to a contract or accomplish a task, the wingman should inform the flight lead at the earliest opportunity. Wingmen should strive to be in position, ready for the next task, with systems prepared and crew briefs complete IAW Lead's intent.

8.2.3.2 Wingman Assumptions. It is assumed wingmen are in position or correcting, NO JOY and BLIND, TIMBER and feed SWEET. Wingmen should advise if they are unable to quickly get in position or with changes to SA on targets, friendlies, or ability to monitor Lead.

8.3 Two-Ship Formation. Mutually supportive two-ship surface attack (SAT) can provide significantly expedited effects with greater reliability. The following sections build on single-ship SAT TTP to present how a formation can efficiently prosecute targets. The difference between two-ship tactics and coordinated attacks is that the two-ship will mission plan, brief, execute, and debrief together using the TTP established below.

8.3.1 Mission Planning. Developing a strong plan will significantly increase two-ship SAT efficiency and effectiveness. As with any mission set, mission planning begins with understanding the intent and developing a game plan to effectively and efficiently achieve the desired intent. Generally, the same principles of single-ship mission planning apply to two-ship. However, there are some considerations which must be made to account for the addition of a wingman, weapons, and available sensors. Thorough mission planning enables increased flight performance. The following concepts should be added to mission planning to execute as a formation.

8.3.2 Delegate Tasks. Effective mutual support begins in mission planning. The flight lead must delegate tasks to the wingman so that Lead can focus on the larger and more complex mission tasks.

8.3.2.1 Wingman's Responsibilities. At a minimum, the non-experienced wingmen should be able to file flight plans, run GWTS, GBIT and RMIT, and pull weather, airspace, and NOTAMs. Experienced wingmen can be tasked to build or update mission execution products such as lineup cards, attack cards, Zeus and CLAW overlays, or design integrated SAR search plans in conjunction with the Lead SO. Experienced wingmen can also weaponeer specific attack parameters in JWS, IMEA, and other weaponeering software, as required.

8.3.2.2 Lead Sensor Operator's Responsibilities. The lead SO is responsible for developing and briefing a two-ship TGP plan, search plan, and SO contracts in accordance with the flight lead's overall execution plan and mission objectives.

8.3.2.3 Wingman Sensor Operator. The wingman SO should be tasked to support lead SO.

8.3.3 Communication Planning. Establishing an effective communication scheme between internal and external players is critical for formation success. The following is a prioritized list flight leads should use to select the best communication plan. A dedicated SO channel to assist search execution, but not at the expense of pilot or crew coordination, has proven a successful technique. At a minimum, Lead should select two methods of intraflight communication, a primary and an alternate. Every method will be referenced by type or channel with radio frequencies annotated by UNIFORM or VICTOR depending on respective UHF or VHF bands.

8.3.3.1 ClearCom, Audio MLS, or similar. For cockpits equipped with a multi-channel intercockpit communication system, ClearCom is the best option. The low latency, high fidelity, security, and configurability of these systems make them highly suited to formation flight communication.

8.3.3.2 VOSIP. When cockpits are outfitted with appropriate headset connectivity, VOSIP offers a quick and convenient means to communicate with other RPAs and personnel in established ground locations. VOSIP 'conference calls' enable communication between aircrews and other ground based players. It is the flight lead's responsibility to enforce radio discipline and the use of brevity on VOSIP.

8.3.3.3 Internet Protocol (IP) Radio. Squadrons using IP radio for coordination with supported units can simply add an additional flight channel. IP radio drawbacks include a long initial setup and limited ability to manually program frequencies due to permissions that are centrally managed outside of the squadron.

8.3.3.4 Ground ARC-210. For cockpits equipped with ground-based ARC-210s within range of each other, this option provides rapid use of voice communication. The ARC-210 can be loaded with HQ II and KY-100 crypto. Using the radio control panel wafer switch can be cumbersome when continually changing between the airborne and ground-based ARC-210s.

8.3.3.5 Telephone. Use of a secure telephone system takes advantage of MQ-9 ground-based operations. The telephone is a viable means to communicate among the flight if more desirable means are unavailable. Consider using the speaker phone option to maximize crew SA and avoid having to cradle the handset. Cockpit CRM will likely suffer and audio recording will be unavailable without additional hardware modifications.

8.3.3.6 Airborne ARC-210. For dislocated MQ-9 multiships, this may be the only communication option available due to LOS or equipment limitations. While this is a viable option, multiship coordination may cause undue interference and distraction to other players on the frequency. The multiship may leave the primary frequency for its own flight frequency, but the multiship will most likely miss critical and SA-building communication. Multiship flight leads may request agencies simulcast information to limit lost SA.

8.3.3.7 mIRC. This medium should be used as a last resort. mIRC should be reserved for coordination and administrative communication not critical to mission execution. Sensor operators may elect to use mIRC or Zeus chat as the primary means of communication for search plans, search results, coordination, and battle damage assessment (BDA).

8.3.4 Mission Tools. The two most helpful mission tools to formation execution are the tactical situation (TacSit) display and the other aircraft's feed. Together, these two tools give the flight SA on the other aircraft's position and TGP posture.

8.3.4.1 TacSit. Zeus is likely the formation's primary positional reference and TACSIT display. Zeus allows flight members to fly formation off the other's position and battle track. For an expanded discussion of Zeus, see **Chapter 11**, "Tactical Tools."

8.3.4.1.1 Zeus 2.2 breaks different aircraft out with individual track numbers and allows for Collaborations, a means to share information within a flight without cluttering other formation's TacSits. As a baseline, each crew should be in their own collaboration as well as the other collaboration(s) for the remaining flight members.

8.3.4.2 VideoLAN Client (VLC)/Video Feed. When able, squadron communication support should provide links or computer scripts to view feeds from other cockpits. Viewing the flight lead or wingman's feed will assist sensor deconfliction, DPI confirmation, and overall mission execution. This feed should be visible and sized on peripheral monitors with enough fidelity to break out objects of interest and reference from both the pilot and SO seats. If internal squadron video feeds are unavailable, secondary online sources such as unified video dissemination system (UVDS), should be employed. (Flight leads should adjust briefings and contracts for the inherent delay of online video feeds when used). See **paragraph 5.4.2.2**, Search Plan Development, for further discussion.

8.3.5 Formation Minimum Equipment Serviceability List. The mutually supportive two-ship formation can accept increased system degradation and still be effective where the same inoperative equipment would cause mission failure for a single-ship. However, formations still incur certain equipment requirements to operate safely and effectively. Below is a mission equipment serviceability list (MESL) discussion on what is typically required for any given mission as a two-ship formation.

8.3.5.1 Sensors. Between the two aircraft, one working TGP for missions requiring target correlation or laser weapon guidance is required. Missions requiring wide area search (WAS) to find targets will require one working SAR.

8.3.5.2 Communication System. The formation needs a means of voice communication for real-time coordination. An airborne ARC-210 or other means of communicating with supported squadrons and controlling agencies, preferably monitored by the flight lead, is required for a missionized sortie. See **paragraph 8.3.3**, Communication Planning, for a detailed description of available systems.

8.3.5.2.1 TacSit Display. The primary method of deconfliction is positioning by the flight lead, but is significantly enhanced by a TacSit (Zeus) for each flight member to monitor. Without a viable TacSit, flight leads will require additional position reports from wingmen (by contract or on request).

8.3.5.3 Weapons. A combination of one aircraft with employable weapons and another with an operable TGP is enough to continue as a two-ship assuming they can still provide mutual support in accordance with mission intent and priorities. If one aircraft has neither a working SMS nor TGP, the healthy aircraft is recommended to continue as a singleton.

8.3.6 Contracts. Effective contracts increase flight efficiency by establishing expected reactions, minimizing communication, and decreasing reaction time to anticipated situations. Well-defined contracts answer what criteria must be met for a given action, who has the authority to execute the contract, the associated communication (if any), and the resulting action. Formation contracts, whether briefed or part of squadron standards, will significantly expedite a formation's shared mental model when approaching target sorts, labels, and prosecution. The following are default two-ship standards which should be adopted and manipulated to meet squadron-specific requirements.

8.3.6.1 Standard Biases. Another way to expedite holds, searches, or responsibilities is to assign default "biases." Table 8.1, Standard Formation Biases, is a list of formation biases which can be used in follow-on chapters.

Table 8.1 Standard Formation Biases.

Contract	Flight Lead	Wingman
Default Sector, Search, and Squirter Control	N and/or E	S and/or W
Vehicle Squirters (US Rules)	Left side, then front	Right side, then rear
HVI Control	HVI	Largest non-HVI group

8.3.6.2 Default Maneuvering. The flight lead should establish default airspeeds and angles of bank to assist formation positioning by being predictable for wingmen. As a technique, 165 KTAS and 30-degree angle of bank provide tactical maneuverability with room on either side for wingman consideration.

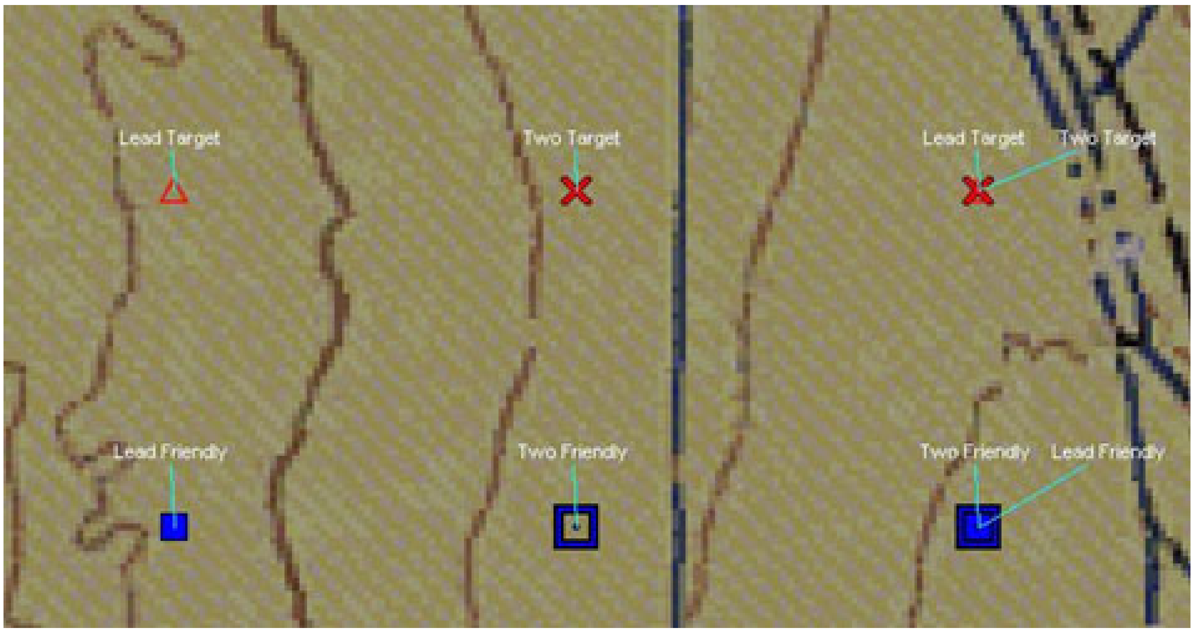
8.3.6.3 Weaponeering. Flight leads, based on the proficiency, may elect to brief default weaponeering or fuzing solutions for expected targets. For example, all personnel in the open will be targeted with Hellfires, LOAL-H and airburst and vehicles will be LOAL-D. This can be explicitly briefed or included on a line-up card for wingmen to review and reference.

8.3.6.4 TacSit Display Battle Tracking. Battle tracking contracts are imperative for timely and effective information passage and overall SA through the TacSit display. See Chapter 11, "Tactical Tools," for more information on Zeus.

8.3.6.4.1 Folder Deconfliction. Give each cockpit in the formation its own folder, and each crew position a folder nested within the cockpit folder. Each crew member will plot within the respective folder while leaving the rest "penciled on" (i.e., not hidden).

8.3.6.4.2 Icons and Labels. As a means to differentiate the plots between formation members, each should be given a different icon to plot items of interest. Assign plots of the same color that, when overlapped, provide a distinct visual reference. For example, friendly locations for Number One would be a "Blue Square" and the wingman would plot a "Blue IP" that, when collocated, combine to create one large blue square. See **Figure 8.1**, Two-Ship Plotting Icons, for a suggested template for enemy positions and friendly locations. The icon labels should include a brief description as well as the time individual plots were fixed/updated to assist tracking multiple or dynamic targets.

Figure 8.1 Two-Ship Plotting Icons.



8.3.6.4.3 Constrained Shape. Adding a 3 NM, unfilled shared constrained shape around other formation aircraft assists Fluid Tight positioning, airspace awareness, interval attack pacing, and weapon deconfliction.

8.3.6.5 Deconfliction. Ensuring safe and efficient deconfliction starts with a good plan. The primary means of formation deconfliction is vertical separation, but as weapon employments are added, lateral and/or timing deconfliction methods may be required.

8.3.6.6 Stack. As a default, Number Two should stack low as they are likely the primary shooter. If Number Two is WINCHESTER, Lead should consider executing an altitude swap when conditions permit to simplify weapons deconfliction.

8.3.6.7 Lateral. Lateral deconfliction measures are partially determined by the formation's overall position relative to the target or object of interest. In mission planning, one technique is to establish contracts that force the formation to automatically assume beneficial lateral separation, such as perpendicular sectors or co-flow wheels. "Be No" lines are another effective means of ad hoc deconfliction with each aircraft maintaining a hemispherical sector relative to a target, geographic feature, or coordinate. More on formation positioning can be found in **paragraph 8.5.1.2**, Formation Positioning.

8.3.6.8 Time. Air traffic control (ATC) route clearances or other factors may force a formation to stack co-altitude and limit the ability to laterally deconflict. In this case, a 5-mile minimum trail is recommended and an offset emergency mission. See **paragraph 8.5.1.2.3.6**, Trail, on execution.

8.3.6.9 Weapons Resource Management (WRM). The MQ-9 has incredibly versatile weapons, especially considering the latest version of the Hellfire and in-flight programmability of the GBU-49 and GBU-54. That said, techniques to retain the most flexible weapons assist overall mission success. On the whole, defaulting to GBUs on the first static, non-factor threat, non-factor collateral targets with acceptable effects will retain the longer range, tailorable fuzing of the Hellfire. The following is a non-exhaustive list of considerations for WRM.

8.3.6.10 Best Weapon. Very specific effects or targets require the capabilities of a specific weapon to achieve effects. Moving targets are best serviced by a Hellfire; area targets best engaged by a GBU-12/49/54; laser-denied targets (laser guidance unavailable, targeting pod jammers, laser spoofers) by an inertially-guided weapon.

8.3.6.11 Fastest Weapon. Fleeting or time-sensitive targets might best be attacked with the first weapon available. Conveniently aligned or rapidly employable weapons (like the Hellfire) could be the best weapon even though the warhead effects will not completely destroy the target.

8.3.6.12 "Vul-Limited" Weapons. When aircraft are nearing the end of their on-station time while others will remain longer, using the weapons which will otherwise RTB is preferable to keep the maximum number of weapons on station.

8.3.6.12.1 PRF Allocation. Sequential and easily remembered guidance PRFs are recommended for each flight position and weapon. For Hellfires, 1111/1122/1133/1144 are assigned to Number 1, 2, 3, and 4, respectively. 1511/1522 are convenient and allowable PRFs for GBU-12s/49s/54s for Number 1 and 2, respectively.

8.3.6.12.2 PRF Deconfliction. Expecting two-missile salvos and/or two-bomb ripple releases, code the left wing weapons set to Lead's guidance PRF (e.g., 1111/1511) and the right wing's to Number Two's (e.g., 1122/1522). This allows a minimum-interval between missiles/bombs (one off each wing) and efficient PRF deconfliction in a "Shooter Buddy" or "Buddy Shooter" attack. See **Figure 8.2**, PRF Allocation/Deconfliction.

8.3.6.12.3 SHOTGUN. During dynamic situations, wingmen can assist the flight lead by passing SHOTGUN, defined by ALSA Brevity as a "prebriefed weapons state." While the prebriefed weapons state is dependent on flight lead technique, suggested SHOTGUN criteria are two total weapons or less than two Hellfires remaining.

8.3.6.13 Loadouts. Loading or configuring weapons differently between flight members is a technique to diversify the flight's ability to effectively attack expected targets.

Figure 8.2 PRF Allocation/Deconfliction.

8.3.6.13.1 Mixed Weapons Loadouts. Depending on the flight's expected targets and the mission environment (i.e., weather), flight leads may consider carrying different weapons between aircraft. With additional magazine depth, flight leads may find value in carrying a single weapon variant with a narrow, but highly lucrative, target set (i.e., AGM-114N4) over a complete load of flexible but less effective weapons (R2s/R9Es).

8.3.6.14 Default Weapon Fuzing and PRFs. Planning to employ two-ship tactics can rapidly expedite default game plans and therefore effects. The following techniques assist coordinating timely employment through planned differences in weapon configuration.

8.3.6.14.1 Varied Fuzing and Weapons Profiles. Having eight missiles, or four two-missile salvos, provides flight leads options to have multiple fuzings preset and saved as profiles, thereby reducing time to employ. One technique sets all inboard missiles to instantaneous, Lead's outboards set to 3.5 ms delay and Number Two's outboards to airburst. This can be adjusted depending on the expected target set.

8.3.6.15 Standards. Squadron formation standards expedite all aspects of formation planning, briefing, execution, and debriefing. **Table 8.2**, Formation Standards Example, provides a set of baseline formation standards for an operational squadron.

Table 8.2 Formation Standards Example.

Joining the Formation
- On gaining, Number Two will request same sector, 1,000 feet below Lead
- Number Two calls "REQUEST JOIN UP" when ready and checks complete
- Lead will coordinate joining as a "non-standard formation" (3 NM and 1,000 feet) with ATC
- For transit, Number Two will set squawk to STBY inside 3 NM of Lead and established "fluid tight" in altitude block
- To establish the formation lead will check in the flight (e.g., "Savage Flight Check" "2")

When Formation Joined
- Lead will coordinate with ATC and Tactical C2 agencies
- Climbs/Descent: minimum 1,000 feet separation or BENO line during alt changes with emergency mission start points separated by the BENO line
- Emergency mission loiters will be set to 20 minutes for Number Two and 30 minutes for Number One
- In transit, a range bearing line will be locked between aircraft in Zeus
- A 3 NM constrained shape will be placed around other formation aircraft in Zeus

POSIT/Flight
- Number Two will stack low until Winchester unless LOWAT
- Default holding/target sort: Number Two has south and west, Number One has north and east
- Wheel—Number Two will hold outside and behind Number One, opposite side if able, min 90 degrees sector separation
- Urban—Default sector 90 degrees off for maximum coverage between buildings

Weapons
- Number Two is primary shooter
- HF default LOAL-H IMPACT fuzing
- Number One's Hellfires will be coded 1111, Number Two's Hellfires will be coded 1122
- TOTs will be Lead's choice. All timing attacks will be given with at least six minutes from 'hack' or notification if able
- Number Two will inform Lead if > 10 seconds early/late for TOT
- Weapons/laser ready and in position call "TARGET READY"

Strike Comms
- Buddy lasers will call "TGT READY"—ClearCom
- Shooter will call "IN" with direction—ClearCom (radio as required)
- Buddy gives lasing call "LASING"—ClearCom
- Shooter gives "RIFLE/WEAPONS AWAY [X] SECONDS"—ClearCom (radio as required)
- Post Splash 'HITS' means good effects, 'MISS' means weapons effects did not meet intent

Battle Tracking
- Both crews will plot Blue forces
- Crews will plot targets, POIs and NAIs as derived by or passed to aircraft
- If prosecuting the same target, all formation aircraft will plot
- Intel will only plot Intel derived points in Zeus

8.4 Formation Brief. Formation flight briefs are led by the flight lead and cover similar topics to single-ship flight briefs, but emphasize formation coordination and execution. The formation's goal is to be more effective than a single-ship mission; thus, much of the brief revolves around expectations, contracts, delegation of responsibilities, and information passage. Single-ship execution only has a place in formation briefs when that is the mission's desired learning objective.

8.4.1 Two-Ship Brief. Prior to the execution of a mission, the brief will establish the expectations for the formation's operations. The flight lead pilot will lead the brief with a portion of the brief specifically allocated to the flight lead SO to brief sensor-specific contracts, priorities, and TTP. The amount of two-ship SAT TTP to brief is wholly dependent on the mission objectives and wingman proficiency. Squadrons building proficiency for flight leads and wingmen should initially execute two-ship SAT as part-task training (PTT) sorties. Once squadron competencies are proven, executing the TTP as part of a greater mission will drive flight leads to briefing two-ship TTP in a missionized context.

8.4.1.1 PTT Sorties. While some two-ship squadron standards or flight expectations may be included in a mission's "Tac Admin," the majority of two-ship execution should be incorporated in the main body of the brief. This is especially true if the flight is instructional. The flight lead should brief SAT examples which demonstrate Lead's decision criteria for executing various TTP. Doing so will develop an understanding and expectations with the other members of the flight on how the sortie will be executed.

8.4.1.2 Missionized Sorties. Since two-ship SAT is simply an enabler of mission effects, missionized sorties should focus on the execution of that mission set with specific triggers for formation reaction (i.e., weaponeering, game plans, labels, and sorts). Squadron standards and Tac Admin contracts can facilitate focusing on the mission and PTT execution.

8.4.2 Brief Preparation. Flight leads may delegate brief preparation to flight members, such as printing products, bringing weather or NOTAMs, and preparing visuals or briefing tools. The primary focus of the brief should be how the flight plans to execute the mission with a focus on contracts, phases, and execution flow.

8.4.3 Brief Responsibilities. The flight lead owns the flight brief. It is up to the flight lead to delegate any tasks. It is recommended to give the lead SO time to brief the TGP plan. Time management for each topic must be weighed against task complexity compared against other mission segments and crew member experience/proficiency.

8.4.4 Individual Aircraft Briefs. While not discouraged, individual aircraft briefing requirements should be minimal after an effective flight brief. Topics remaining may include intercockpit expectations, contracts, and CRM specifics. These topics can be covered informally after the flight brief.

8.5 Execution Flow. The following discussion describes the complete flow of a two-ship attack. Squadron standards and flight contracts should be built upon the following execution TTP. Doing so can quickly decrease or negate some of the communication described in the following paragraphs. Flight leads should use the following flow during execution: join the formation and complete flight admin, receive the intent, position the formation in order to execute a search, get and label the target picture, develop a game plan, pass the fighter-to-fighter brief, execute, and finish by assessing BDA. Table 8.3, MQ-9 Formation Execution Flow, summarizes the criteria of each of the formation execution phases.

Table 8.3 MQ-9 Formation Execution Flow.

Phase	Summary
Flight Admin	MQ-9s join up under the leadership of the flight lead • FENCE/Check-in. See Table 8.4, FENCE Check Example. • FAWG Check. See Table 8.5, FAWG Check Example. Establish and position the formation for transit and/or tasking. • See Figure 8.3, Tactical Formations; Figure 8.4, Formation Climbs/Descents; and Table 8.1, Standard Formation Biases.
Receive Intent	Communicate and build shared mental model with tasking authority, as required. Determine formation F2T plan. Target: • Understand desired end state/effects • Determine attack restrictions See Figure 8.5, Two-Ship SAT Restrictions Decisions Matrix, for any potential restrictions in the intent.
Position Formation	Update formation position, as required, in order to expedite effects after receiving the intent. • See Figure 8.6, Two-Ship SAT Formation Decision Matrix
Get and Label Target Picture	Develop and label target picture. See Figure 8.7, Target Labeling Examples. Pass picture and label. See Figure 8.8, Two-Ship Comm Example.
Develop Game Plan	Develop formation attack game plan. See paragraph 8.5.5.5, FROTIES. • See Figure 8.9, Two-Ship SAT Role Assignment Decision Matrix, for multiple options based on the tactical scenario. • See Figure 8.10, Two-Ship SAT Roles, for a depiction of various role combinations.
Fighter-to-Fighter	Pass game plan immediately following the picture and label. See Figure 8.12, Fighter-to-Fighter Example.
Execution	Each MQ-9 will execute individual attack procedures IAW Chapter 7, "Single-Ship Surface Attack Tactics," and Lead's Game Plan. Comm Flow: • "TARGET READY"—Called by first BUDDY. See paragraph 8.5.7.1, TARGET READY. • "IN"—SHOOTER will call "IN" once all assets TARGET READY. • "LASING"—BUDDY will auto lase at "IN" and respond "[position number], LASING." • "RIFLE/WEAPONS AWAY"—SHOOTER will call Rifle/WEAPONS AWAY with TOF. • "Splash"—See paragraph 8.5.7.4, Splash, for additional information.
BDA	Maneuver aircraft into position for reattack IAW game plan, as required. Conduct BHA/BDA. Execute reattack procedures, if required. Safe systems once it is determined a reattack is not required.
FOUO	

8.5.1 Flight Admin. Lead should be at a briefed location and altitude no later than the planned check-in time. Number Two should be in position, within 3 NM of Lead and 1,000 feet below Lead's altitude. Number Two will get own ATC clearances until this point.

8.5.1.1 Check-In. The check-in is where the flight "forms up" and assumes the formation command and control construct. Until then, the formation is two single-ships acting in coordination. The flight check-in establishes the tone for the rest of the formation's flight. A poorly executed check-in may indicate a flight is simply not on the same page and is indicative of the poor performance to come. A proper check-in, on time, and crisply executed prepares the flight for similar tactical execution.

8.5.1.1.1 Trigger. The flight lead should set a trigger for flight check-in during mission planning such as a time or phase of flight. As a technique, if the wingman is ready early call "2's UP" on interflight (swap-out or gaining handover checklists complete and emergency mission sent).

8.5.1.1.2 Means. Check-in should occur via the primary and secondary interflight channels (ClearCom, ground ARC-210, etc.).

8.5.1.1.3 Method. The flight lead will check-in the flight using the phrase "[CALL SIGN] CHECK" and the wingmen will reply in order with position number. The flight lead should then provide some sort of direction if not previously briefed. In a scenario where both aircraft are completing gaining handovers or crew swaps, the direction will likely be positional; completing FENCE checks is assumed to be the next step. Wingmen will acknowledge once FENCE complete with "2's FENCE COMPLETE." See **Table 8.4**, FENCE Check Example.

Table 8.4 FENCE Check Example.

SAVAGE 1: (ClearCom): "SAVAGE FLIGHT CHECK"
SAVAGE 2: (ClearCom): "2"
SAVAGE 1: (ground ARC-210): "SAVAGE CHECK VICTOR"
SAVAGE 2: (ground ARC-210): "2"
SAVAGE 1: (ClearCom): "2, GO FLUID FREE"
SAVAGE 2: "2"
SAVAGE 2: "2's FENCE COMPLETE"

8.5.1.1.4 FAWG Check. Once both aircraft are FENCE'd, the flight lead will complete a FAWG check. FAWG stands for Fuel, Alibis, Winds and GMT. Fuel is the amount of fuel remaining, in thousands of pounds. Alibis are any systems not fully operational passed by previous crews or discovered during the FENCE-in. If crew is actively troubleshooting a system with a good chance of it working, pass "standby (system);" otherwise, pass "(system) bent." Winds come from the tracker display. GMT is the Zulu time read on the HUD. The wingman should compare their GMT when lead is passing theirs so the wingman is able to pass a "delta," or the difference in their clock from Lead's clock. For example, if the wingman's clock is one second behind Lead's, they should pass "minus one" (take Lead's clock and subtract one second). Lead will pass their FAWG check, with the wingman parroting the same style and pacing with their own information. See **Table 8.5**, FAWG Check Example.

Table 8.5 FAWG Check Example.

SAVAGE 1: "1's 2.6, NO ALIBIS, 2-7-0/29, 17-09-22...23...24"
SAVAGE 2: "2's SAME, STANDBY SAR, 2-9-0/33 MINUS THREE"

8.5.1.1.5 Formation Establishment. Due to launch and recovery limitations, MQ-9 formations will not likely take off at the same time. Because of this the formation is considered established at the conclusion of the FAWG check. At this point the flight lead should provide initial direction for the wingman and contact ATC to notify them that a standard formation has been established. Once the formation has been acknowledged by ATC, the wingman may cease to squawk, depending on SPINS and ATC preferences, provided that the wingman remains inside of 3 NM and 1,000 feet of lead. It is recommended that the wingman maintains an active squawk when the formation is not engaged in transit.

8.5.1.1.6 Formation Establishment Inside of a Working Area. If the formation is joining up in a MOA, ROZ or otherwise established area with freedom of movement, the formation may be established with controlling agencies upon the completion of the FAWG check, regardless of aircraft proximity. Upon exiting a working area, if transiting as a formation, Lead must notify ATC of the nonstandard formation, and obtain a clearance for the formation.

8.5.1.2 Formation Positioning. After checking in the flight and as a normal function of flight leadership, Lead will need to position the flight, either by transiting to a target area or positioning relative to an object of interest.

8.5.1.2.1 Directing Formation Positions. Flight leads should direct the formation to a specific formation and/or position; for example, "SAVAGE, GO FLUID FREE." If a flight lead needs to direct a specific flight member or element to a formation, Lead will preface with flight number "2, SECTOR WEST." Wingmen should respond with number, "2."

8.5.1.2.2 Transit Formations. Transit formations are beneficial for a flight lead when the formation needs to move to new target areas or RTB. Because the MQ-9 does not fly visual formation, flight leads need to give the wingmen a direction and speed to keep the flight in a position to provide mutual support. These are "REFERENCE" and "SET" calls, respectively.

8.5.1.2.2.1 Reference. Reference is a directive call to set a heading (technique: set a contract for headings to be magnetic to align with ATC assigned vectors and restricted run-ins) or a geographic reference. These geographic references can be any shared point (i.e., "reference Creech" or "reference NAI 1").

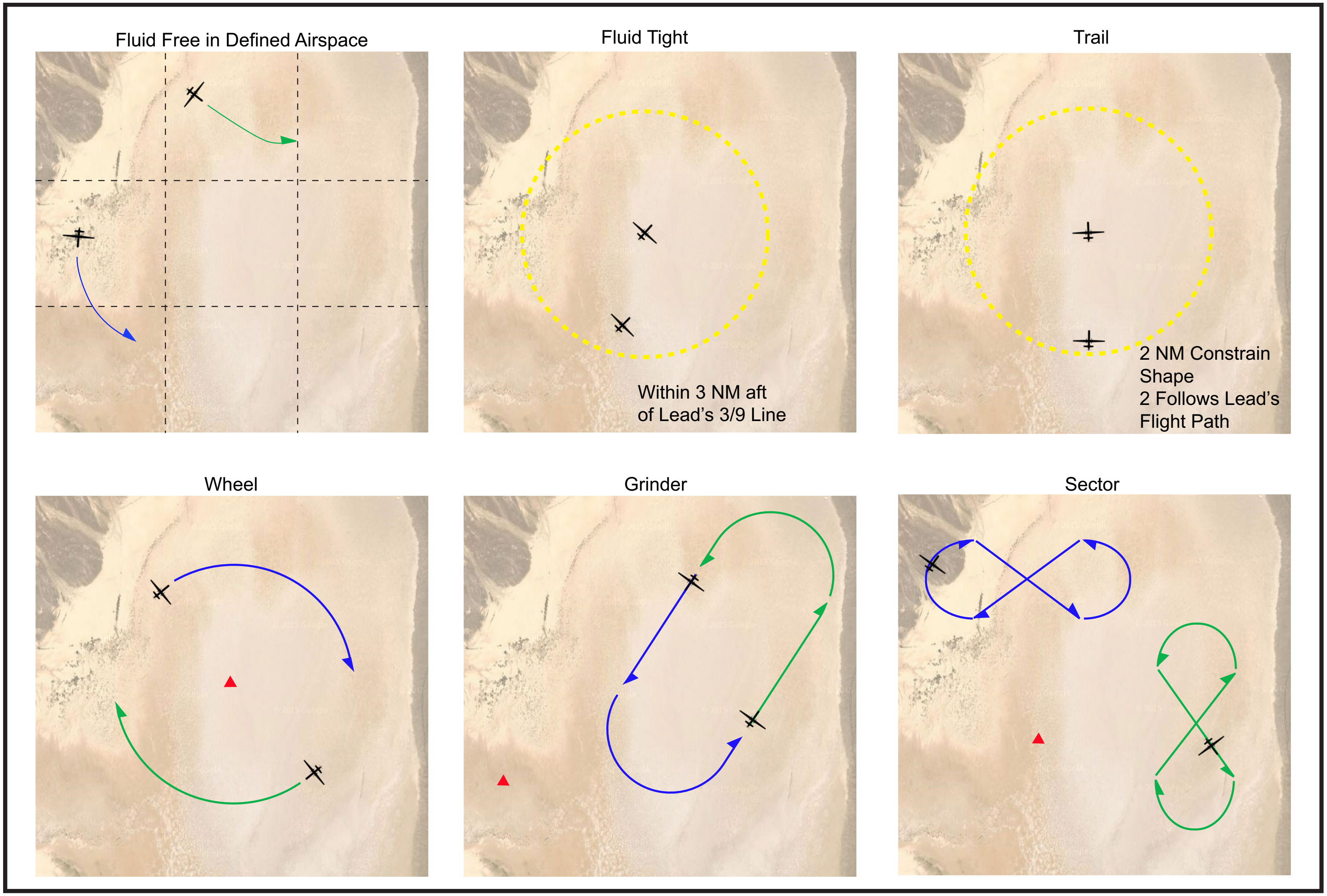
8.5.1.2.2.2 Set. Set is a directive call to set an airspeed. As a default, these are airspeeds True; however, the flight lead may use ground or indicated if KTAS is not effective at maintaining positioning. Indicated airspeed may be used to ensure certain weapons delivery conditions are met, and ground speed may be used to transit at the same rate when flight level winds are dramatically different (i.e., “Set 180 Ground”).

8.5.1.2.3 Tactical Formations. MQ-9s and other advanced aircraft use a concept called “detached mutual support,” which means formation members are not limited to remaining VISUAL when positioning for optimal effects. This is enabled by the ability to monitor flight positioning through the TacSit and other cues. Flight leads must balance the wingman’s task load when selecting a formation. If too restrictive, the wingman will focus on position at the expense of tactical tasks; if too loose, the wingman may be out of position to achieve Lead’s intent. This section defines common formation positions and execution. See **Figure 8.3**, Tactical Formations.

8.5.1.2.3.1 Fluid Free. Fluid Free provides wingmen the “longest leash.” Wingmen are free to maneuver to achieve effects, but with little-to-no direction to laterally deconflict from lead, other assets, or threats. Without proper contracts and intent, mutually supportive weapons and sensors will be unavailable if the wingman is out of position. Fluid Free is the least task saturating of the tactical formations, and is well-suited for wingmen when completing individual tasks such as FENCE-in or independent area searches. Bounds can be added to a Fluid Free formation, such as maintaining within a geographical region or within a specified range of the flight lead.

8.5.1.2.3.2 Fluid Tight. Fluid Tight typically places the wingman rear-aspect and within 3 NM of lead, though this range can be adjusted as required and should be noted if different. Fluid Tight can be difficult to maintain; wingmen spend the majority of the time maintaining position and not supporting tactical engagement. The benefit of Fluid Tight is that Number Two will be in a very specific position relative to Lead. For administrative transit purposes while working with ATC, maintaining within 3 NM also places the formation within range requiring only one squawk, as a ‘nonstandard’ formation as described in AFI 11-202-V3, *Flying Operations*, paragraph 3.24.4.3.

Figure 8.3 Tactical Formations.



8.5.1.2.3.2.1 Fluid Tight Rejoin. Due to the stringent positional requirements of Fluid Tight and the MQ-9's limited ability to change energy states (accelerate or decelerate, trade speed for altitude, or execute sharp turns), flight leads can assist 2's rejoin geometry. If Number Two is in greater than 5 NM trail attempting to rejoin, Lead can execute a single 360-degree turn at 40-degree angle-of-bank to roughly close the gap. Another technique is for lead to turn at 20-degree angle of bank while Number Two makes an initial 30-degree turn inside of Lead, pull lead, then turn as required approaching 4 NM to intercept the rear aspect at the appropriate range while matching Lead's heading. Significant airspeed changes are another way for Number Two to catch Lead, but can take time depending on Lead's speed and may prove difficult to accurately slow at the right time to intercept the appropriate range. Latency in Zeus exacerbates these difficulties. If Lead perceives latency that will significantly challenge a wingman's rejoin. Lead should tell wingmen the correction they are providing and how the wingman should execute a rejoin. Flight leads can facilitate Number Two's positioning by using "set" and "reference" as discussed in **paragraph 8.5.1.2.2.1**, Reference, and **paragraph 8.5.1.2.2.2**, Set.

8.5.1.2.3.3 Sector. This formation position places a flight member at a specific bearing from a target and implies holding in a way to facilitate an expeditious weapons or laser employment (unless ISR considerations trump). Using the standard biases in **Table 8.1**, Standard Formation Biases, are recommended to reduce extraneous communication.

8.5.1.2.3.3.1 Sector Range. The ideal range in a sector is situationally dependent and possibly defined by multiple criteria: detection reduction profile (DRP), weapons (minimal time-to-impact, max range), buddy lase angles or sensor effects (to include maintaining CAPTURED). Flight leads need to define the default or criteria-based ranges during the flight brief unless defined in squadron standards. Flights may use different criteria between members, i.e., Lead may maintain a CAPTURED priority range/sector while Number Two (the primary shooter) maintains an optimum time to release (TTR) range along the deconflicted run-in heading.

8.5.1.2.3.4 Wheel. Wheel formation is the easiest to fly and provides a constant 360-view of the target. Wheel should not be used if the target is masked during significant portions of a Wheel or with restricted attack axes. Flight leads need to avoid having both aircraft on the same sector of Wheel simultaneously.

8.5.1.2.3.4.1 Wheel Flow. Co-flow Wheels are recommended for similar formations, either 90 or 180 degrees out. Decision criteria are mission and tactical situation dependent. Number Two is responsible for maintaining position relative to Lead. Lead should fly a consistent, heart-of-the-envelope range such that Number Two can achieve effects while adjusting range to maintain the directed offset relative to Lead. For example, if Number Two is in front of the desired offset, fly outside Lead's radius but inside the maximum range. Conversely, if Number Two is behind, cut inside and re-establish Lead's radius at the appropriate offset.

8.5.1.2.3.5 Grinder. A grinder provides constant on-axis/near on-axis positioning enabling rapid employment of weapons within very strict run-in headings or weaponeered conditions. It is defined as two or more aircraft holding, equally spaced, in a Racetrack with alternating “primary shooter” responsibility.

8.5.1.2.3.5.1 Leg Length. The “hot leg” is the portion of the grinder where the aircraft is pointed towards the target. The minimum and maximum ranges to target are those which provide the minimum required effects. For example, if a Hellfire minimum acoustic warning is the desired effect, the leg length would be defined by those ranges defined in RMIT where the warning was equal to or less than the maximum. Similarly, if a GBU-12 needs to be released within a specific amount of time after clearance, that time on final would be considered the maximum with the minimum likely being a few seconds prior to planned release. The “cold leg” is the outbound leg used to reposition while the other formation member(s) are on the “hot leg” and is almost completely defined by the other leg’s length.

8.5.1.2.3.5.2 Maintaining Position. Target presentation, winds aloft, and hold tolerances drive the difficulty of positioning within a grinder. In other tactical formations, it is typically Number Two’s sole responsibility to maintain position off Lead; however, since maintaining the “hot leg” is the driving factor, positioning responsibility will be based on being able to keep the flight in position based on two decision points. These decision points are the hot aircraft reaching minimum leg range and the cold aircraft reaching the range required to turn and intercept the hot leg at maximum range. Number Two should strive to fix any relative out-of-position on the cold leg. Typically, several laps will be required to iron out nuances based on specifics of the individual tactical scenario. The following techniques are a start to assist formation integrity, but are in no way exhaustive.

8.5.1.2.3.5.2.1 Airspeed. Minimum practical airspeed is that which allows a 30-degree angle of bank. The flight should strive to fly the ground speed for that minimum practical airspeed on the downwind leg, as the upwind aircraft should be able to increase airspeed to match that ground speed.

8.5.1.2.3.5.2.2 Hot Leg. While on the hot leg, aircraft should fly a course to maintain the desired weapons heading, crabbing as appropriate.

8.5.1.2.3.5.2.3 Cold Leg. The cold leg should be flown to match ground speed and the reciprocal course of the hot leg, again crabbing as appropriate. Since range cues on the cold leg may not exactly match those on the hot leg due to the effects of wind in the turn, assess the change in range during the first turn to hot leg.

8.5.1.2.3.5.2.4 Turn. Turns should be planned at 30-degree angle of bank. This allows any headwind or tailwind assumed during the turns to be mitigated with adjustments in bank to maintain the hot leg’s axis. The turn’s offset direction should be chosen to first maintain target capture, and second to capture a tailwind in the turn to expedite clearing the lane for the turning-hot aircraft.

8.5.1.2.3.5.3 Establishing the Grinder. The flight lead should, like any other formation positioning, provide clear direction to the wingman on what position to assume. This includes what leg the wingman will establish on, expected ground speed to hold, and what defines the desired axis and minimum and maximum ranges for the hot leg. Depending on wingman proficiency, a flight lead may elect to define the max range for the cold leg as well. The first aircraft to turn from cold to hot will pass the change in maximum range cue and will be refined through additional turns.

8.5.1.2.3.5.4 Grinder Communication. Efficient communication, as with any formation direction, is key to the passing required information with minimal distraction or confusion. Below are different points during a grinder a flight should be communicating.

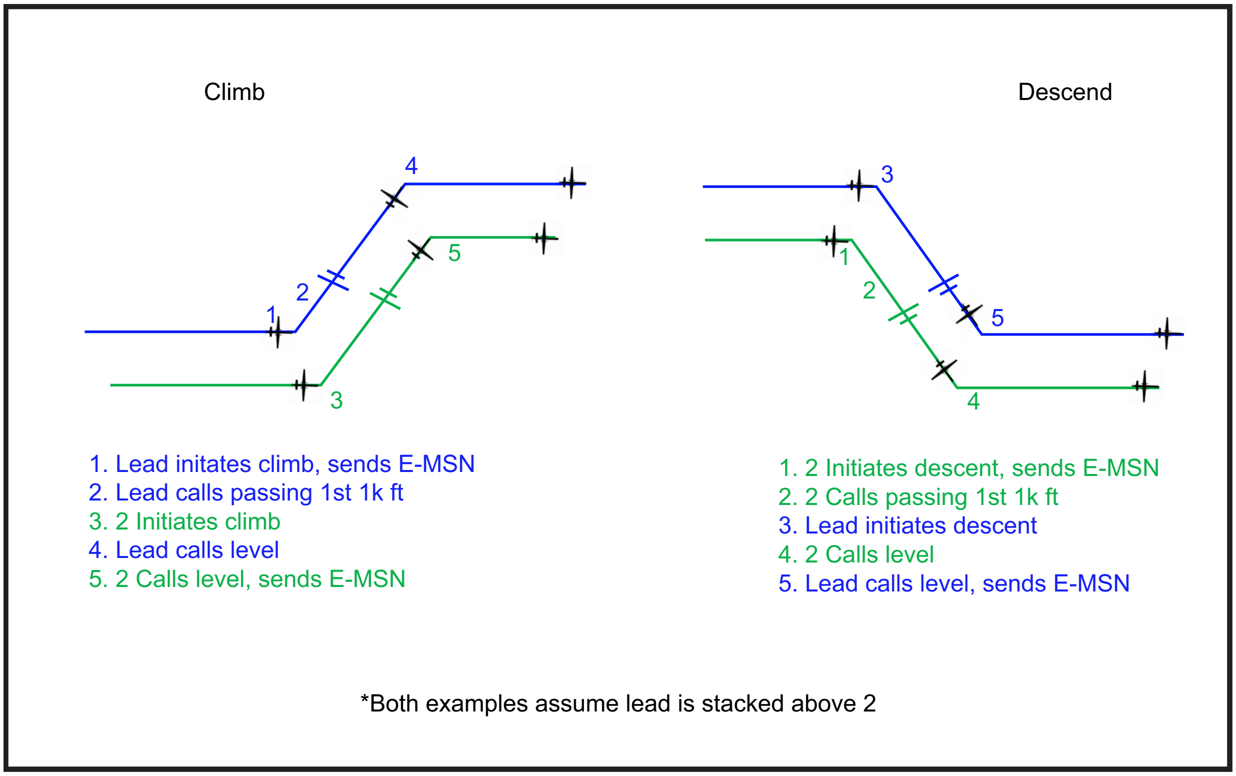
8.5.1.2.3.5.4.1 Min Range on Hot Leg. When the hot aircraft reaches the minimum range on the hot leg, the pilot should pass "Turning cold" over interflight. In two-ship grinders, this is the cue for the cold aircraft to begin its turn to the hot leg. The other aircraft should acknowledge. In grinders with more than two-ships, where more than one aircraft is likely hot at one time, this is the passage of primary shooter to the next closest hot aircraft. This aircraft should acknowledge with position number and "hot."

8.5.1.2.3.5.4.2 Max Range on Cold Leg. In two-ship formations, when the cold aircraft reaches the range where it needs to turn to intercept the hot leg's max range, the pilot should pass "Turning hot." The flight lead may elect to delay this turn if is the cold aircraft, matching the delay to match Number Two's remaining time prior to minimum range.

8.5.1.2.3.6 Trail. Trail formation directs wingmen to follow Lead's flightpath at a specific distance or time interval. Trail can only be consistently accomplished with a situation display showing both aircraft. If altitude deconflicted, recommend a minimum of 2 NM to allow the wingman room for geometry corrections. If co-altitude, recommended minimum of 5 NM or 90-second spacing for lateral deconfliction (whichever is less). A technique to maintain the desired range is a constrained shape set on one aircraft. When passing this formation, the flight lead should set a desired speed if not previously defined to assist the wingman in maintaining position. If greater than 5,000-foot altitude difference, it is recommended to pass this airspeed as KGS due to differences in wind speed and altitude density on KIAS. The wingman is free to deviate from that airspeed to facilitate proper positioning. A variant of Trail has Lead following the wingman and requires the intent or route to be very clear.

8.5.1.2.4 Climbs/Descents. To expedite altitude changes, climb and descent rates should be set to 2,000 fpm. In an altitude deconflicted formation, the high aircraft should begin climbs first or the low aircraft should begin descents first. After the first thousand feet of altitude change, the first aircraft should call passing the altitude MSL as the cue for the second aircraft to begin the climb or descent. If using the Zeus Track Graph feature, flight members should monitor the climb rates to ensure the second aircraft does not pass the first. If the Track Graph is unavailable, a combination of lateral deconfliction and/or calling passing every thousand feet is an additional technique to ensure deconfliction. Each aircraft should call established once level at the new altitude. See **Figure 8.4**, Formation Climbs/Descents.

Figure 8.4 Formation Climbs/Descents.



8.5.1.2.4.1 Emergency Missions. The first aircraft should set its new emergency mission altitude when vacating the initial altitude. The second aircraft to begin the altitude change should set the new emergency mission altitude once established at the new altitude.

8.5.1.2.4.2 Formation Max Rate Descent. When the flight lead prioritizes establishing a lower altitude block and an Altitude Hold descent is not fast enough, they can call for a max rate descent: "2, DESCEND TO FL100, MAX RATE." The high aircraft must pay additional consideration to not only maintaining the flight envelop of own aircraft, but also managing descent rate to not pass the low aircraft on the way down and/or adhering to any lateral deconfliction measures. See **paragraph 3.3.2.5**, Max Rate Descent, for further discussion on how to execute a max rate descent.

8.5.1.3 Lead Swaps. Swapping the flight lead position can happen for a variety of reasons, to include training or an in-flight emergency. In some instances, such as training or an upgrade, the "tactical lead" may be passed but overall formation leadership may reside with an instructor or otherwise senior, and predetermined, flight member. If this is the case, that overall leader may reassume flight lead at any time; however, there should never be any question as to who is currently the "Tac Lead." Wingmen need to maintain overall SA on the mission and be prepared to take lead at any moment due to changing conditions (i.e., emergencies, shoot down, lost link, etc.).

8.5.1.3.1 Execution. Prior to executing a lead swap, the outgoing flight lead ensures positive deconfliction and that minimal administration is required in the moments following lead swap to assist the transfer of responsibility. If an altitude swap is expected, positioning the flight prior to the swap can expedite the change. Once ready, the outgoing lead will say "2, YOU HAVE THE LEAD." The incoming flight lead will acknowledge with "2 HAS THE LEAD." Following this, and as a technique, the new flight lead may conduct a check-in as discussed in **paragraph 8.5.1.1**, Check-In, time and conditions permitting. Following or concurrent with the check-in, the incoming flight lead can begin positioning the flight or delegating tasks.

8.5.2 Receive Intent. With more weapons, sensors, and aircraft-and therefore options-understanding the attack's intent becomes more nuanced than a single-ship attack. The flight lead must be sure to understand the intent for the upcoming attack. The intent for attacking target formations may not automatically be maximum attrition, but may instead only be reducing the array to a certain percentage. In a missionized sortie, flights should query intelligence professionals what attrition level makes enemy units combat ineffective. A flight may also be able to provide suppressive effects (a task not usually required of MQ-9s) with limited but highly accurate point weapons and long loiter times. With appropriate contracts, this intent may lead to automatic intercockpit CRM. For example, with the intent to destroy six tanks, point targets requiring Hellfires, a wingman may begin coding all four of the missiles to instantaneous fuzing and auto-sorting to the southernmost downwind tank while setting the own laser PRF to 1122. See **Figure 8.5**, Two-Ship SAT Restrictions Decision Matrix, for any potential restrictions in the intent.

8.5.3 Position Formation. Due to the MQ-9s relatively slow-speed, the flight lead should position the formation as soon as possible to expedite effects after receiving the intent. The positioning reflects a search plan and initial game plan based on target orientation, expected weapons, and flight roles. **Figure 8.6**, Two-Ship SAT Formation Decision Matrix, can quickly distill efficient two-ship attack game plans. As an additional technique, the flight lead should pass the weapon(s) the wingman will employ first so they can begin preparing the SMS and attack briefs. A downwind sector is an easy default pending a complicated target environment.

Figure 8.5 Two-Ship SAT Restrictions Decision Matrix.

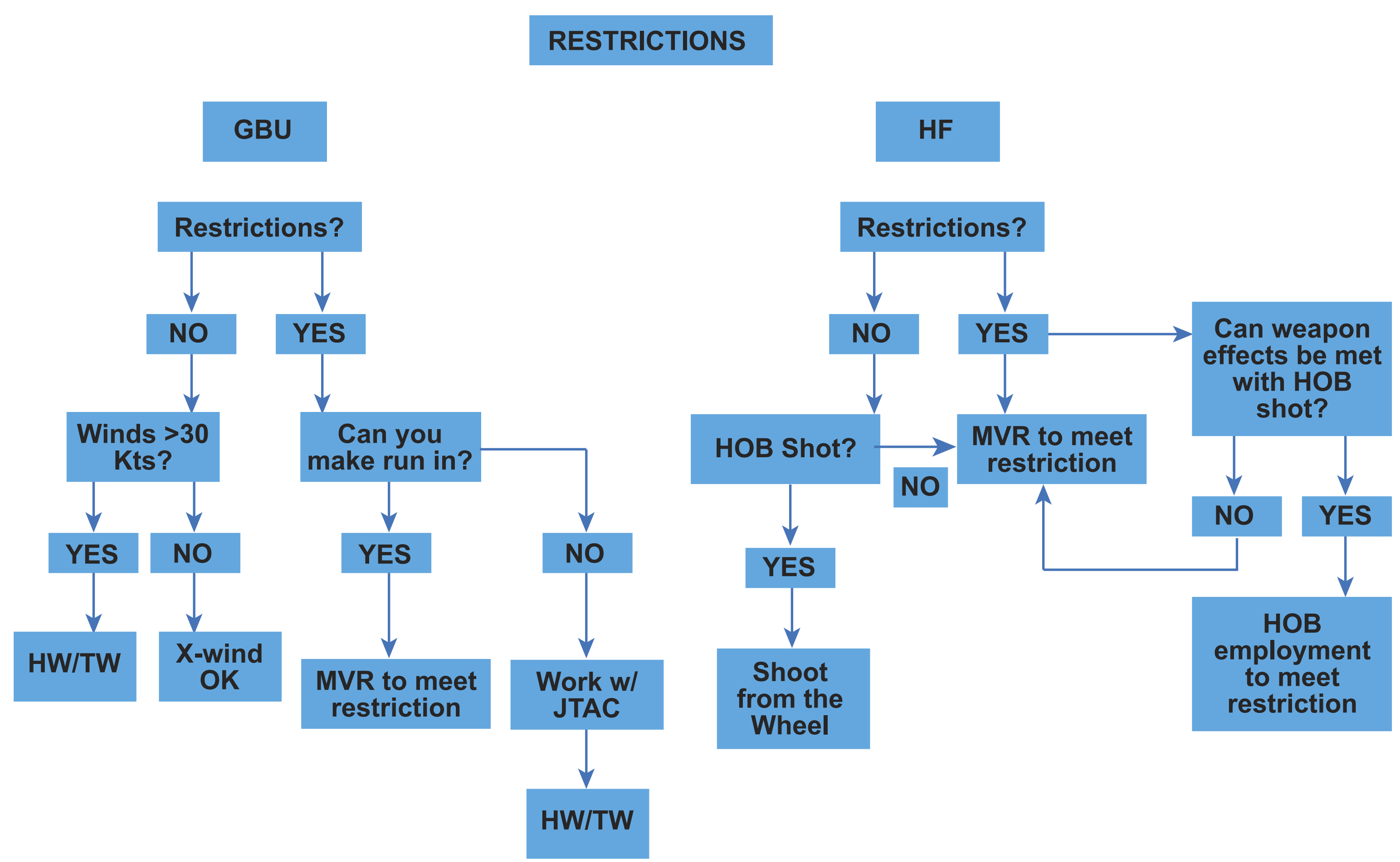


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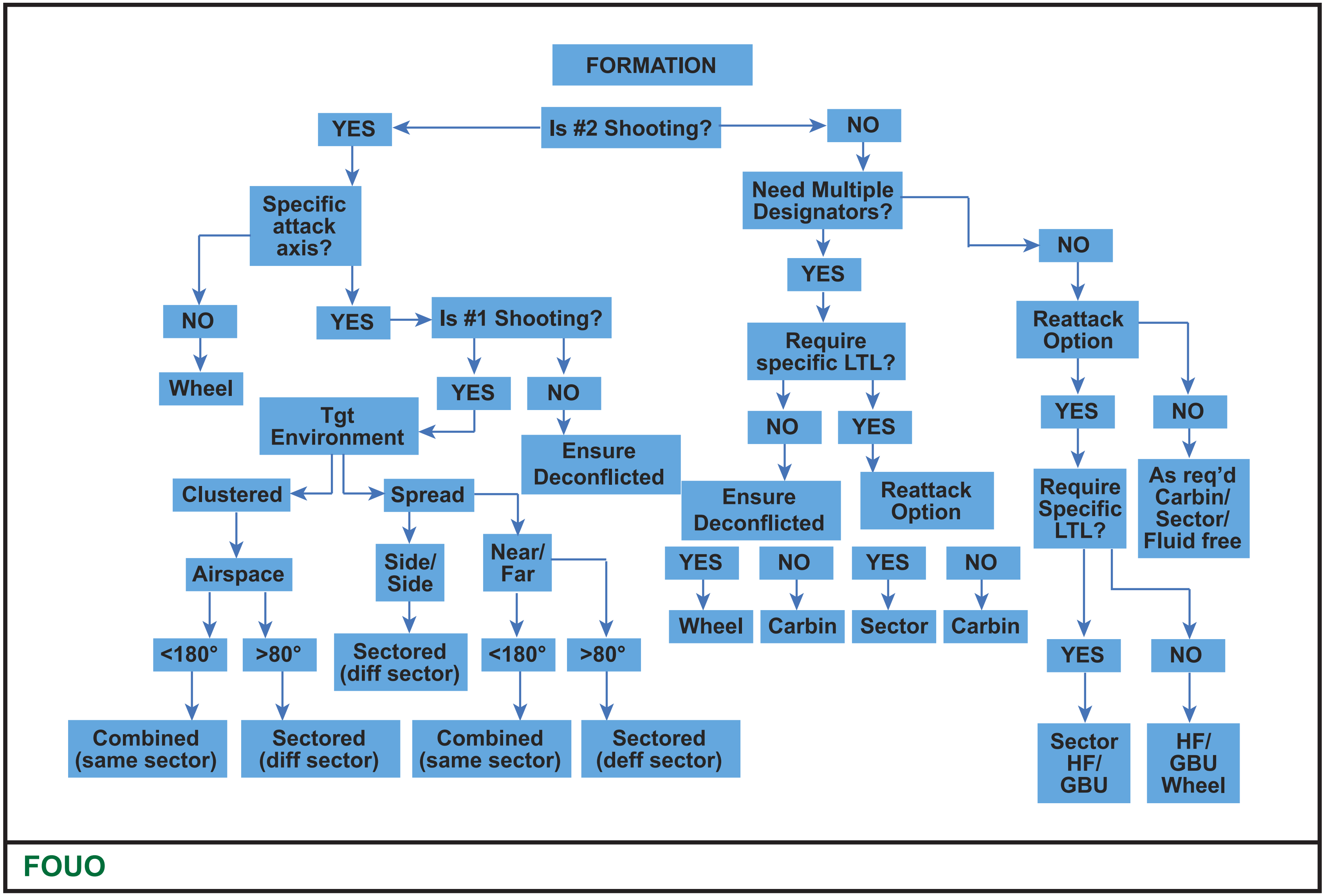
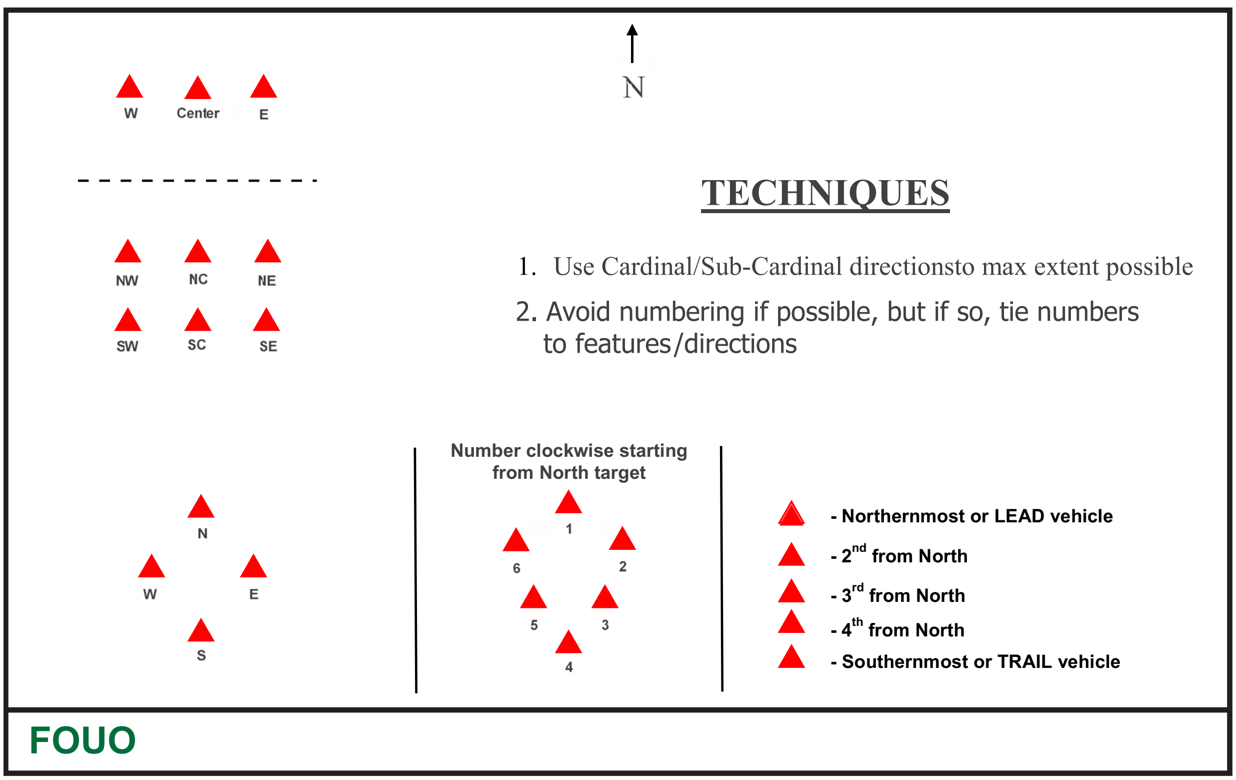
Figure 8.6 Two-Ship SAT Formation Decision Matrix.



8.5.4 Get and Label Target Picture. The purpose of labeling targets or other key features in the target area is to establish a shared mental model amongst the flight. The target set may be passed in a variety of methods, but it behooves the flight lead to assess geometry through current imagery, either through the TGP or SAR. The TGP can help break out DPIs and environmental factors detrimental to effects, while SAR imagery is easily held and analyzed (with direction and distance) within a single cockpit. Target pictures and labels must, for the most part, be passed via interflight, and, thus, clarity is paramount. Another technique is to pass the picture to the wingman using a live video feed (i.e., VLC), if available. Limited visual references are useful with Zeus plots (minimized by imagery and SPI location inaccuracies) and interflight MELD calls (limited by TLE inaccuracies and marginal ability to process the surrounding environment. See Figure 8.7, Target Labeling Examples, for labeling techniques.

8.5.4.1 Target labels are the specific name or reference given to an individual target within a larger array or "picture." Use of cardinal or sub-cardinal directions, along with "center" or "middle" groups, are a simple and quick way to label targets, especially when comparing to the "N" indicator in the TGP graphics. If cardinal directions do not easily facilitate, in the case of a long convoy, using "Northern most, second from north, third from north, etc.," can still speed data passage. If creating sequential labels is unavoidable, briefing a consistent sequence is recommended: North-to-south, west-to-east, and downwind-to-upwind (relative to briefed/updated surface winds) are all proven techniques. Figure 8.7, Target Labeling Examples, provides detailed techniques of how to label targets.

Figure 8.7 Target Labeling Examples.



8.5.4.1.1 Linear. If targets are conveniently in line with a cardinal direction, label accordingly. If orientation is not conveniently aligned and wingman is Tally, the flight lead can use the comm, “CALL THOSE SIX TANKS ORIENTED NORTH-SOUTH.” For four or more targets aligned linearly (in a row, column, or convoy), label the target set with numbers in-line with the cardinal orientation or from lead to trail.

8.5.4.1.2 Circular. Use cardinal directions for arrays of four or less. For five or more, define starting target (one distinctly different from others, either by target description, its position relative to others, or crosshair placement by Lead’s SO), and number sequentially clockwise.

8.5.4.1.3 Gaggle. Break into smaller groups to use linear/circular definitions. Group based on clusters, distinguishing features, or geographic boundaries (separated by roads, rivers, other visual references). “NORTH GROUP, THIRD TARGET.”

8.5.4.2 Pass Picture and Label. Wingmen can facilitate receiving an accurate description by building own picture prior to receiving the picture and label from Lead. This will support Lead by providing additional sets of eyes on a target set and facilitate receipt of the picture and labels. Preparatory words prior to passing a complex sort may mitigate wingmen’s request for repeats.

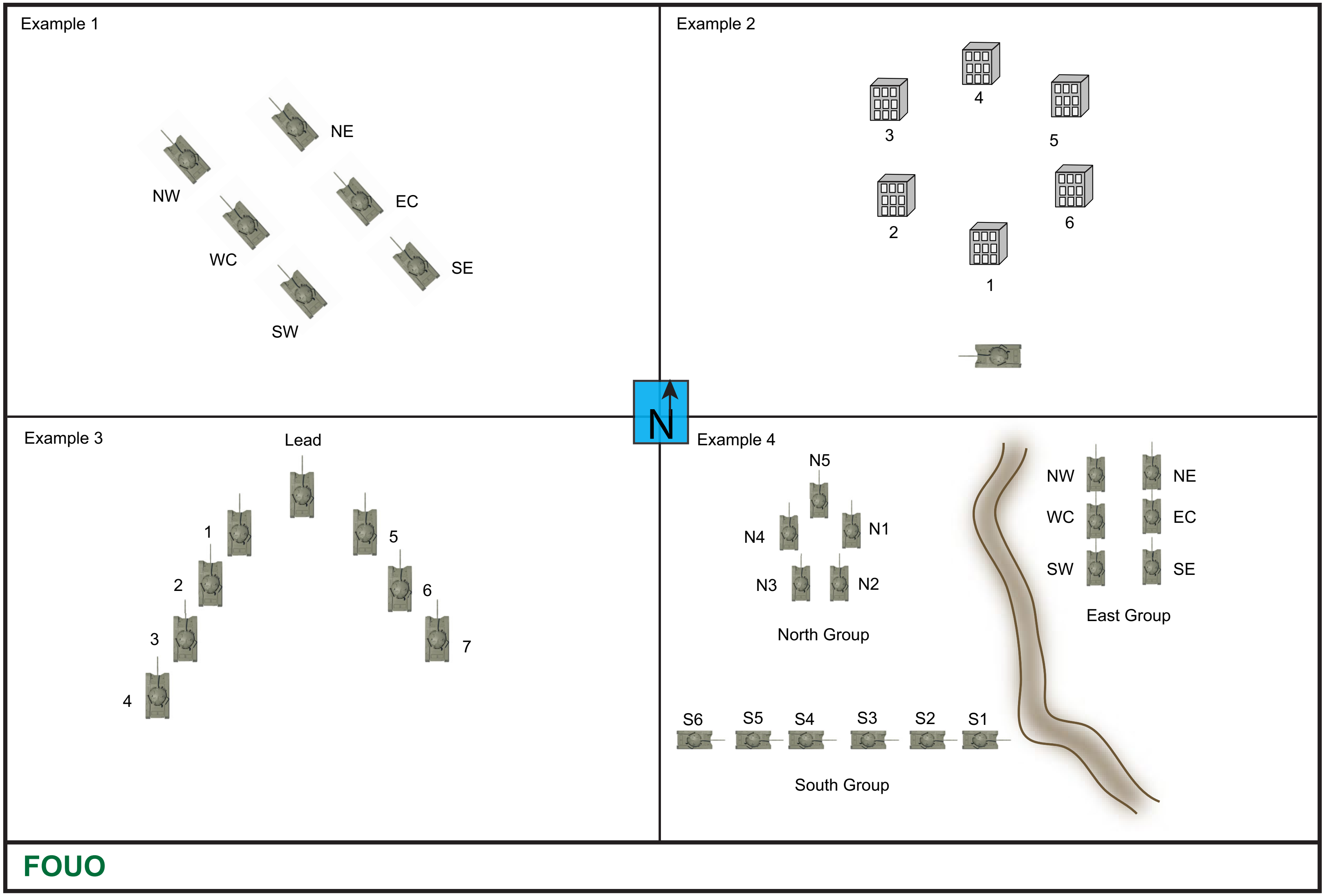
8.5.4.2.1 Comm Example Number 1. See **Figure 8.8**, Two-Ship Comm Example, “PICTURE 6 TANKS IN TWO COLUMNS ORIENTED NORTH/SOUTH.” This relies on techniques to “realign” with convenient cardinal direction, therefore able to use subcardinal and “middle” terminology (e.g., NW, NE, WC, EC, SW, and SE).

8.5.4.2.2 Comm Example Number 2. See **Figure 8.8**, Two-Ship Comm Example, “PICTURE SIX BUILDINGS. SOUTHERN BUILDING WITH TANK OUTSIDE IS BUILDING 1, LABEL CLOCKWISE.”

8.5.4.2.3 Comm Example Number 3. See **Figure 8.8**, Two-Ship Comm Example, “EIGHT TANKS VIC, POINTED NORTH. WITHOUT INCLUDING LEAD TANK, NUMBER WEST LEG FROM NORTH TO SOUTH, ONE THROUGH FOUR, EAST LEG FROM NORTH TO SOUTH, FIVE THROUGH SEVEN.” Target array geometry can be simplified using brevity (i.e., VIC, CHAMPAGNE, and WEIGHTED).

8.5.4.2.4 Comm Example Number 4. See **Figure 8.8**, Two-Ship Comm Example, “PICTURE THREE GROUPS OF TANKS. EAST GROUP, SIX TANKS ORIENTED IN TWO NORTH-SOUTH COLUMNS. NORTH AND SOUTH GROUPS ON WEST SIDE OF ROAD. NORTH GROUP, FIVE TANKS IN A CIRCLE. SOUTH GROUP, SIX TANKS IN SINGLE EAST-WEST COLUMN. IN NORTHERN GROUP, LABEL EASTERN-MOST TANK NORTH 1, LABEL CLOCKWISE.” This breaks the large formation into three smaller and more manageable formations. The flight lead starts by setting the expectations of labeling three sub groups divided by easily referenced geographic features. Each group is given a name (relying on directions to the maximum extent), then within each group individual targets are implicitly given labels: “EAST GROUP, EAST CENTER TANK.”

Figure 8.8 Two-Ship Comm Example.



8.5.5 Develop Game Plan. While an initial plan should be passed to position the flight, flight leads must think through the entire attack prior to execution. The flight lead must consider the entire array, how best to pass the picture, target-to-weapon pairing, the attack sequence, and how each weapon will be guided to target. See **Figure 8.9**, Two-Ship SAT Role Assignment Decision Matrix, for multiple options based on the tactical scenario and **Figure 8.10**, Two-Ship SAT Roles, for a depiction of the various role combinations.

8.5.5.1 SHOOTER. The SHOOTER is the aircraft designated to employ ordnance. Normally wingmen are assigned to be SHOOTER to allow the flight lead to monitor the larger picture and overall pacing of the attack. Of note, the SHOOTER may self-lase one weapon if releasing multiple weapons.

8.5.5.2 BUDDY. The BUDDY is the aircraft providing terminal guidance for a weapon in support of the SHOOTER.

8.5.5.3 GOALIE. A back-up guidance capable platform appointed to guide a weapon to the target if the primary platform's guidance system fails after weapons release. If the call "GOALIE, GOALIE, GOALIE" is made, the GOALIE will turn the laser on and provide terminal guidance for the weapon as soon as they are in a position to guide the weapon to the proper aimpoint.

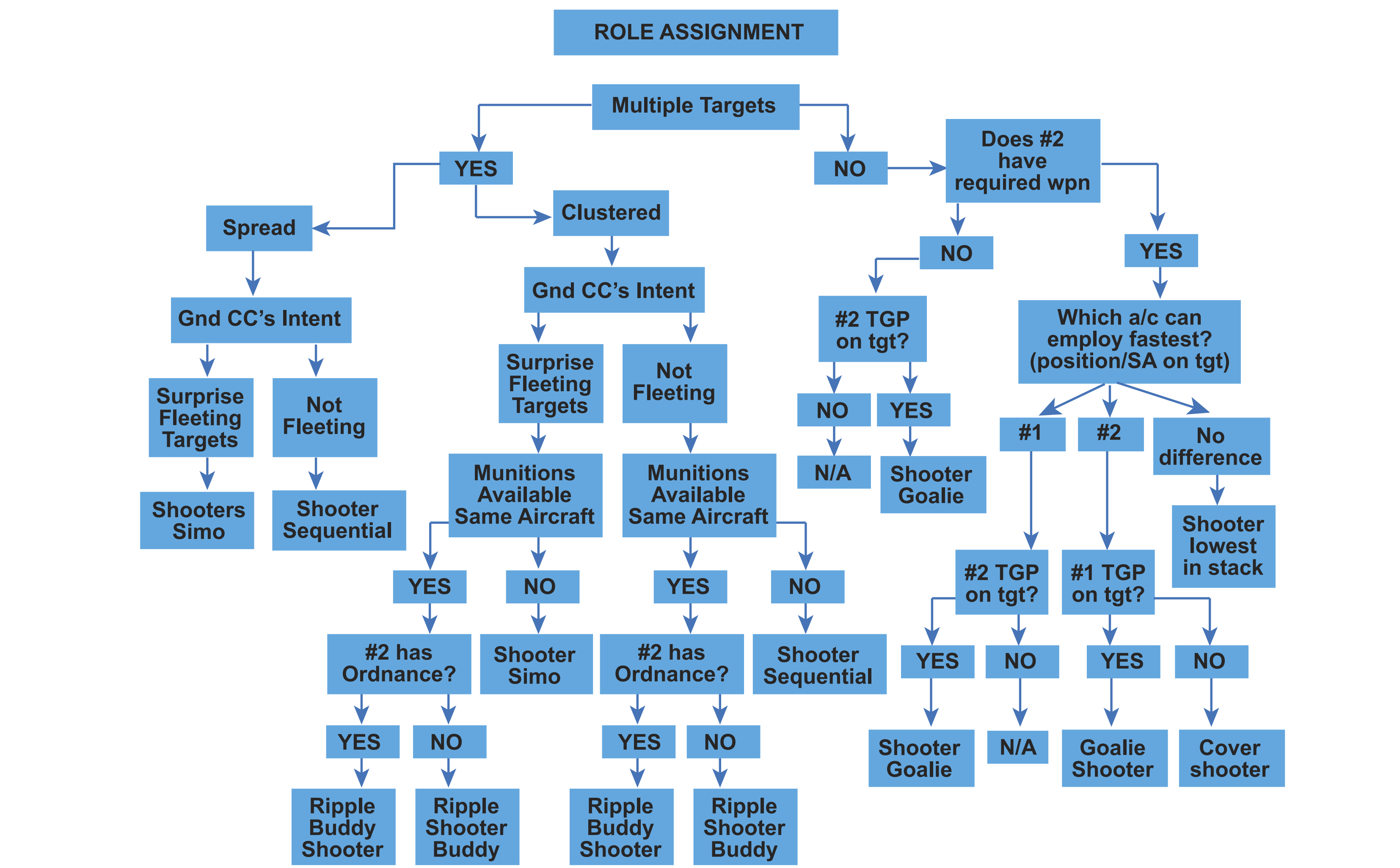
8.5.5.4 COVER. The COVER provides larger SA on the target area by maintaining a more zoomed out view than the other player, and is normally focused on potential collateral concerns. Depending on the situation, the SHOOTER can transition to a COVER role post weapons release. The COVER should also be in a position to employ and/or provide timely reattacks if required.

8.5.5.5 FROTIES. The FROTIES acronym is a template to convey all the required information to the wingman executing the buddy lase. The FROTIES acronym stands for: Formation, Roles, Ordnance, Timing, Ingress, Egress, Sort, and is used by most USAF strike assets between specific formations to pass "fighter to fighter." The flight lead owns the brief and will pass it to the wingman. The sequence to which FROTIES is passed is assumed flight lead first, wingman second. However, the wingman should speak up if there is any confusion or if any part of the plan is not tactically sound after coordination. **Figure 8.11**, Example FROTIES, depicts the buddy lase coordination using FROTIES and provides communication examples.

8.5.5.5.1 Roles. As a default, two-ship attacks use BUDDY-SHOOTER/ SHOOTER-BUDDY tactics with two weapons being released per attack. Doing so embodies the increased efficiency and effectiveness of an MQ-9 formation. **Figure 8.10**, Two-Ship SAT Roles, provides examples of these tactics. The following are common roles used for two-ship attacks.

8.5.5.5.1.1 SHOOTER-BUDDY. Lead will release two weapons as the SHOOTER with one weapon guided by Lead and one weapon guided by the wingman as the BUDDY.

Figure 8.9 Two-Ship SAT Role Assignment Decision Matrix.



FOUO

Figure 8.10 Two-Ship SAT Roles.

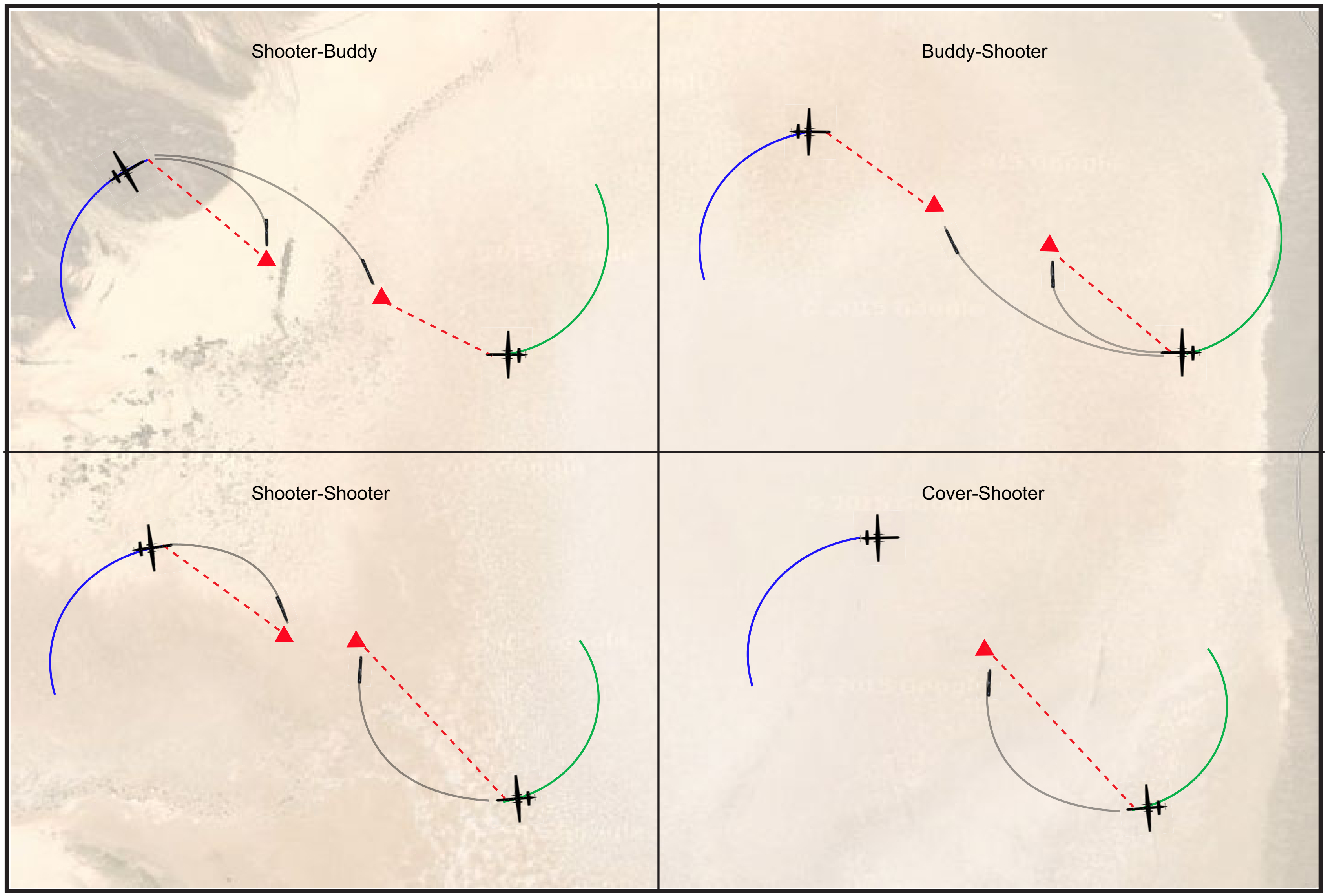
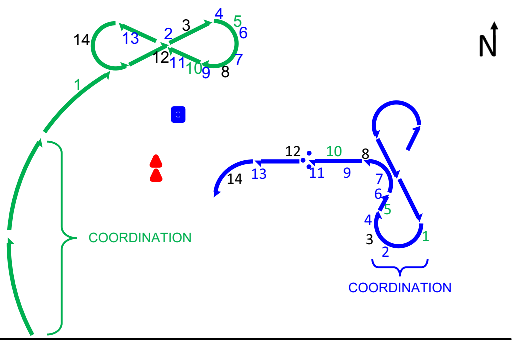


Figure 8.11 Example FROTIES.



EXECUTION:

1. "SE12, SECTORED NORTH"
2. "SE11, THUNDER"
3. "PANTHER 42"
4. "SE12, SE11, CALL CAPTURED NORTH GROUP, 1122 SET"
5. "SE11, SE12 CAPTURED NORTH GROUP, 1122 SET"
6. "SE11"
7. "PANTHER 42, SE11, IN FROM THE EAST"
8. "SE11, PANTHER 42, CLEARED HOT"
9. "SE12 LASER ON"
10. "SE12 LASING"
11. "SE11, RIFLE, 26 SECONDS"
12. "PANTHER"
13. "SE11 SPLASH"
14. "SE11, PANTHER 42, TWO BY HITS, STANDBY BDA, CALL CAPTURED ANY SQUIRTERS."

PLAYERS AND ROLES:

PANTHER 42 – JTAC

SAVAGE 11 – SHOOTER

SAVAGE 12 – BUDDY

TASK:

DESTROY TWO GROUPS OF INDIVIDUALS WITH SIMULTANEOUS IMPACTS,-9 LINE AND READBACKS ALREADY PASSED WITH ROLES AS DEFINED ABOVE.

COORDINATION:

"SAVAGE 12, SAVAGE 11, CALL CAPTURED TWO GROUPS OF PAX OUTSIDE OF BUILDING 432."

"SAVAGE 11, SAVAGE 12, CAPTURED"

"SAVAGE 12, SAVAGE 11, LABEL THE TWO GROUPS NORTH GROUP AND SOUTH GROUP. CALL READY FROTIES BRIEF (OR CALL READY GAMEPLAN IF ASSET IS UNFAMILIAR WITH FROTIES)."

"SAVAGE 11, SAVAGE 12, COPY, READY"

SAVAGE 11 delivers FROTIES brief:

F – "SE11 SECTOR EAST, SE12 SECTOR NORTH 4 NM"

R – "SHOOTER – BUDDY"

O – "2 X HELLFIRES"

T – "EXPECT THUNDER CALL AND IN ASAP"

I – "SE11 IN FROM THE EAST…"

E – "…AND OFF SOUTH. SE12 MAINTAIN NORTH SECTOR.

S – "SE11 SOUTH GROUP PRF 1111, SE12 NORTH GROUP PRF 1122"

REMARKS – "SE11 HAS SQUIRTERS SOUTH, SE12 SQUIRTERS NORTH, SE12 CALL SECTORED NORTH. HOW COPY?"

"SE12 COPIES ALL."

FOUO

8.5.5.5.1.2 BUDDY-SHOOTER. The wingman will release two weapons as the SHOOTER with one weapon guided by the wingman and one weapon guided by Lead as the BUDDY.

8.5.5.5.1.3 SHOOTER-SHOOTER. Lead and Number Two will both release and self-guide one weapon each.

8.5.5.5.1.4 COVER can be substituted for the BUDDY role in cases when the formation is targeting a single target and the SHOOTER releases and self-guides a single weapon. Example: COVER-SHOOTER.

8.5.5.5.1.4.1 GOALIE can be substituted for the COVER role above in cases where the flight lead wants to ensure another laser is ready to provide terminal guidance in the event the primary laser fails. Example GOALIE-SHOOTER.

8.5.5.5.1.5 For game plans with multiple attacks, the BUDDY-SHOOTER roles can be combined to further increase efficiency. However, as a rule of thumb, the combination of attacks should be limited to two per game plan (e.g., sequential attacks the combination of BUDDY-SHOOTER/SHOOTER-BUDDY roles can be combined to increase efficiency for back-to-back strikes or immediate reattacks.

8.5.5.6 Sort. Target sorts are the assignment of a laser and/or weapon against a specific target. Briefed and prioritized sorts can simplify in-flight decision making and shared flight perceptions. Below are several techniques to use when creating target sorts.

8.5.5.6.1 Standard Biases. Flight lead defaults to North or East group, the wingman defaults to South or West. Sort sequence from there (e.g., [2 columns of 5 oriented north south], "SORT STANDARD, WORK NORTH TO SOUTH").

8.5.5.6.2 Odd/Even Sorts. Another technique is by defaulting Number One to odd numbered targets, Number Two to evens, working lowest to highest (e.g., [circular array of 6 targets], "2, SORT EVENS"). This works particularly well with "downwind to upwind" labels, assuming the target array has already been labeled.

8.5.5.7 Develop attack sequence and sort. The attack sequence is primarily driven by target presentation, weapons available, attack restrictions, environmental factors such as surface winds or obscurations, and laser or weapon geometry. Lead should update flight position immediately if the initial game plan will not work and a new position is required. Reattack considerations will likely add additional complexity to the game plan.

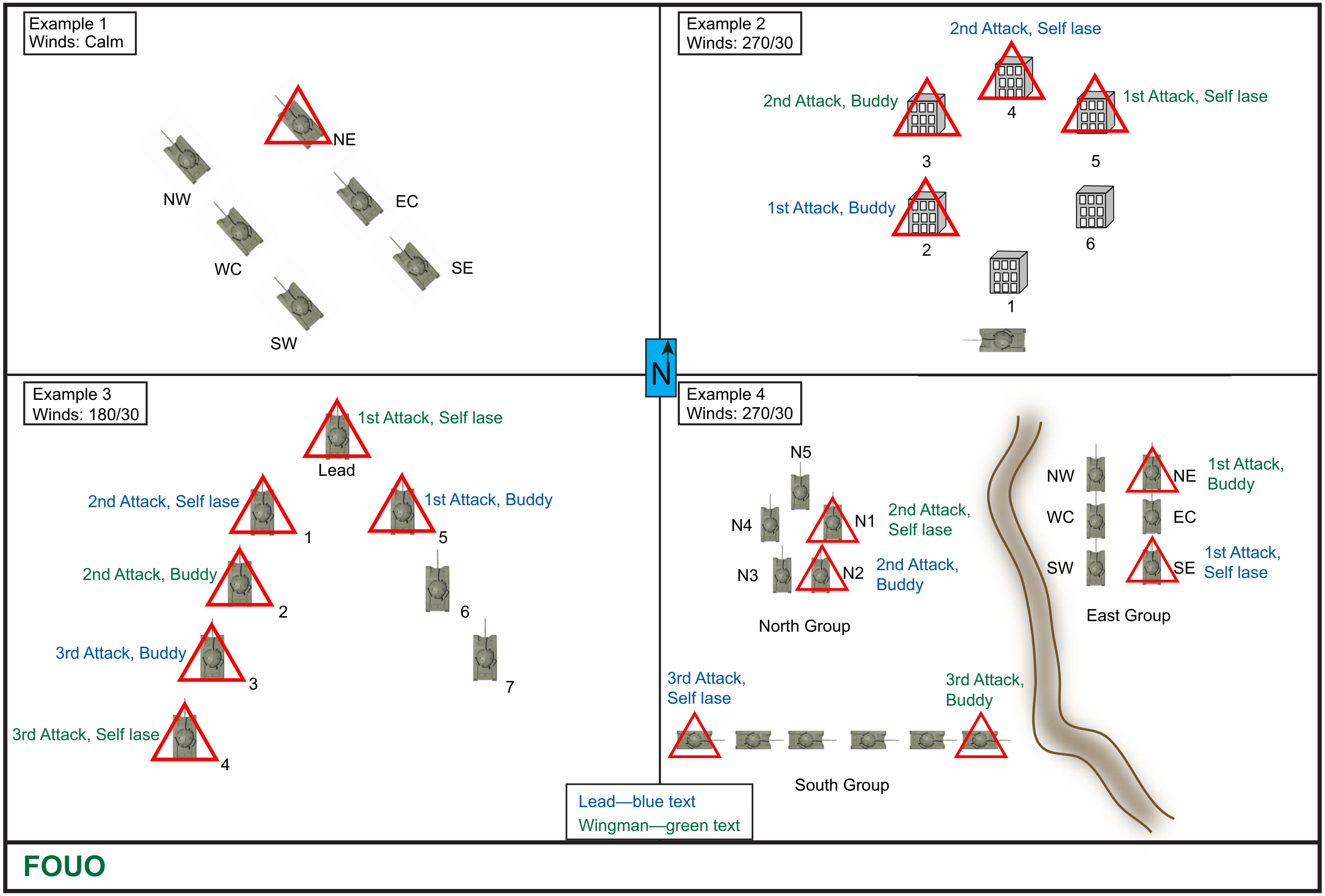
8.5.6 Fighter-to-Fighter. It is recommended to pass the fighter-to-fighter brief, or game plan, immediately following the picture and label to minimize time between tasks. Formation fighter-to-fighter briefs follow the same "FROTIES" as previously discussed in **paragraph 8.5.5.5**, FROTIES, however, elements can be skipped based on standards, contracts, and previously passed information. "Formation" can be skipped if the flight's position has already been established. If no delineation is made between the ingress, egress, and sort for Number One and Number Two, the wingman should assume that information is for them. Flight leads should pass weapons if not already stated, or if the weapons change between salvos. Timing is assumed as immediate unless otherwise specified. Ingress is expected to be the position Lead has already positioned the flight in, and egress defaults to the same. Keeping fighter-to-fighter briefs limited to two salvos will reduce the time for first effects and keep the data passage simple; additional briefs may be passed before or after the first attack, but waiting until afterwards will allow for adjustments to the target presentation, environment, or unmet effects. Once the fighter-to-fighter brief is completed, crews can finish outstanding intracockpit preattack checks.

8.5.6.1 Fighter-to-Fighter Comm. See **paragraph 8.5.5.5**, FROTIES, for standard passage TTP. The following figures below provide examples of how FROTIES can be integrated based on the tactical situation.

8.5.6.1.1 Fighter-to-Fighter Example 1. See **Figure 8.12**, Fighter-to-Fighter Example. The intent is to take out the NE-most tank. An example brief is, "FIGHTER-TO-FIGHTER, BUDDY-SHOOTER, HELLFIRE, EGRESS WHEEL, SORT NE TANK."

8.5.6.1.2 Fighter-to-Fighter Example 2. See **Figure 8.12**, Fighter-to-Fighter Example. The intent is to take out as many buildings as possible without targeting the southernmost. Artillery is positioned north of target area with a gun to target line (GTL) of 180 degrees. An example brief is, "FIGHTER-TO-FIGHTER, BUDDY-SHOOTER, SHOOTER-BUDDY, GBU-12s, IN EAST, OFF SOUTH, LEAD HAS BUILDING TWO THEN FOUR, TWO TAKE BUILDING FIVE THEN THREE." Since the sort for the wingman is five then three, they should self-lase on building five first then BUDDY LASE on building three next. Lead will BUDDY LASE building two then self-lase building four.

Figure 8.12 Fighter-to-Fighter Example.



8.5.6.1.3 Fighter-to-Fighter Example 3. See **Figure 8.12**, Fighter-to-Fighter Example. The intent is to destroy 2/3 of the tank array. An example brief is, "BUDDY-SHOOTER, SHOOTER-BUDDY, ALTERNATING, 2X HELLFIRES EACH SALVO, IN NORTH, OFF WEST WHEEL, NUMBER TWO SORT LEAD, THEN TWO, THEN FOUR ON WEST LEG." For this example, the flight lead plans to sort around the targets given to Number Two. Though Number One plans to attack tank five, tank one, then tank three, ownship sort plan is not communicated to expedite game plan passage. The brief breaks the "two salvos per brief" rule of thumb, but passing a second fighter-to-fighter to complete an attack with an obvious sequence would have unnecessarily delayed effects.

8.5.6.1.4 Fighter-to-Fighter Example 4. See **Figure 8.12**, Fighter-to-Fighter Example. The intent is to attrite 1/3 of enemy tanks while preserving Hellfires with a TOT for first Splash. An example brief is, "FIRST FIGHTER-TO-FIGHTER: 2 GO 3 NM TRAIL, SHOOTER-BUDDY, BUDDY-SHOOTER, GBU-12S, IN EAST, OFF NORTH WHEEL, SORT EAST GROUP NORTH-EAST TANK THEN NORTH GROUP FIRST TANK. SECOND, SHOOTER-BUDDY, HELLFIRES, SOUTH GROUP EAST TANK." The flight lead takes the primary shooter role in this by default because the TOT is the more difficult problem (giving the wingman the simpler problem of maintaining trail). Three nautical miles is chosen because that will give the wingman approximately one minute of spacing, enough to shift targets and execute the appropriate checks. The sort attacks the downwind targets first, moving to targets crosswind from each other. Lead gives the wingman easily passed targets and higher priority targets for himself to work within his own cockpit. The second fighter-to-fighter brief is triggered by the switch in weapons and only pertinent changes from the egress or end state of the first brief are included. ***NOTE:*** Another technique to simplify the first fighter-to-fighter is to target flight members against individual groups, wind and distance dependent, and let flight members sort within those group independently.

8.5.6.1.4.1 While Lead is the default for executing timed attacks, there are conditions where Lead might require the wingman to execute the timed attack. Examples of when the Wingman should execute timed attacks include, but are not limited to, when Lead is out of position, the complexity of the game plan development requires Lead to load shed, or Lead does not have the correct weapon to meet desired effects. Additionally, if simultaneous effects are required against multiple targets outside of target handover boundary (THB) or downrange/crossrange (DR/CR) of the weapons and/or require dissimilar weapons, expect a SHOOTER-SHOOTER timed attack where both members will execute timed attack procedures.

8.5.7 Execution. The trigger into the execution phase is the flight being TARGET READY. Formation attack efficiency hinges on timely data passage and contract adherence as the individual weapons deliveries are not significantly different from single-ship employment. Unnecessary delay, or confusion between flight members, will significantly decrease flight effectiveness.

8.5.7.1 TARGET READY. TARGET READY is defined as in position, weapons and TGP set (picture optimized, target captured, track built as required, laser coded and armed), briefs complete, and nothing to otherwise delay immediate execution. Initially, this will be passed from the first BUDDY/GOALIE/COVER to the first shooter. The shooter will acknowledge and pass any delay greater than a few seconds. Between salvos, as defined by the Splash of the previous salvo, the next BUDDY/GOALIE/COVER will pass TARGET READY to the upcoming shooter. "Auto-shift, PRF change, and laser on" contracts are the default in these engagements and flight leads should have explicit reasons to deviate from this. Flight leads may direct CONTINUE if the GOALIE or COVER roles are delayed in TARGET READY calls.

8.5.7.2 IN. Once the shooter is TARGET READY, and appropriate procedures complied with (range and/or clearance), the shooter will call IN. This is an informative call and is an auto "LASERS ON" unless otherwise briefed. The BUDDY will reply with "[position number], LASING."

8.5.7.3 Rifle/WEAPONS AWAY. Shooters will call out Rifle or WEAPON(S) AWAY with a valid TOF countdown referenced from the HUD. A second technique to be used without an accurate countdown or when the call is delayed, is to call the release and "TIME-OUT AT" followed by the GMT second when weapons effects are expected. For example, "RIFLE, TIME-OUT AT 26" would imply Splash is expected 26 seconds after the minute.

8.5.7.4 Splash. Weapon impacts, especially in a training scenario, may not be evident to the other aircraft. The shooter, with accurate TOF data, should call "[position number] HITS" with good effects, "MISS" with unachieved effects, or "TIME-OUT" with no observed effects. If a TIME-OUT is passed and effects are subsequently observed, update as required. The BUDDY LASER will parrot the shooter's call with weapons effects. When impact is observed for all weapons, the flight will transition to the next target or conduct BDA/BHA as appropriate.

8.5.7.5 No Spot, Hangfire, Misfire. With any kind of weapons malfunction in a training scenario, a KNOCK IT OFF should be called to facilitate running of the proper emergency procedure. In a missionized scenario, if timely effects are prioritized, continue with the passed fighter-to-fighter briefs and cleanup missed targets with reattacks.

8.5.7.6 Reattacks. Reattacks on formation engagements can be very fluid and depend highly on desired effects. "Cleaning up" incomplete targets depend on number, priority, presentation, and effects required. Assuming weapons are deconflicted, the fastest way to reliably achieve effects is to target individual flight members. Deciding who targets what is highly dependent on who is Tally first. If the flight lead needs to task the wingman, they should say "2, TARGET," followed by the target or any amplifying data. Weaponeering remains the same from the initial attack. Use of a salvo reattack will delay effects, but provide options for simultaneous impact or contribute to WRM balancing. Efficient fighter-to-fighter briefs are crucial, and it is important to consider how target handover boundary and a more complicated and dynamic target environment may change from the brief through weapons impact.

8.5.8 Battle Damage Assessment. In order to properly assess whether or not the intent was met, BDA must be accomplished to ensure valid weapon effects were achieved on the desired targets. Once a strike sequence has been completed, Lead should direct a BDA assessment in accordance with the formation brief. In most cases, Lead and Number Two will conduct BDA on the targets they individually sorted. Another technique is for Number Two to zoom out and maintain overview of the entire target set while Lead conducts BDA on each target. The use of either technique should be based on the target array and the distance between targets.

8.6 Crew Change-Out. Crew change-outs within a formation should be staggered between the two aircraft. Depending on the scenario or mission, Lead should change-out first with a recommended 30-minute delay until Number Two changes out. This delay provides Lead the time to gain the SA required to effectively lead the formation. If 30 minutes is not possible, a minimum of 15 minutes should separate the change-out between Lead and Number Two.

8.7 Contingencies. There are multiple contingencies that prevent or hinder effective two-ship execution. When mission planning, flight leads should consider the following.

8.7.1 Fallout. Since the majority of the MQ-9 squadrons are familiar with single-ship execution, fall-out to a single-ship game plan will, for the most part, only slow execution, decrease weapons available, and increase risk. Proper mission planning should identify and prioritize the most critical tasks should aircraft fall out. Additionally, and unique to an MQ-9, is the ability to prioritize which crew members to fly the single-ship mission. Furthermore, if the situation warrants, the crew without an aircraft can still perform delegated battle tracking duties using ZEUS, mIRC, and ClearCom monitoring or otherwise assist the flight lead. In most cases, Lead is going to take the good aircraft and/or the good cockpit.

8.7.2 Late to the Fight. Similar to fallout, late to the fight considerations center on single-ship execution as well as the proficiency of the wingman. In most cases, Lead will take the good aircraft and execute while Number Two catches up. Lead needs to be directive with Number Two in regards to ingress, check-in, re-join, as well as any other situations to which Number Two may need specific directions. Timing of Number Two's rejoin should also be considered to ensure Lead is aware and not interrupted during a critical phase of flight or pivotal point of the mission.

8.7.3 TacSit/Zeus Fallout. Lack of a TacSit will greatly complicate the formation's ability to maintain SA with respect to both aircraft positioning as well as battle tracking. Lead will have to use procedural comm to ensure Number Two is in position and moving in direction with Lead's guidance. Instead of plotting targets for battle tracking, target arrays will have to be drawn either on a line-up card or on a whiteboard. Obvious challenges will be involved with trying to communicate labels and sorts for complex target arrays. Furthermore, any plans to use Link 16 for battle tracking and target talk-ons will no longer be an option.

8.7.4 VLC/Wingman Feed Sour. If only one feed is sour (i.e., Lead can see Number Two's feed, but Number Two cannot see Lead's), then the cockpit without a feed will have to use other systems and contracts for target correlation and talk-ons. A TacSit with an aircraft SPI can be used in place to ensure both aircraft are MELDed to the same target. Otherwise, pod-to-pod, LTM, or visual talk-ons will be used for target confirmation and correlation. Should both feeds be sour, then confirmatory comm will be used for all target talk-ons and correlation.

8.7.5 Communication Failures. A primary, alternate, contingency, and emergency (PACE) plan should be part of the formation brief. Doing so will identify alternate means of communication should one or more fail. Having a PACE plan established during mission planning will ensure all players are able to circumvent communication failures which occur during the mission.

8.7.6 Weather. Mid and low-level cloud decks can have a significant impact on the primarily TGP-driven and laser-guided weapon tactics of the MQ-9. Formations can mitigate some of the effects of the cloud decks. The size and the type of the formation can determine if the formation can safely operate between the ground and the weather. Crews need to analyze the terrain in the target area as well as ingress and egress routes. Flight leads will determine what stack can most efficiently achieve desired sensor and weapons effects.

8.7.6.1 High/High. Stacking both aircraft high still allows the formation to get effects if weather, the tactical situation, or commander's intent dictates. From a formation perspective, positioning the formation to maximize sensors may be the best course of action. A large lateral distance between flight members would expedite SAR mapping, or positioning to enable collection. Without coordinate seeking weapons or another laser below the weather, weapons employment will be ineffective.

8.7.6.2 High/Low. Getting at least one aircraft below the weather enables the formation to use significantly more MQ-9 capabilities. Of note, flight members could be dealing with significantly different tasks. The low aircraft will be avoiding terrain and weather while positioning to avoid sensor body masking; the high aircraft may be dealing with strong winds aloft, positioning for SAR imaging or GMTI while allowing for timely weapons delivery through the weather. Flight members should keep each other abreast of significant environmental conditions. See Low HAT procedures found in **Chapter 7**, "Single-Ship Surface Attack Tactics."

8.7.6.3 High/Low and Weapon Deconfliction. To facilitate weapons delivery on target, one aircraft can drop from above the weather and the other can buddy lase from beneath the weather deck. A weapon can be dropped at a higher altitude from above the weather helping to achieve a steeper impact angle and higher velocity. Flight leads need to deconflict the high aircraft's weapon with the low aircraft's position; lateral deconfliction works well. Refer to AFTTP 3-1.MQ-9 Chapter 2, "MQ-9 Weaponeering," for all-weather air-to-surface considerations.

8.7.6.4 Low/Low. Special considerations must be made about MSA, terrain, sensor limitations, reduced weapons employment options, and lost-link missions. While both aircraft will be able to use their TGP for coordinated search plans and attacks, the task saturation or reduced options may not be optimal.

8.7.7 Emergency Aircraft. Formations can provide significant mutual support during an in-flight emergency. While the specifics of each situation will dictate a different response, the formation can either split during an emergency or remain intact. Situations that may warrant the formation remaining intact include engine failures, wingman lost link, battle damage or other mechanical failures. During the in-flight emergency, the emergency aircraft will likely focus on the MATL process and running checklists while the non-emergency wingman can assist with communication with outside agencies, clearing flightpaths, coordinating with the launch and recovery unit. Additionally, the wingman can gain and maintain visual contact of the emergency aircraft.

8.8 Debrief. Debriefing a formation flight can prove instructional for each member based on feedback from other positions even if no instructor is present. Young wingmen learn decision making processes of flight leads, and flight leads improve leadership based on how they enabled the wingman to provide mutual support. Flight leads should strive to maximize available learning from each event.

8.8.1 Debrief Responsibilities. The responsibilities prior to and during debrief depend on the role each flight member played in the flight. The following discussions are discussed down to single crews with the addition of the flight lead. Instructors, filling any position within the flight, have an obligation to ensure appropriate learning takes place. Individual PICs have the options to conduct own crew debrief once the flight debrief is complete.

8.8.1.1 Flight Lead. The flight lead is responsible for the timing, tone, direction, and overall lessons of the debrief. Flight leads should state in the brief what data wingmen should bring to the debrief, as well as any individual responsibilities (i.e., prepping boards, loading HUD video, Zeus recordings, or contacting the range controllers for weapons scoring). The PIC will own the pens for debrief, and pass them to the SO as appropriate for specific reconstruction or learning.

8.8.1.2 Wingman. Wingmen should bring notes to debrief and be prepared to learn. When asked a specific question by the flight lead, they will answer Lead's questions clearly and concisely. Wingmen will save questions for when lead asks for them.

8.8.1.3 Each PIC: Prior to starting debrief, each PIC should complete own data compilation of significant events, shot times, and shot/buddy-lase validity. Significant events include, but are not limited to, those which may result in safety-of-flight issues, tactical events (check-in, taskings, threat passage), and deviations to the plan. PICs should bring any questions that arose during the flight as a result of confusing or unbriefed topics. PICs should ensure they include the SO's feedback into this list as well. As a technique, PICs can delegate pulling video, Zeus recording, and mIRC-logs to SOs. The 26 WPS Debrief Guide has example matrices for data compilation and should be used as a means to assess the effectiveness of the sortie.

8.8.2 Flow. While the flow of a flight debrief should not be any different than a single-ship debrief, establishing a consistent flow across squadron flight leads will expedite debriefs and facilitate learning through expected structure. Depending on the desired learning objectives for the sortie, a flight lead may decide to focus on the formation execution of a mission, or mission effects themselves.

8.8.2.1 Flight Member Inclusion. It is recommended flight leads cover each topic with notes or highlights, solicit inputs from the lead SO and other instructors, query for additional inputs not yet addressed, provide any relevant learning, and then close the topic.

8.9 Multiship/Ad Hoc Formation Considerations. Current formations seen in combat are often a result of two or more MQ-9s working together to strike a target without previous mission planning or coordination. More often than not, the MQ-9s are also flown from different and geographically separated squadrons. Furthermore, multiship formations may contain aircraft other than MQ-9s. As a result, the ad hoc multiship is forced to quickly develop a shared mental model and build a game plan using a common communication system. The following sections will discuss ad hoc multiship considerations, buddy lase coordination, the 4 C's, as well as coordinated strike TTP with dissimilar assets. Table 8.6, Multiship Execution Flow, summarizes the overall flow of multiship execution.

Table 8.6 Multiship Execution Flow.

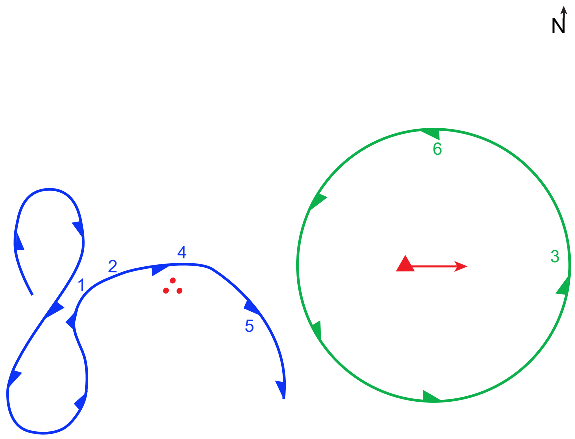
1. Receive intent
2. Admin—receive call sign(s), weapons, PRFs, location, and altitude
3. Find/Fix/Track a. Target talk-on b. Pass target picture and label
4. Target a. For simple BUDDY LASE only, pass 4 Cs b. For coordinated attacks, develop and pass game plan (TIES)
5. Engage
6. Assess a. Conduct BHA/BDA b. Reattack, as required

8.9.1 Buddy Lase Procedures. Lasing in weapons from other dissimilar or similar aircraft is a common task for MQ-9s due to extended loiter time and SA of the target area. The buddy lase involves two main players: the SHOOTER, who delivers the ordnance and typically passes the coordination brief, and the buddy lase aircraft that provides terminal guidance, known as the BUDDY.

8.9.2 Buddy Lase Coordination. The SHOOTER is responsible for ensuring all proper coordination for the buddy lase attack is complete. This includes attack geometry for both aircraft in relationship to the target, aircraft deconfliction, and weapon/PRF pairing to target. There are two techniques commonly used for coordination. The 4 C's is used for relatively simple targets and requires minimal communication. For more intricate target sets, a technique to ensure that all necessary coordination items are accomplished in the coordination (coord for short) brief is to use the acronym FROTIES as a template. FROTIES format and examples can be found in paragraph 8.5.5.5, FROTIES.

8.9.2.1 4 Cs. The 4 Cs, which stands for "Code, Confirm, Capture, and Clearance," allows for a quick and concise means for coordinating a buddy lase between two MQ-9s as well as between an MQ-9 and dissimilar assets. The shooter will pass the PRF code of the weapon to which the buddy will be lasing, confirm the shooter's laser is off or set to a separate PRF for a multiple weapons delivery, ensure the buddy has the correct target captured, and ultimately ensure clearance is passed prior to weapons release. Additional coordination can be accomplished (such as final attack heading, laser-to-target line, and timing call outs) as desired or when the situation dictates. However, all additional coordination should remain clear and concise in order to remain aligned with the simplistic nature of the 4 Cs. See Figure 8.13, 4 Cs Example, for an example of communication flow and pacing.

Figure 8.13 4 Cs Example.



Players and Roles:
PANTHER 42 - JTAC
REAPER 26 - Shooter
GRIM 11 - Buddy

Task:
Destroy moving vehicle

Coordination:
"GRIM 11, REAPER 26, SAY WHEN READY COORD BRIEF"
"GRIM 11, READY"
"GRIM 11 REAPER 26, SET 1542, MY LASER IS OFF, CONFIRM THE TARGT VEHICLE IS CAPTURED"
"GRIM 11 IS CAPTURED, 1542 SET"

Post-Coordination Flow:
1 "PANTER 42, REAPER 2 IN FROM THE WEST, LASER ON"
2 "REAPER 26, PANTER 42, CLEARED HOT"
3 "GRIM 11, LASING 1542"
4 "REAPER 26, RIFLE, 26 SECONDS"
5 "REAPER 26, SPLASH, CEASE LASE"
6 "GRIM 11, LASER OFF"

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8.9.3 Buddy Lase Hold. The SHOOTER will execute hold, preattack checks, execution, and egress as required for the chosen weapon and tactical situation as covered earlier in this chapter. During a Buddy Lase, the SHOOTER's additional responsibilities are to create and pass the Coordination Brief to the BUDDY (using the FROTIES format) and ensure deconfliction from the designator aircraft. Other tactical platforms may have a different variation of FROTIES, but the overall content is the same. As the BUDDY, the crew will still execute the four phases of an attack to ensure the aircraft is ready to successfully BUDDY LASE in accordance with the coordinated plan. Executing a wheel around the target is the simplest means of maintaining high depression and target area SA. However, consideration must be given to SHOOTER's position (i.e., stacked above or below BUDDY), environmental factors, terrain, restrictions, and possibly friendly position. Depending on the considerations mentioned above, the SECTOR hold not only enables specific look angles, but also meets the intent of potential run-in restrictions, restricted laser-to-target lines (LTL), and mitigates deconfliction issues.

8.9.3.1 Preattack Checks. Crews should accomplish SLAPUM WTARSEC. The only difference in the standard brief is that BUDDY crews should discuss what the BUDDY's SMS is set to (default to Hellfire for potential reattack) and ensure the Laser is Armed and coded per coord brief. WTARSEC will be what weapon the SHOOTER will be releasing, what target the BUDDY is responsible for, aimpoint for BUDDY's DPI, any restrictions for BUDDY (i.e., LTL), shift plan (if briefed), egress/deconfliction plan for SHOOTER and BUDDY, and expected clearance authority, type (if required), and when to expect it. This will provide normal strike pacing and highlight any gaps in the game plan (e.g., no briefed/coordinated shift plan). Crews should prepare for an immediate reattack (SMS configured, contracts for Squirters and PRF change); however, buddy lase position should never be sacrificed for a potential reattack. At a minimum, BUDDY crews will ensure the LRD is armed, set to the PRF per the coord brief, and run WTARSEC. If an immediate reattack is required, consideration should be giving to running an ASULT prior to commencing reattack since the target/aimpoint may have changed.

8.9.3.1.1 Buddy Lase Execution. The attack phase begins when the SHOOTER aircraft calls "IN." As directed by the SHOOTER, the BUDDY will lase the target and provide appropriate comm/responses. Buddy lasers are not responsible for weaponeering or getting clearance; however, they should backup the SHOOTER if necessary. A technique for the BUDDY is to request a one minute time to release call from the SHOOTER. This allows the BUDDY to assess current aircraft position and make adjustments to be in the optimal position for terminal guidance. However, the BUDDY LASE aircraft should be in position to execute and anticipate an attack from the SHOOTER any time after the coordination has been complete. The tactical situation may not always allow for a 1 minute TTR call nor is it required during a BUDDY LASE.

8.9.3.1.1.1 Unrestricted Laser-to-Target Line. With no restrictions, a buddy lase will look very similar to the postrelease phase of a Hellfire employment. Time permitting, closer ranges (higher depressions) are preferable for smaller laser spot and less chance for target obscuration. Flying between a 45- and 60-degree wings level depression angle is an optimal range in most environments. Time allowing, a technique to maintain SA of this optimal ground range is to use the "Draw Circle Editor" on the tracker display to drop two separate circles around the target. The pilot can use the Planning Tool to determine the Ground Range (in km) for 45- and 60-degree wings level depression angle and input these ranges into the "Draw Circle Editor" to give a visual depiction of where to hold. If given a THUNDER call from the SHOOTER, pilots can Turn-In, roll out tangent to the 60-degree ring with 90 degrees of azimuth, and provide a stable, high depression look for SOs through TOF.

8.9.3.1.1.2 Restricted Laser-to-Target Line (LTL). Techniques to achieve buddy lase LTL restrictions become more limited as the restriction narrow. High depression looks are still preferable but are prioritized after the restrictions. In these situations, coordinate with the SHOOTER to identify the required time for correct aircraft positioning to meet the LTL. If extremely narrow restrictions apply, consider setting a TOT to allow the BUDDY to be in position at the desired time. The crew will use the "BRG" in the bottom right of HUD (selectable in TRUE or MAGNETIC) to verify that the restriction is met (regardless of aircraft heading). Consideration should be given in the CAS environment (where all restrictions are passed in MAG) to displaying "BRG" in degrees magnetic.

8.9.3.1.1.3 Restricted LTL With TOT. With narrower restrictions there is less room for error or variation in SHOOTER release time. In these cases, executing a modified CP Timing attack can provide very precise positioning. Place the CP along the desired LTL with a high depression (approximately 60 degrees). While the SHOOTER is the default for calling the TOT, consider recommending a TOT if limitations are exceptionally restrictive. Reference Timed Attack procedures in **Chapter 7**, "Single-Ship Surface Attack Tactics."

8.9.3.1.2 Egress. Post-impact, the BUDDY should position as required for follow-on roles such as BDA, custody of Squirters, reattack, or next tasking. If SHOOTER/BUDDY were SECTORED initially, both players should return to the prebriefed SECTOR.

8.9.3.2 Buddy Lase Pacing. The SHOOTER drives the pacing and needs to ensure enough cuing is passed to the BUDDY in order to successfully complete the attack. Once the SHOOTER has developed a plan, the SHOOTER should pass the Coordination brief (using the FROTIES template) to the BUDDY. The BUDDY should let the SHOOTER know that the plan was received and understood or ask for any clarifying information. After receiving the Coordination brief, the BUDDY will call "CAPTURED, (PRF)" and complete own preattack checks to ensure they are ready to execute. As a technique, the crew can add target information passed in Coordination brief to the CAPTURED call (e.g., "CAPTURED, WESTERN APC, PRF"). After the SHOOTER calls "IN" and obtains clearance from controlling agency (as required), the SHOOTER will make a "10 SECONDS" call to inform the designator when to expect "LASER ON." Following the "10 SECONDS" call, the SHOOTER will request, "(BUDDY call sign), LASER ON." The BUDDY will fire the laser, confirm good returns, and respond with, "LASING, (PRF)," assuming a continuous lase scenario (crews should avoid firing the laser until the SHOOTER calls for "LASER ON"). The SHOOTER should call "One (or two based on scenario) AWAY, TOF" to provide SA to the designator. If a delayed lase is required, the 10 SECONDS and LASER ON call could potentially be after weapons release. If the attacking aircraft or laser designator uses the brevity Splash when weapon impacts are observed, CEASE LASER is implied.

8.9.4 Coordinated Attacks. Coordinated attacks include multiple flights of aircraft (either similar or dissimilar and NOT prebriefed as a formation) using either combined or sectored tactics in conjunction with some type of deconfliction measure. Generally, the tactical lead is the flight lead or FAC(A) with the most SA, and may be tasked to assist in coordinating attacks. The Type, Ingress, Egress, Sort (TIES) method is a useful way to brief a coordinate attack. See **Table 8.7**, JFIRE Table 40—Coordinated Attacks. The primary reference for coordinated attacks and TIES is AFTTP 3-2.6, *JFIRE*. Additional discussion specific to MQ-9 specific coordinated attacks can be found in AFTTP 3-1.MQ-9.

8.9.4.1 Type. The type of attack is based on the avenue to the target/target orientation and is broken down by type and timing. The types of coordinated attacks include combined or sectored with simultaneous, sequential, or random timing.

8.9.4.1.1 Combined. Combined attacks should be used when both assets will use the same avenue of attack to the target. Factors that may drive combined attacks include run-in restrictions, terrain buildup, friendly position, target ID, or environmental factors.

8.9.4.1.2 Sectored. Sector attacks are executed the same as previously discussed in BUDDY LASE procedures. See **paragraph 8.5.1.2.3.3**, Sector.

Table 8.7 JFIRE Table 40—Coordinated Attacks.

Type of Attack		Simultaneous	Sequential	Random
Combined	Same avenue of attack	Visual or timing simultaneous time on target or time to target	Visual or timing (visual spacing or time separation)	Not normally used
Sectored	Acknowledged sector	Visual or timing simultaneous time on target or time to target	Visual or timing (visual spacing or time separation)	Free flow (must ensure strafe fan or bomb and missile fragment deconfliction)
OVERALL NOTE: * The joint standard for coordinated attack deconfliction refers to the avenue of approach.				

8.9.4.1.3 Simultaneous Timing. Simultaneous effects are based on either visual or timing cues. Since the MQ-9 is not able to get VISUAL other assets while maintaining PID, a time hack (in the form of TOTs or TTTs) should be used in order to achieve simultaneous effects.

8.9.4.1.4 Sequential Timing. Sequential effects are based on the same cues as simultaneous effects.

8.9.4.1.5 Random Timing. Random timing is usually used with larger target arrays and when a line of demarcation, such as a BENO line is established between aircraft. This allows for simultaneous attacks to take place using different attack axis.

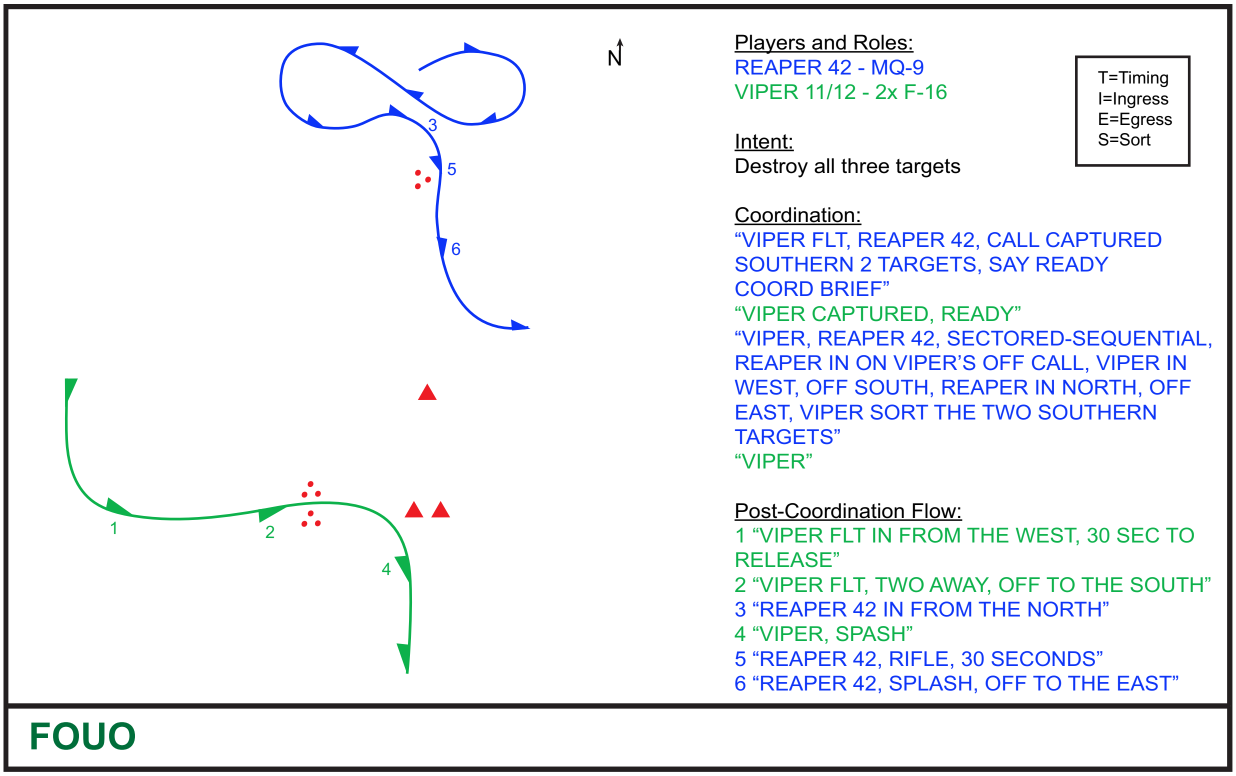
8.9.4.2 Ingress. Ingress direction is briefed for each attacking flight.

8.9.4.3 Egress. Egress direction is briefed for each attacking flight.

8.9.4.4 Sort. Sort is briefed based on desired effects. See **paragraph 8.5.5.6**, Sorts, for amplifying remarks.

8.9.4.5 Coordination. One flight lead may be established as the tactical lead of the attacks if all flights/sections agree to work coordinated attacks. The TAC lead should brief the attack to all players using the TIES mnemonic as previously outlined. **Figure 8.14**, TIES Example, provides an example of communication flow and pacing for a coordinated strike.

Figure 8.14 TIES Example.



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CHAPTER 9

MOVING TARGET ENGAGEMENT

9.1 Introduction. MQ-9 moving target engagement (MTE) is a difficult task due to the multitude of dynamic factors that crews need to take into account for each engagement. Engagements vary due to target characteristics, environmental factors, and asset availability/capability. For single-ship MTE, the shooter needs to ensure that positioning not only supports weaponeering considerations for release at Rifle, but also positioning requirements during the weapon TOF and at Splash. Common to formation and single-ship MTE the most important factors are:

- Track establishment at Splash with crosshairs on intended DPI.
- Lasing aircraft in proper position with respect to missile trajectory and spot size considerations.

9.2 Assumptions.

- A moving target is a vehicle (soft skinned or armored) or motorcycle, not individuals walking.
- The engagement time line precludes waiting for the target to stop.
- This chapter assumes the AGM-114 Hellfire meets weaponeering requirements.
- While the GBU-12/49/54 is useful in the appropriate situation, the AGM-114 is normally the weapon of choice.
- As of writing time for this chapter, the MQ-9/GBU-54 moving target capabilities have not been fully tested/developed. Expect a flash bulletin release updating MQ-9/GBU-54 MTE employment TTP.

9.3 Target Characteristics. In order to properly weaponeer for a MTE scenario, crews need to take into account vehicle type and velocity/maneuvering in conjunction with desired intent.

9.3.1 Vehicle Type/Weaponeering. Assuming the desired intent is to maximize effects on passengers inside the vehicle, vehicle type will most directly affect optimal fusing. For large or normal-sized (four passengers or greater) cabbed vehicles, select either instantaneous or delay 1 fuzing. For small-cabbed vehicles and motorcycles, select airburst fuzing. If the desired effect is a mobility kill, use airburst fuzing for soft-skinned targets, lightly armored targets, and instantaneous for armored targets.

9.3.1.1 AGM-114 Fusing. Use Instantaneous/Delay 1 over Airburst (AB) against normal sized vehicles assuming the crew is confident in being able to hit the cab. Use AB against motor cycles and on small cab vehicles if conducting single-ship MTE, or instantaneous if an MQ-9 buddy laser is available. Refer to AFTTP 3-1.MQ-9, Chapter 3, “Mission Planning Considerations,” for full discussion.

9.3.1.2 AGM-114 Inst versus Delay 1 Fuzing. Combat data from 2016 to 2018 shows higher lethality for Inst fuzing; however certain circumstances (i.e., precise aimpoint, buddy lase, or CDE mitigation) may favor a delay 1 fuzing. If restricted to a certain fuzing (e.g., per JTAC or targeting cell), crews should comply and prioritize overall execution as opposed to delaying the strike due to extraneous discussion.

9.3.1.3 Time of Flight (TOF). If the intent and restrictions of the engagement drive an on-azimuth shot (inside 45 degrees azimuth), crews should strive for a rear aspect engagement with at least 30-second TOF. Inside of 45 degrees azimuth, pre-Rifle tracks have a greater propensity to enter coast mode, decreasing the probability that the track will continue to hold. 30 second TOF is a balance between both, allowing for a high vertical impact angle (V-IA) while also giving the sensor operator multiple attempts to establish a track on the target post-Rifle. Pilots should avoid shooting with less than 25-second TOF.

9.3.1.4 Audible Warning (AW). Combat data shows no positive correlation between lower AW and higher lethality for moving target engagements, and thus do not consider AW as a priority except for very specific circumstances (e.g., slow moving truck in a rural environment with multiple personnel in the back who might detect an AW).

9.3.1.5 Vertical Impact Angle. RMIT produces impact angles based on a static target. For moving target engagements with LOAL-H profile, the target's velocity and aspect affect the achieved V-IA. For targets engaged from a rear aspect, the V-IA decreases by 5 degrees for every 25 mph increase in target speed. For targets engaged from a front aspect, the V-IA increases 5 degrees for every 25 mph increase in target speed. In most cases, planning for a 70 degrees V-IA based on RMIT endgame parameters will lead to desired effects.

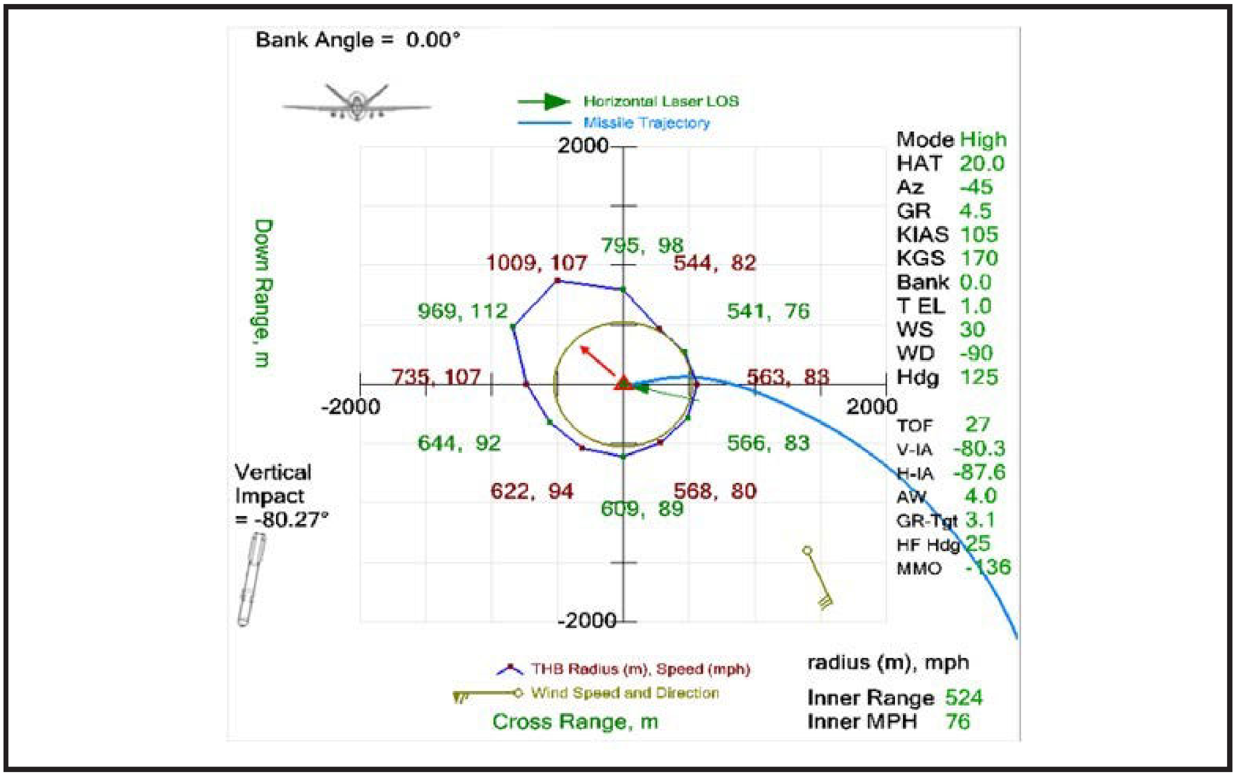
CAUTION: A shallower V-IA against a "high speed" mover leads to a less than optimal fragmentation pattern for effects with an AB fusing.

9.3.2 Vehicle Velocity/Maneuvering. In general, as vehicle speed increases the target will have less ability to change direction quickly. When maintaining a relatively constant direction of travel, a faster vehicle is generally a more cooperative target, making it easier for the sensor operator to refine crosshair placement during the endgame portion of the engagement and allowing the pilot to position the aircraft for a rear aspect. As vehicle speed decreases, the vehicle's maneuverability increases. While a slower target helps from the target velocity boundary (TVB), sensor operators will struggle to maintain crosshairs on the DPI of a direction-changing target. In part, the target environment affects whether or not it is a cooperating target or a non-cooperating target. A "rule of thumb" for holding in relation to target velocity is to hold 0.5 km closer for every 30 mph the target is moving away from the aircraft.

9.3.2.1 Target Handover Boundary. THB is for static targets. THB provides the crew with the surface area that the hellfire will detect laser energy at lock-on enable (assuming no podium or masking effects) and result in a 0.97 probability of hit (P_H). THB is larger along the same axis as the missile heading beyond the DPI location with LOAL-H. LOAL-D will give the largest and most evenly distributed THB. The THB will have a significant effect on weaponeering solutions for split DPIs. Rifling with one or more DPIs outside the THB will result in lost weapons effects. THB is only a concern if trying to engage multiple moving vehicles split by a significant distance.

9.3.2.2 Target Velocity Boundary. Use TVB values, also known as escape velocity, for moving targets. It represents the maximum velocity a moving target can travel for the missile to still acquire and intercept the target. For a successful MTE, the missile seeker must be able to see the laser energy at lock-on enable and the missile must have enough kinetic energy to fly to and intercept the target with a P_H greater than 0.97. TVB assumes that the handover target is collocated with the moving target when the aircraft delivers the R09 message to the weapon at release. Rifling on a moving target that is going faster than the TVB will likely result in lost weapons effects. Aligning the missile heading with the direction of vehicle travel maximizes the TVB value. See **Figure 9.1**, TVB Graphic.

Figure 9.1 TVB Graphic.



9.3.2.3 LOAL Mode. R-guidance variants can have a significant TVB capability difference between LOAL-H and LOAL-D. For moving targets, LOAL-D provides a larger TVB; however, this is typically at the expense of V-IA. LOAL-H can result in a similar TVB as LOAL-D when engaging the vehicle on-azimuth from a rear aspect. When possible, recommend LOAL-H to maximize V-IA. Crews should cross-check TVB on the real-time footprint with estimated vehicle speed on the HUD and adjust towards a rear aspect approach if required. Some LOWAT environments or targets moving greater than 100 mph may require the use of LOAL-D to meet TVB considerations.

9.4 Environmental Factors. The target vehicle's environment affects the way MQ-9 crews need to approach a MTE. A vehicle traveling a constant speed on a hardball open road presents a different problem than a vehicle traveling at slower speeds through a built up urban environment. For all attacks, crews should build SA on the upcoming area in the vehicle's direction of travel to be aware of terrain or obstacle masking and possible changes in the direction of the vehicle's route of travel. There are several ways to build SA on the target environment, including having another asset clear ahead of the vehicle, using Zeus or other imagery products to reference ahead of the vehicle's route of travel, and using prebuilt "engagement zones." Road type and terrain are the two major factors that MQ-9 crews need to consider when building situational awareness.

9.4.1 Road Type. "Paved/hardball" road surfaces are concrete surfaces typically found in built-up areas or developed countries. "Dirtball, unimproved roads" are unprepared surfaces (i.e., ditch bank) typically found in rural areas or countries that are less developed. Paved roads may allow for higher speeds than a dirtball road, but typically the environment (urban versus rural) and terrain will be the driving factors for higher or lower speeds.

9.4.2 Terrain. The terrain the vehicle is traveling through is equally as important as the road. Vehicles traveling in dense urban environments (majority buildings 3+ stories), present a particularly difficult problem. As vehicles move into a city with buildings three stories or higher, MQ-9 crews are forced to maintain follows in a Wheel hold at a high depression angle of 60 to 75 degrees. Even if the environment does not present masking problems from buildings, trees, other traffic can make it difficult for sensor operators to build tracks and can potentially lead to decreased track stability.

9.5 Asset Setup and Capabilities. MQ-9 crews historically struggle the most during MTE with maintaining crosshairs on the DPI without an AVT. This was always the driving factor for using a buddy laser. With improvements to aircraft/targeting pod software and TTP, single-ship MTE success rates have nearly improved to the success rates with a buddy laser from operational data. Operational requirements still desire buddy lase engagements. However, depending upon the tactical situation, aircraft/targeting pod capabilities, and crew proficiency, MQ-9 crews should not hesitate to execute MTE as a single-ship.

9.5.1 Moving Targets. Moving targets are targets that are currently in motion. They can be tracked or wheeled vehicles, motorbikes, aircraft and surface vessels. Dismounted personnel at walking or running speeds are not considered a moving target. Moving target track (MTT) is a critical skill-set that requires extensive situational awareness and crew coordination. The game plan for MTT can be either sensor- or weapons-driven. Considerations should be made to disable assisted track to maintain PID during the track phase.

9.5.1.1 SAR. The SAR provides a limited ability to track a moving target. Unlike the TGP, the SAR does not provide sufficient fidelity to ensure the GMTI hits are the same target. Its use is recommended in rural settings or when tracking a large amount of vehicles (e.g., armored column, friendly convoy) as it will free the TGP to be able to search for additional targets or threats. GMTI spot mode is the recommended mode to maintain track on a MTT.

9.5.1.1.1 GMTI Spot. Command GMTI spot on the TGP SPI displayed on the CLAWs main map region while the SO is CAPTURED on the moving target. A Figure Eight hold with turns into the moving target is required to continuously track the moving target using the SAR. Cross-check the back edge of the SAR batwings and begin turning into the target prior to the target exiting the SAR GMTI field of regard. Continue to update the location of the SAR GMTI spot as the vehicle moves to maintain track. If radar contact is lost, execute a SAR cross-cue to quickly slew the TGP to the last known location to reacquire the target.

9.5.2 Mobile Targets. A mobile target is a target that is currently stationary, but has the potential to move (e.g., parked car). While the target is stationary, execute static target track TTP. If the mobile target begins to move, transition to moving target track TTP. Identify mobile targets in the vicinity of static targets and query the applicable source for required actions if the mobile target begins to move. If a target has a detection concern, confirm if the detection concern is dropped or minimized if required to execute a MTT. When the mobile target begins to move, immediately pitch-in to decrease range and minimize the potential for masking. Additional considerations apply if the target is already moving and stops. When the intent of the track is to collect on the individuals inside, once the vehicle stops and passengers dismount, the aircraft should be in a position to provide the required fidelity for the SO to zoom-in and ID the passengers. If a detection concern is a factor when the vehicle stops, the pilot must maneuver the aircraft back out to the minimum slant range for the detection concern once the vehicle stops.

9.5.3 TGP Setup and Considerations. Proper TGP setup and control is critical to successful MTE execution. The root cause of many-failed MTE is usually due to poor TGP setup and control.

9.5.3.1 Field of View (FOV) Selection. Optimal FOV is primarily dependent on slant range and target dimensions. SOs must choose a FOV that provides sufficient target detail to allow precise crosshair placement to achieve desired effects. Target fidelity should be such that it is clear when the center of the crosshairs is on the cab of a vehicle. For example, if it looks like the crosshair width gap completely covers the vehicle that is probably not enough fidelity for the SO to achieve precise aimpoint placement. A balance between target fidelity and track stability is often required to meet the intent of an engagement. The starting FVW for vehicles is 50 to 90 meters and for 30 to 50 meters for motor bikes. This will generally provide sufficient target fidelity to ensure accurate crosshair placement to achieve desired effects while ensuring track stability and survivability. With the AGM-114 fused to airburst, consider using a slightly larger FVW; however, do not sacrifice track stability and survivability. SOs must consider the zoom lock function of the TGP and establish an appropriate FVW prior to lasing.

9.5.3.2 Camera Selection. Each TGP camera has different strengths and weaknesses for moving target tracking. Camera selection will be determined by many factors, including traffic volume, aircraft standoff, and target size. The SO should select a camera based on these considerations to determine best/most contrasting scene to aid in acquisition and tracking.

9.5.3.2.1 Infrared Camera. IR tracking is generally preferred over DTV due to the wider FVW provided in equivalent FOVs. Following moving targets in IR gives the ability to identify specific IR signatures not visible in DTV (e.g., engine, exhaust pipes, and tires) and facilitates reacquisition if the mover becomes obscured. In situations where the IR camera provides more significant contrast than the DTV camera, the IR camera should be selected to improve tracking and track employment.

9.5.3.2.2 Day Television Camera. Tracking moving targets in DTV is ideal for specific color cuing in order to establish specific identification features to facilitate target reacquisition, if required. In situations where the DTV camera provides more significant contrast than the IR camera, the DTV camera should be selected to improve tracking and track employment.

9.5.3.2.3 Low-Light Television Camera or SWIR. Tracking moving targets in LLTV/SWIR is ideal during periods of darkness when the moving target is using a light source (e.g., vehicle headlights or taillights). Aside from a small possibility of a unique light signature (e.g., left taillight is inoperable on a vehicle), LLTV/SWIR does not provide the crew specific identification features that would facilitate target reacquisition, like in DTV or IR. LLTV/SWIR allows the SO the ability to track a moving target without direct line-of-sight to the target by tracking the light source's reflection off of other objects (e.g., headlights reflecting off of a road or buildings while the vehicle is under a bridge). There is a limited ability with the LLTV/SWIR camera to continue to track a moving target light source through weather (e.g., clouds, fog, haze), where the IR camera would be less effective. Well-lit environments (e.g., a densely populated city) can over-saturate the LLTV/SWIR camera and make moving target tracking difficult or impossible. LLTV/SWIR has significant contrast to improve tracking and track employment.

9.5.3.2.4 Fusion. Fusion takes advantage of the combined strengths of two cameras while mitigating the weaknesses of an individual camera. Tracking moving vehicles with IR/DTV fusion during daytime provides color and emissivity information and reduces SO workload by eliminating the focal length changes induced by switching from IR to DTV as single source. Having IR/DTV fused prior to tracking a moving target will negate the momentary loss of SA while the cameras are switching. IR/LLTV or IR/SWIR is ideal for night operations and should be set up prior to vehicle departure. SOs should set a blend ratio as required to gain the desired effects of the LLTV/SWIR, but retain as much of a detailed IR image as possible. Crews should establish specific identification features on moving targets to facilitate reacquisition, if required.

9.5.3.2.5 Camera/Field-of-View Changes. FVW change is the biggest consideration when changing between IR and DTV cameras, or adjacent FOVs with the same camera, while tracking a moving target. The WIDE through 4x FOV FVW will be smaller than the corresponding IR FOV FVW. When switching from IR to DTV, or zooming-in with the same camera, SOs need to ensure that the moving target will remain within the anticipated FOV by centering-up on the moving target as much as possible prior to changing FOVs.

9.5.3.3 TGP Moving Target Track Considerations. TGP considerations the crew must account for during moving target track include camera selection, slew control, track employment, and the target environment.

9.5.3.3.1 Track Employment. The ability to drop a stable AVT on a moving target reduces SO workload during MTT and allows for precise crosshair control during weapons employment while self-lasing or buddy lasing during a moving target engagement. Without proper slew control, employing tracks on moving targets are near impossible. Each type of track has advantages and disadvantages against moving targets. Against moving targets, refined offset feature and point tracks are the recommended track types; whereas, area tracks are not recommended.

9.5.3.3.1.1 Target Environment. The crew needs to plan and react appropriately to the target environment to ensure successful moving target track prosecution. A proactive mind-set is required by the crew due to the dynamic nature of a moving target track. The unpredictable path of a moving target requires the aircrew to real-time plan or quickly react to dynamic factors, some of which include urban/rural environment, terrain masking, and glare/blooming.

9.5.3.3.1.1.1 Urban/Rural Considerations. Urban moving target tracking presents unique challenges, such as the high volume of traffic and structures that can obstruct the view of the target. Using narrower FVWs aids in maintaining target custody when in a heavily congested area. The visual cues obtained with a narrower FVW can make a target stand out from its surroundings. In rural environments, the primary concerns are vegetation and terrain obstructing line-of-sight to the moving target. Aircraft placement is the primary method to mitigate these concerns. Without line-of-sight obstructions in a rural environment, the widest FVW practical should be used to reduce SO workload and identify upcoming obstructions or changes in direction. The TacSit displays should be setup to provide as much awareness as possible to upcoming road intersections, terrain features, or built-up areas. Zeus provides the ability to maintain a zoomed-out view of the target area with a separate zoomed-in view slaved to the TGP SPI via the Magnifier tool. The pilot should set the magnifier to be slaved to the TGP SPI and zoomed-in to satellite imagery with approximately 500 meters of coverage around the SPI, while the main TacSit display remains zoomed-out for target area awareness. The SO should set the magnifier to the overview of the target area with the main TacSit display zoomed-in to provide satellite imagery coverage with the map slaved to the TGP SPI. To slave to the TGP SPI, right click on the SPI and select “Slave View to” and then “EO/IR.”

9.5.3.3.1.1.2 Terrain Masking. The risk of terrain masking should be assessed prior to the movement of the target, if able, and should always be in the crew’s cross-check while the target is in motion. Terrain masking may occur in both urban and rural environments. When terrain masking occurs, the sensor operator should zoom out and move to the most probable point along the target’s path, while remaining cognizant to potentially hidden target movements. The TacSit display, off-board sensors, and the Tracker Display are tools that assist in avoiding terrain masking and reacquiring the target once no longer masked. Proper aircraft placement is the only way to effectively mitigate terrain masking.

9.5.3.3.1.1.3 Glare/Blooming. The target and/or surrounding environment can reflect energy directly into the TGP causing glare (DTV) or blooming (IR). While this can be mitigated by aircraft positioning, certain situations (e.g., airspace limitations, terrain features, target maneuvering) may lead to this undesirable look-angle. Glare/blooming has the potential to cause momentary loss of SA and subsequent loss of target custody. If preventative aircraft positioning is not possible with glare/blooming concerns, auto iris should be used during moving target tracks and the bearing in the TGP along which glare/blooming occurs should be noted for anticipation of subsequent events.

9.5.3.4 Automatic Video Track (AVT). Operational experience has demonstrated a significant increase in success when using an AVT over manual track for MTE. MTD/Assisted Track enabled with a feature track is the primary method with which SOs should establish a track on a moving target. The order of AVT preference is offset feature track primary, offset point track secondary, and manual track tertiary. When using a point track, crews need to assess track survivability after the track is established. Point tracks are more susceptible to breaking because of scene change with the highest point of contrast. Point tracks break due to vehicle aspect change, direction change of the target, or aircraft maneuvering. Do not use area tracks for moving targets. Additionally, area tracks do not work with Assist Track. Be aware of the tendency of the feature track to track the edge of the road when the track gates are too large or when the vehicle changes aspect, which could result in the track switching or breaking and the loss of the target. In specific circumstances, such as targets with significant contrast (e.g., DTV with light vehicle on a paved road or a dark vehicle on a dirt road) and in rural areas, a point track may be a more viable option than a feature track. If using a point track, be proactive in analyzing for possible axis changes that may cause the track to break through loss of contrast.

9.5.3.5 Moving Target Detection (MTD). MTD uses the details of the environment to establish a stationary base. The more detail in the FOV, the better MTD will be able to distinguish moving and stationary objects. Enable this feature for all moving target engagements, unless the system is providing poor or inconsistent reports. When MTD is enabled, the system uses an open loop tracking and automated detection of up to 12 moving targets within the center 640 x 480 pixels of the FOV. The tracker processes and analyzes the image scene, using a process known as change detection. The sensor should strive to optimize the image, with the focus being on the target, along with attempting to match direction/velocity of the target. While both Feature and Point track will work, MTD was designed to work with feature tracks. If MTD is not working or inconsistent, attempt to optimize the picture/zoom level to the target to see if this provides, or improves reports. If this does not work, toggle MTD off and then on. If neither of these items corrected the problem, consider turning off MTD for the engagement and use an AVT.

9.5.3.6 Assist Track. With Assist Track on objects that are moving greater than 5 mph, and have been determined by the tracker to be moving, will give a visual cue on the TGP, known as reports. When dropping an AVT, the system builds a track around the nearest report to the crosshair and then drags the crosshair to the center of the track gate. If there is only one report on the screen, the SO can command a track with the crosshairs well off the moving target and Assist Track will slew the TGP and drop the commanded track on the desired target. Command a track as close to the desired moving target as possible, as Assist Track will disable control stick inputs while it is active. When a track is dropped with/without MTD, rate gain is automatically lowered to between four and six (45 pixels/seconds) despite the SO's setting. With MTD and Assist Track on, SOs must still strive to match a moving target's course and speed to drop tracks. Tracking moving vehicles is a perishable skill that SOs must practice to remain proficient.

9.5.3.7 Track Suspend Disable. Disabling track suspend allows the SO to build and maintain the track prior to Rifle. The benefit is that the SO can take more time establishing a reliable feature track on the moving vehicle, and is no longer constrained by TOF of the missile. If the target vehicle makes any unanticipated turns or sudden accelerations/decelerations, the track is already established and has a greater probability to hold. Pre-Rifle tracks with track suspend disabled mitigate sensor induced oscillations and mitigate satellite delay limitations. If equipped with OFP 2403 or greater, SOs have the ability to turn track suspend off. Accomplish this step during the FENCE. The major consideration with growing an AVT pre-Rifle and turning off track suspend is that the track may enter coast mode from a missile IR plume. In order to minimize the plume, the line of sight of the TGP must be pointed away from the selected weapon. Shots taken greater than or equal to 45 degrees off-azimuth, opposite wing, have historically not entered coast mode. The track could still break for other reasons, scene change, vehicle aspect change with a poorly built track, and/or target masking; however, if a pre-Rifle track does not enter coast mode the engagement has a much higher probability of success. Shots taken with 45 degrees azimuth off the nose have historically shown a greater chance of entering coast mode due to missile plume, but has a high probability of reacquiring assuming the target continues at the same rate and direction. The missile plume will only wash out the screen for 1 to 2 seconds if unable to mitigate the plume.

9.5.3.7.1 Coast Mode. If the target changes direction while in coast mode, there is an increased probability that the track will not reestablish after Rifle. Reliable feature tracks on dynamic targets require the track to be established completely on the target in order to give the track logic the best chance of reacquiring should the track enter coast mode. If the vehicle changes aspect during coast mode, it is impossible for the feature track logic to reacquire the targets since the "mapped scene" is no longer available. In self-lase engagements, pilots should hold fire until the vehicle completes any immediate/abrupt turns or aspect changes.

9.5.3.8 Retrack. Retrack makes it easier to regrow a track on a moving target using MTD or manually. When the trigger is pulled while tracking a target, the TGP LOS pointing maintains the tracked targets velocity but grows a new acquire gate. Use retrack to establish a new track during an MTE situation in order to increase track stability without losing the tracked target. It is important to remember that aircraft maneuvers will affect the sensor pointing vector. In **Figure 9.2**, Bad Feature Track, the Feature Track is partially on the vehicle and the road. Instead of the SO breaking track, having to reacquire the vehicle, and establish a new track the SO should center the crosshairs on the cab of the vehicle and pull the trigger. Once the MTD reports are populated around the vehicle or the crosshairs are centered the SO can release the trigger establishing a new track. See **Figure 9.3**, Good Feature Track.

Figure 9.2 Bad Feature Track.

Figure 9.3 Good Feature Track.

9.5.3.9 Iris Settings. In all auto track modes, focus and iris settings affect the quality of the track and the system's ability to maintain it. When time and conditions permit, typically during the vehicle follow or the engagement Hold, the SO should manually adjust the picture to increase AVT stability; optimization which should take no longer than 15 to 20 seconds. If the tactical situation, target scene, and/or environmental preclude effective manual adjustments, the SO should use auto iris local area processing (LAP) mode. Employing in LAP can greatly reduce the risk of significant IR returns washing out of the HUD in the event that the target moves past a hot object or if sun glare is a factor. However, there are circumstances when manual iris may be required to accentuate contrast for track survivability. When using manual iris, SOs should be ready to switch to LAP if the changing conditions of the picture dictate.

9.5.3.10 Rate Gain. Optimal rate gain settings will vary from situation to situation, but a baseline of 42 should be used as a starting point. The desired rate gain of 42 is assessed based on a worst-case scenario with the aircraft and the target tracking directly towards one another with the vehicle traveling at 80 mph and the TGP approaching nadir. This worst-case assumption is not the norm. If determined that a rate gain of 42 is not required, ensure that the vehicle's speed would not enable it to outrun the TGP's slew rate at the selected rate gain.

9.5.3.11 Camera. Time of day, atmospherics, and target will determine camera selection. Consider previous discussions on FVW, track selection, and rate gain settings when choosing the appropriate camera. In certain situations, DTV may provide the best opportunity for a successful MTE. However, IR is the recommended camera for most MTEs.

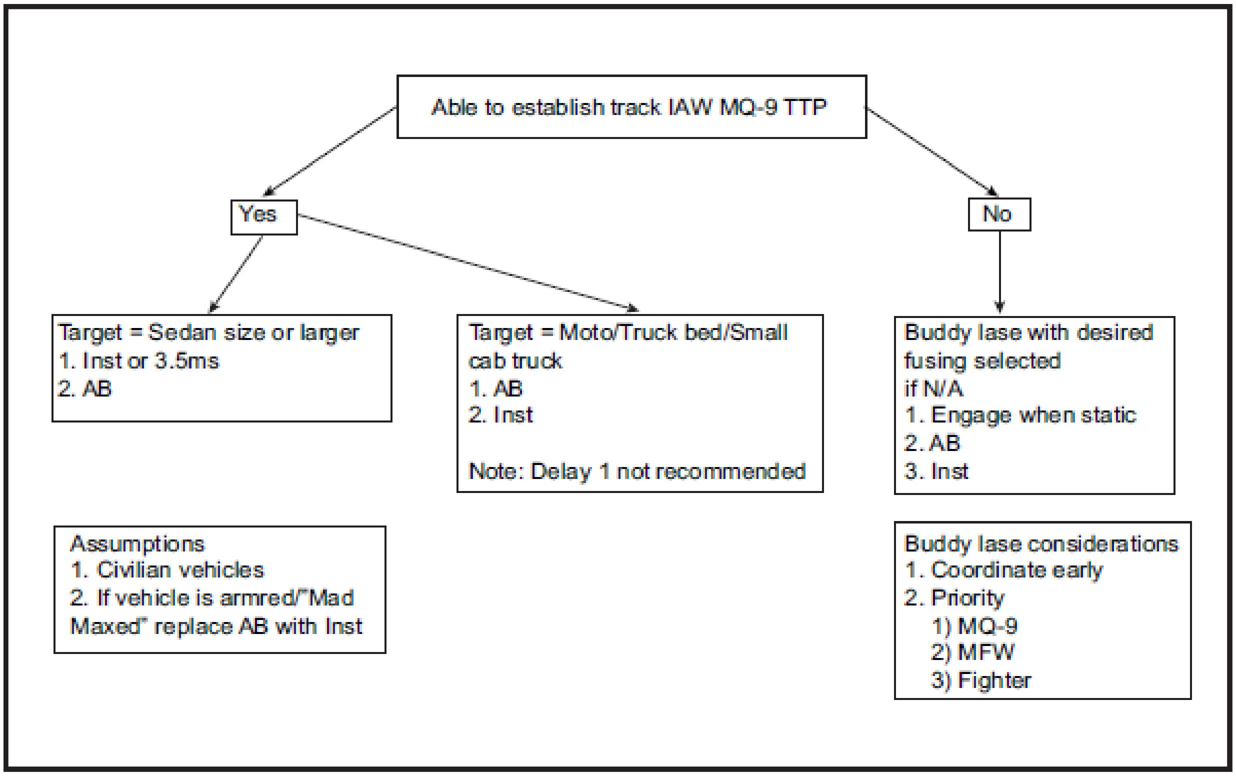
9.6 Single-Ship MTE. The shooter needs to ensure that positioning supports weaponeering for release at Rifle and throughout TOF to Splash. Track establishment, crosshair placement, and aircraft positioning to provide a tight laser spot are the most important keys to success. For overall success, it is not sufficient to ensure P_H; rather, the crew needs to maximize overall lethality. There are a number of different types of MTE engagements. It is critical to train to single-ship MTE whenever possible, ideally with a variety of target types and environments. The following section will focus on the execution portion of MTE attacks, walking through the basic attack flow.

9.6.1 Intent. This phase of the attack has three parts: determine intent, weaponeering, and developing the hold plan.

9.6.1.1 Determine Intent. Normally the intent is to maximize effects on vehicle occupants. In contingency situations, the intent might be to achieve a mobility kill (e.g., a VBIED traveling in the direction of friendlies).

9.6.1.2 Weaponeering. The weaponeering solution consists of TVB analysis, LOAL profile selection, hellfire fuzing, attack geometry and TGP considerations. As single-ship engagements generally have a lower P_H, use the fuze with a higher near-miss lethality IAW **Figure 9.4**, MQ-9 MTE Fusing Chart. Refer to weaponeering considerations outlined in the beginning of the chapter, along with AFTTP 3-1.MQ-9, Chapter 3, "Mission Planning Considerations," for more details. Use desired single-ship MTE weaponeering parameters found in **Table 9.1**, Single-Ship MTE Pre-Rifle Track Employment Parameters.

Figure 9.4 MQ-9 MTE Fusing Chart.



9.6.1.3 Hold Plan. The type of hold selected depends on the desired effects (intent) and any restrictions (environment).

9.6.1.3.1 Wheel Hold. Wheel hold is the default starting selection for any MTE engagement. Initial hold position should be R_{DL} + 1 km + turn radius. The pilot is striving for an initial starting point of 7 to 9 km, adjusting for R_{DL}, winds, time on final, and vehicle target velocity.

- Positioned to immediately turn to final when triggers are met.
- Minimal variation in range, limiting need for MTS adjustment.
- Easiest way to maintain azimuth opposite of selected missile.

9.6.1.3.1.1 From this hold position, the crew needs to determine whether the Wheel hold will work for all aspects. The following are some considerations for when the crew needs to transition from the Wheel to a sectored hold. Factors preventing a Wheel hold include the following.

- Attack run-in restrictions (airspace, other aircraft deconfliction, or threats).
- Target speed/TVB requiring a rear aspect engagement.
- Target masking (i.e., urban, mountainous, forested).

9.6.1.3.2 Sector Hold. If the aircrew determines a sectored hold is required, the order of preference for aircraft position is Tail aspect, Abeam, and Nose aspect.

Table 9.1 Single-Ship MTE Pre-Rifle Track Employment Parameters.

Parameter		Explanation
VIA	70 degrees minimum	Rifle with a minimum of 70 degrees VIA. This number is the maximum release for the engagement.
AZ	45 degrees	The end game of the maneuver is to have the aircraft rear aspect and 45 degrees off AZ of the target vehicle at Rifle.
TOF	NA	TOF is not a driving factor due to VIA requirements and overall positioning. In most cases, TOF will be around 20 to 25 seconds. Although a lower TOF typically adds risk to MTE, using a pre-Rifle track with the missile selected from the opposite wing significantly reduces the chance of missile plume causing coast mode, mitigating the risk of the track breaking.
LOAL Mode	LOAL-H	Unless TVB is the default, LOAL-H is the default. At most HATs, LOAL-H is sufficient with optimized geometry for a rear-aspect approach even with the AZ up to 50 degrees off. Additionally, LOAL-H reduces missile plume effect on pre-Rifle tracks vice LOAL-D. **NOTE:** Missile tip over is often a result of shooting minimum WEZ. However, shooting rear aspect with a target vehicle moving away from the HF will force the missile to ProNav in the same direction as the vehicle. Thus, any missile tip over caused by a minimum WEZ shots should be mitigated.

9.6.2 Holding. After determining the hold plan in the intent phase, position the aircraft while working through track optimization and the pre-attack checks.

9.6.2.1 Track optimization. Pre-Rifle track is the desired track TTP. If environmental factors or engagement restrictions preclude the use of pre-Rifle tracks, use a post-Rifle track. Understanding the suitability and sustainability of a track on a moving target is one of the most important aspects to a successful MTE. Appropriate attack pacing ensures the SO has the analysis of a track's health prior to the release of a weapon, and should be prioritized even in the fastest employment scenarios.

9.6.2.1.1 Pre-Rifle Track. Use a pre-Rifle track for all single-ship MTEs when azimuth is 45 degrees or greater off the opposite side of the aircraft. Expect the pre-Rifle track to hold with minimal chance of coast mode due to the missile plume. If azimuth will be 30 degrees or less, it is crucial that the SO make a determination of whether or not the pre-Rifle track will be a viable option. To assess this, the SO should consider the path of the vehicle, MTS behavior during coast mode, and atmospheric effects on track survivability. If the vehicle is on a long straight roadway and is likely that it will continue based on past behavior, the SO may elect to accept the limitations associated with track suspend and coast mode. In the event the SO determines there is a risk that the track will be unable to reacquire, the post-Rifle track should be considered.

9.6.2.1.2 Post-Rifle Track. If using post-Rifle track plan, practice establishing tracks on the target. In a post-Rifle track situation, SO must be able to establish a feature track within 2 to 3 attempts assuming a 30-second TOF. See **Table 9.2**, Single-Ship Post-Rifle Track Employment Parameters.

Table 9.2 Single-Ship Post-Rifle Track Employment Parameters.

Parameter		Explanation
TOF	30 seconds	A minimum of 30 seconds is desired to allow the sensor operator at least two attempts to build an AVT.
AZ	0 to 30 degrees	Releasing within 30 degrees AZ provides predictable missile heading for crosshair placement and predictable TVB considerations.
VIA	Approximately 70 degrees	Weaponeer to achieve the highest possible VIA while ensuring a minimum TOF of 30. Maintaining an AZ within 30 degrees will maximize VIA.
LOAL Mode	LOAL-H	Unless TVB is the default, LOAL-H is the default. At most HATs, LOAL-H is sufficient with optimized geometry for a rear-aspect approach even with the AZ up to 30 degrees off. Additionally, LOAL-H reduces missile plume effect on pre-Rifle tracks vice LOAL-D.

9.6.2.2 Pre-Attack Checks.

9.6.2.2.1 SLAPUM. Pre-Rifle track SMS manipulation should adjust fusing/LOAL mode and select the desired AGM-114 opposite the line of sight of the TGP. If weapons loadout allows, consider setting up another AGM-114 with the same fusing/LOAL mode on the opposite side for easy "SMS manipulation" when using a sectored hold. During the Payload step, disable track suspend (if not accomplished at FENCE), optimize picture, and execute track plan.

9.6.2.2.2 WTARSEC. The crew should specify type of employment TTP they are using. For sedan and SUV sized thin-skinned vehicles, aim for the center of the cab regardless of personnel location. Shifting the aimpoint to a certain part of the cab (i.e., front left or back right) increases the chance of the missile not hitting the vehicle and decreases overall lethality.

9.6.3 Execution. For single-ship MTE, the trigger to leave the hold is with pre-attack checks complete and when the crew is confident that the track plan will be successful through repeated demonstration. At a minimum, the crew should be confident in getting an AVT to hold in a 15 to 20 second window. For turns from a sectored hold, verify missile is on side opposite planned TGP AZ. If unable due to loadout availability, plan to overturn to final AZ.

9.6.3.1 Turn to Final. Turn using minimum 30 degrees AOB, position the aircraft on desired azimuth, and ensure the laser is on with good returns. When using AZ at the top of the HUD, initiate rollout approximately 15 degrees prior to desired final azimuth. If using predicted AZ on BSL, begin rollout when BSL reads desired AZ.

9.6.3.2 Final. During the STAT check for MTE, analyze track stability with respect to the changing target environment.

9.6.3.2.1 Steering. Cross-check azimuth, ensure the azimuth matches the employment parameters for the briefed TTP (pre-Rifle: 45 AZ, post-Rifle 0-30 AZ).

9.6.3.2.2 Tracks. Analyze target and track for the following considerations.

9.6.3.2.2.1 Is the track stable and appropriate type? Delay Rifle until there is a reasonable certainty vehicle will not change aspect or become masked. Reasons to delay Rifle—vehicle approaching a turn, bend in the road, and slowing before reaching an intersection.

9.6.3.2.2.2 If the pre-Rifle track breaks at any point prior to Rifle, the SO must inform the pilot immediately. Exercise tactical patience and wait to shoot until the SO can reestablish a reliable feature track. If weapon effects are required immediately, switch to a post-Rifle track plan as a contingency.

9.6.3.3 Rifle to Splash.

9.6.3.3.1 Pre-Rifle Track.

9.6.3.3.1.1 Ensure a stable platform prior to 10 seconds TOF to enable fine crosshair stabilization on target. If required for maintaining PID, use up to 10 degrees of bank into the target to increase closure. ***Note:*** Stable does not necessarily mean level. Stable means not changing bank or applying rudder.

9.6.3.3.1.2 If the track enters Coast mode, the SO needs to immediately assess the situation for track survivability by ensuring the track gates do not have a vector away from the target. If the track gates are still coasting over the target and the target does not change aspect (due to vehicle or aircraft maneuvering), the sensor operator should wait for the track to reacquire. If the track gates are moving away from the target, break track or retrack. The track typically reacquires within 1 to 4 seconds after Rifle.

9.6.3.3.2 Post-Rifle Track.

9.6.3.3.2.1 For a planned post-Rifle track, have the course and speed matched striving for the crosshairs to be on top of the target. While MTD has proven highly effective, strive to be as close to the target as possible.

9.6.3.3.2.2 If the post-Rifle track does not survive or is terminated by the SO in Coast mode, the SO must quickly match course and speed and strive to get the crosshairs as close to the vehicle as possible prior to dropping a new track.

9.6.3.3.3 Contingencies.

9.6.3.3.3.1 Tracking Moving Targets with Assist Track Off. In situations where the assist track is not operating properly, the SO must be prepared to manually track and drop an AVT. In this situation slew control is paramount. In order to effectively place and drop the track gate, SOs must match the course and speed and set a FVW that accounts for target size. The target should be small enough to fit inside the track gate, but distinct enough to clearly stand out from the background. SOs should also consider using manual iris to effectively emphasize the target. Special consideration should be given to retrack techniques and reacquiring the target after entering coast mode. See **paragraph 9.5.3.8**, Retrack, and **paragraph 9.5.3.7.1**, Coast Mode.

9.6.3.3.3.2 Manual Track. Manual track should be used only as a last resort when track did not survive and unable to establish a post-Rifle track prior to 10 seconds TOF remaining.

9.6.4 Egress. Post Splash, maneuver in shortest direction for a reattack in the event of Squirters.

9.7 Self-Lase Urban MTE. MTE tactics on vehicles and motorcycles in high urban environments (defined for the purposes of this section as cities with three-story or higher buildings) create a particularly difficult situation for MQ-9 crews. This situation is further intensified if a buddy lase is unavailable. Transitioning the MQ-9 from a high depression angle vehicle follow to a position for an effective self-lase attack has proven to be quite problematic to execute. Positioning for the strike often results in the loss target custody, the aircraft not being in an ideal position to provide the desired weapons effects, or abrupt aircraft maneuvering post Rifle contributing failed engagements. Finally, this advanced tactic requiring significant practice.

9.7.1 Background.

9.7.1.1 Single-ship MTE TTP as described in the previous section was designed for moving target engagements in open/rural terrain. As vehicles move into a city with buildings three stories or higher, MQ-9 crews are forced to maintain follows in a Wheel hold at a high depression angle of 60 to 80 degrees.

9.7.1.2 This section presents TTP for self-lasing HFs on vehicles and motorcycles in a high urban environment. This TTP satisfies the need to execute a strike when a buddy lase is unavailable, as well as to comply with desired weaponeering requirements and will be referred to as the Urban MTE.

9.7.1.3 The Mission Planning Program (MPP) or Planning can be used to correlate ground ranges to depression angles. Aircraft holding ranges should be calculated and noted for execution. Additionally, the required depression angle can be calculated based on the vertical developments in the target environment.

9.7.1.4 Assumptions.

9.7.1.4.1 Unavailability of a buddy laser.

9.7.1.4.2 Sufficient airspeed to maintain a high depression follow and 30 degrees angle of bank (AOB).

9.7.1.4.3 HAT has a significant impact on the ability to execute strikes against moving targets in urban environments. As seen in RMIT Modeling Tables, the validity of strikes lessens dramatically below a 15,000 foot HAT due to a decreased WEZ. As HATs approach 10,000 feet, the ability to maintain a high depression follow and transition to a strike are significantly limited using the tactics described in this chapter.

9.7.2 Intent. This phase of the attack has three parts: determine intent, weaponeering, and developing the hold plan.

9.7.2.1 Determine Intent. Maximize effects on the target vehicle while mitigating collateral concern and maintaining PID in a built up environment.

9.7.2.2 Weaponeering. Understanding and preplanning HF maximum and minimum ranges is essential to successfully executing an urban MTE. Refer to RMIT to calculate shot ranges for 45 degrees AZ off with max range ensuring greater than or equal to 70 degrees for AGM-114 VIA for clearing buildings. Expect typical Rifle ranges as close as 2 to 3 km due to positioning requirements for highly developed Urban areas. See **Table 9.1**, Single-Ship Pre-Rifle Employment Parameters.

9.7.2.2.1 R_{DL} is dependent on aircraft HAT, height of vertical developments, the distance between buildings (alleyway versus LOC) and whether or not the vehicle is traveling along a main LOC or zig-zagging between side streets.

9.7.2.2.1.1 Each factor drives the crew to flying the aircraft closer or farther away from the target vehicle. Minimum R_{DL} will typically be from a position starting at 60 degrees depression angle (DA) from 45 degrees AZ with a minimum VIA of 70 degrees.

9.7.2.2.1.2 Modeling in RMIT, and displayed in **Table 9.3**, Pre-Rifle Track RMIT Modeling, shows the relationship between HAT, ground range, DA, TOF, and VIA. Remember, RMIT modeling is based on a static target. DA at Splash and VIA will change. The numbers in RMIT Modeling Tables should only be used to correlate the relationship between HAT, DAs, AOB, and the change in TOF and VIA.

9.7.3 Holding.

9.7.3.1 In order to maintain PID of a moving vehicle in a high urban environment, MQ-9 crews need to maintain close proximity to the target with a DA ranging from 60 to 80 degrees. As the buildings approach greater than four stories and streets narrow, a DA closer to 75 to 80 degrees is required to minimize ground range and maintain target custody.

9.7.3.2 Maintaining such a hold requires the pilot to cross-check azimuth (AZ), DA, roll angle on VIT 99, and field of view inclination (FOV INCL). As the need to minimize ground range increases, transition cross-check to maintaining an AZ between 80 and 100, banking into the target for winds, and a FOV INCL consistent with maintaining the required DA.

NOTE: FOV INCL correlates to the aircraft's depression angle with respect to being wings level (i.e., if the target is on the left side of the aircraft at -90 AZ, the pilot has turned away from the target with 15 degrees of bank, and the DA is displaying -75, then the FOV INCL will show 60 [75 degree depression angle minus the 15 degrees of bank away from the target]). Conversely, if the pilot was banking into the target with -15 AOB, the DA displayed -50, then the FOV INCL would show 65 (50 degrees depression angle plus the 15 degrees of bank into the target). As you fly closer to the target, the depression angle will increase and decrease in correlation to the AOB. The FOV INCL, however, will remain consistent in regards to the wing's level DA and ground range of the aircraft to the target. FOV INCL is currently found on VIT XX in 240x software.

Table 9.3 Pre-Rifle Track RMIT Modeling.

HAT (k, ft)	Gnd Rng (km)	FOV INCL	DA (Rifle)	DA (Splash)	AZ	AOB	TOF (sec)	VIA
10	1.76	60	Invalid		45	0	Invalid	
	1.43	65						
	1.11	70						
	0.81	75						
15	2.65	60	60	68	45	0	20	65
	2.13	65	65	72			22	60
	1.67	70	70	74			24	54
	1.22	75	Invalid	Invalid			Invalid	Invalid
20	3.52	60	60	68	45	0	25	74
	2.83	65	65	72			25	71
	2.22	70	70	75			25	65
	1.63	75	75	76			26	58
25	4.41	60	60	68	45	0	30	81
	3.56	65	65	72			29	76
	2.78	70	70	75			29	73
	2.04	75	75	76			30	67

9.7.3.2.1 Flying a high depression wheel around a moving target requires the pilot to keep the target on the aircraft's 3/9 line. Should the target be on the right wing of the aircraft (clockwise wheel follow), then the pilot wants to keep the target approximately 90 degrees off AZ. In accordance with the cross-check discussed in the previous paragraph, reduce the bank angle/fly wings level as the AZ approaches 80. The bank angle/flying wings level should be maintained allowing the AZ to increase to 100. At 100 AZ, the pilot banks into the target vehicle, watch the AZ pass 90, and then reduce the roll/roll wings level to intercept 80 AZ. Rudder into the turn should also be used or as required to counter the effects of strong winds. Conversely, should the target vehicle be on the left wing of the aircraft (counter-clockwise wheel follow), the pilot wants to perform similar actions keeping the target between -80 and -100 AZ.

9.7.3.2.2 AOB required for a high DA follow depends on ground range to the target, aircraft HAT, speed of the target vehicle, and the flight level winds. For vehicle follows at depression angles of 60 to 75 degrees, with winds at 30 knots or less, the AOB required likely remains between 5 and 15 degrees. As the winds increase above 30 knots, the AOB required remains between 20 and 30 degrees. As DA requirements increase towards 75 degrees, the pilot may never fully roll wings level and have to continually adjust bank.

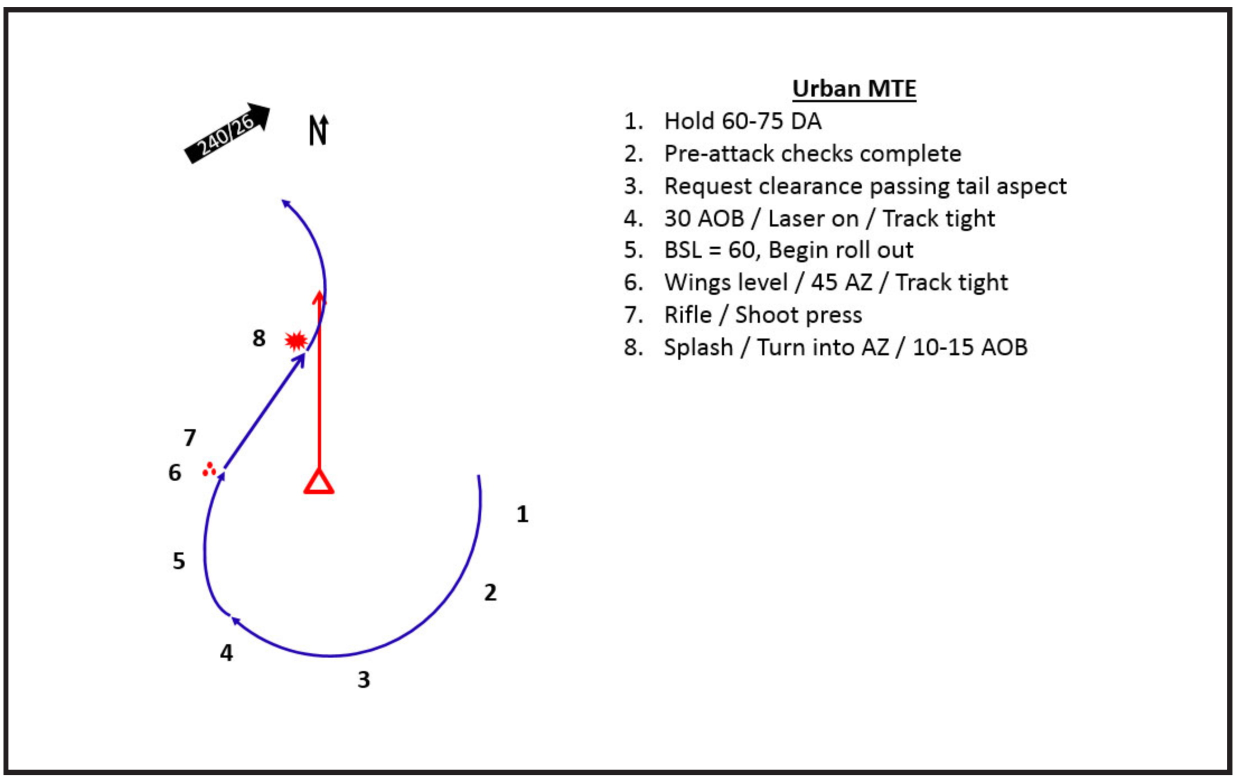
9.7.3.2.3 Nadir can be a concern anytime the depression angle increases past 80 degrees. This hold puts the aircraft in a constant nadir save and avoid situation. Maintaining a high depression hold while executing the cross-check and maneuver enables crews to remain in such a posture.

9.7.3.3 Target vehicle speed affects the pace of the cross-check described above. The slower the vehicle speed, the slower the cross-check and fewer aircraft inputs required. As the vehicle speed increases, the pilots' cross-check and aircraft inputs also increase. Furthermore, the complexity and risk associated with these tactics increase as the vehicle speed increases. Along with the increased cross-check and amount of aircraft inputs, the pace at which the pre-attack checks, turn-in, and execution also increase. The aircrew may need to execute a dry run or be prepared to turn off dry.

9.7.3.4 Pre-attack Checks. Conduct SLAPUM WTARSEC IAW single-ship MTE inputs to SAT in Chapter 7, "Single-Ship Surface Attack Tactics." Use pre-Rifle track and select AGM-114 opposite of TGP AZ.

9.7.4 Execution. Same triggers apply from single-ship MTE to Urban MTE. The transition from holding to the desired WEZ is the key. The turn in from holding requires a sequence of events to occur at the correct time. See Figure 9.5, Urban MTE Summary.

Figure 9.5 Urban MTE Summary.



9.7.4.1 Turn-In. The Turn-In phase begins when the aircraft is parallel to the target vehicle, but traveling in an opposite direction of the target vehicle. Maintain a hold of 60 to 75 degrees DA. Any outside agency coordination must be complete by this point.

9.7.4.1.1 Operating environment dependent, as the aircraft passes through the target vehicle's 6/12 line, the pilot makes request for clearance. If the flight lead/PIC is the clearance authority, turn in passing perpendicular to the target's 6/12 line.

9.7.4.1.2 After passing the 6/12 line, make a 30-degree AOB turn towards the target. Turn the laser on, ensure good returns, assess track stability, and ensure the crosshairs are on the desired aimpoint. Consider resetting if track breaks prior to Rifle.

9.7.4.1.3 During the turn, the pilot's cross-check bounces between the bomb steering line (BSL) and the WEZ. Once the predictive AZ on the TSL displays 60, initiate a rollout to intercept a wing's level AZ of 45.

9.7.4.2 Final. At completion of the Turn-In, the aircraft should be wing's level, 45 degrees off AZ, and rear aspect of the target vehicle with a tight track established.

9.7.4.2.1 STAT check remains the same from single-ship MTE; however, the time available will be minimal. Track assessment in particular needs to be done throughout the turn as there is minimal time in an Urban MTE.

9.7.4.2.2 As soon as the aircraft is wing's level, in desired WEZ, with AVT established, do not delay Rifle.

9.7.4.2.3 Consider Rifle in the bank if the maneuver was prebriefed, confident the track will hold, able to adequately keep RMIT and aircraft positioning in cross-check. Otherwise, the crew should wait to roll wing's level prior to rifling.

9.7.4.2.3.1 Shooting in the bank is limited by the aircraft's HAT (not necessarily range or amount of bank). As the HAT increases, so does the range and validity of strikes. **Table 9.4**, 10 Degrees AOB; **Table 9.5**, 20 Degrees AOB; and **Table 9.6**, 30 Degrees AOB, reflect various AOB along with the DA at both Rifle and Splash.

9.7.4.3 Release to Splash. If wings level at release, follow single-ship MTE instructions. If shooting in the bank, there is additional risk with AVTs and reaching nadir conditions near Splash time. Should the SO track transition to coast mode, then the SO needs to be diligent in assessing the probability of the track re-acquiring due to the rotational nature of the picture.

9.7.4.4 Egress.

9.7.4.4.1 Following Splash, the pilot immediately cross-checks the AZ and turns into the target using 10 to 15 degrees AOB executing a nadir save as required.

Table 9.4 10 Degrees AOB.

HAT (k, ft)	Gnd Rng (km)	FOV INCL	DA (Rifle)	DA (Splash)	AZ	AOB	TOF (sec)	VIA
10	1.76	60	Invalid		45	10	Invalid	
	1.43	65						
	1.11	70						
	0.81	75						
15	2.65	60	54	68	45	10	19	74
	2.13	65	60	74			21	70
	1.67	70	Invalid				Invalid	
	1.22	75						
20	3.52	60	54	68	45	10	24	82
	2.83	65	60	73			23	79
	2.22	70	65	77			24	73
	1.63	75	70	78			29	81
25	4.41	60	54	70	45	10	29	81
	3.56	65	59	74			28	81
	2.78	70	65	77			28	81
	2.04	75	70	78			28	73

Table 9.5 20 Degrees AOB.

HAT (k, ft)	Gnd Rng (km)	FOV INCL	DA (Rifle)	DA (Splash)	AZ	AOB	TOF (sec)	VIA
10	1.76	60	Invalid	Invalid	45	20	Invalid	Invalid
	1.43	65	Invalid	Invalid			Invalid	Invalid
	1.11	70	Invalid	Invalid			Invalid	Invalid
	0.81	75	Invalid	Invalid			Invalid	Invalid
15	2.65	60	50	74	45	20	18	82
	2.13	65	56	79			20	75
	1.67	70	Invalid	Invalid			Invalid	Invalid
	1.22	75	Invalid	Invalid			Invalid	Invalid
20	3.52	60	50	78	45	20	23	83
	2.83	65	56	80			23	86
	2.22	70	62	78			23	76
	1.63	75	72	69			24	61
25	4.41	60	50	81	45	20	28	80
	3.56	65	56	81			28	85
	2.78	70	62	78			27	85
	2.04	75	71	69			28	71

Table 9.6 30 Degrees AOB.

HAT (k, ft)	Gnd Rng (km)	FOV INCL	DA (Rifle)	DA (Splash)	AZ	AOB	TOF (sec)	VIA
10	1.76	60	Invalid		45	30	Invalid	
	1.43	65						
	1.11	70						
	0.81	75						
15	2.65	60	48	80	45	30	20	65
	2.13	65	Invalid				Invalid	
	1.67	70						
	1.22	75						
20	3.52	60	48	77	45	30	23	81
	2.83	65	56	68			23	84
	2.22	70	56	65			23	75
	1.63	75	58	59			24	63
25	4.41	60	47	72	45	30	28	79
	3.56	65	55	64			28	84
	2.78	70	56	63			28	84
	2.04	75	58	58			28	73

9.7.5 Urban MTE Contextual Example.

9.7.5.1 Reaper 42 is on target at FL210 with a HAT of 20,200 feet. Winds are 240 at 26 knots.

9.7.5.2 During the FENCE-IN, the pilot calculated an R_{DL} for vehicles in the high urban environment and a Min range.

9.7.5.3 Reaper 42 is tasked to execute a search for vehicles in the center of the city where insurgents have been known to operate. Shortly after posturing the aircraft over the target area, the SO discovers a sedan matching the description of a vehicle born improvised explosive device (VBIED). With urgency the controlling JTAC passes a game plan and 9-Line to the crew. The crew requests another asset in the area buddy lases, but the JTAC advises all assets are currently tasked and unavailable for reroll. Most importantly, VBIEDs have been known to drive directly towards friendly forces once exposed. The JTAC emphasized the urgency of the situation and needs Reaper 42 to strike, as soon as possible.

9.7.5.4 Understanding the urgency, the crew quickly completes pre-attack checks. As checks are being completed, the pilot positions the aircraft in a high depression Wheel hold in order to maintain PID of the VBIED as it begins to move through the city. The vehicle is currently on the aircraft's right wing, 90 AZ and a DA of 60 degrees, as the pilot maintains a clockwise Wheel. Meanwhile, the SO has begun optimizing the camera, FOV, and track.

9.7.5.5 As the aircraft begins to pass the tail aspect of the VBIED, the crew completes the pre-attack checks and calls "In" for clearance. The JTAC responds with the appropriate clearance triggering the pilot to initiate a right turn towards the target using 30-degree AOB. The SO fires the laser, builds a FTRK, and calls lasing with the displayed PRF.

9.7.5.6 Once 60 is displayed on the BSL, the pilot references VIT 2 and reduces AOB to 15 eventually rolling out to intercept an AZ of 45. As soon as the aircraft is wing's level, the WEZ is cross-checked. Since the Turn-In was initiated into a tailwind, the aircraft is just inside the planned R_{DL}. However, the pilot recognizes the aircraft is still within the Min WEZ and launches a HF off the left wing. "RIFLE, 22 SECONDS" is relayed by the pilot to the JTAC as a shoot-press is executed.

9.7.5.7 During the TOF, the SO inputs minor adjustments to the crosshair placement on the cab of the VBIED. Meanwhile, the pilot has shifted the cross-check to TOF remaining and the DA. At Splash, AZ is quickly assessed at -5. The pilot references VIT 2 as -10 degrees AOB is applied. 10 to 15 degrees of bank is held until the AZ passes -110, after which the pilot reduces the bank and begins evaluating the aircraft position to in order to maintain Tally and assess BDA. Secondary explosions were noted, the VBIED did not make it within an effective range of friendly forces, and the ground commander's intent was assessed as successful.

9.8 Formation MTE Tactics. MTE formation tactics are broken into two categories, preplanned and ad hoc. The main difference between MTE formation tactics and single-ship MTE tactics is in dividing the position requirements for weaponeering and terminal guidance. Historically, the MQ-9 answer was to always use a buddy lase for any MTE. While this has since changed, formation MTE tactics are still primary when asset availability and coordination time is available. Formation MTE can vary from simply basic ATO-assigned two-ship conducting MTE to preplanned engagements as complex as three/four aircraft with a predefined engagement area and rehearsals. The main difference between preplanned and ad hoc is the level of coordination between the assets. Specifically, ad hoc formations involve less formal coordination and depend upon asset availability. There are three distinct roles; shooter, buddy and collateral. This chapter will only cover shooter and buddy roles. See **Chapter 2**, "MQ-9 Weaponeering," on collateral considerations in AFTTP 3-1.MQ-9.

9.8.1 Intent. Ensuring a shared mental model between formation assets is critical for this phase. For preplanned formations, accomplish this in the brief. For ad hoc formations, it will require some time for coordination.

9.8.1.1 Weaponeering. Unless weaponeering requires, recommend employing 1x AGM-114 for WRM considerations. See AFTTP 3-1.MQ-9 for more information. When employing 2x AGM-114, the shooter has the option to either shoot from both wings (at 0.32 second spacing) or employ from the same wing (at 0.64 second spacing). Shooting from the same wing, even with two missiles, significantly reduces the chance of a pre-Rifle track going into Coast mode when employed outside 30 degrees AZ opposite TGP look.

9.8.1.1.1 Shooter. Use LOAL-H and release to ensure a minimum of 70 degrees IA with TVB requirements satisfied. The 30-second TOF requirement from single-ship MTE is not applicable with a dedicated buddy laser.

9.8.1.2 Hold Plan.

9.8.1.2.1 Stack Deconfliction Considerations. With the shooter stacked low, the buddy laser has freedom to maneuver. With the shooter stacked above, lead aircraft needs to ensure lateral deconfliction at Rifle.

9.8.1.2.2 Shooter. Use either a Wheel hold or Sectored hold based upon tactical environment. For shooter stacked low, recommend Wheel if weaponeering considerations can be met from any aspect. For shooter staked high, consider striving for rear aspect from a Sectored hold. This gives the buddy laser predictability in knowing shooter position (if buddy laser stacked low) and will normally ensure TVB is satisfied.

9.8.1.3 Buddy. Manage aircraft positioning for a minimum of 45 degrees DA. Normally, position for 60 degrees DA. The buddy laser is trying to minimize spot size and achieve a high vertical look down while ensuring precise aircraft placement on the intended DPI. As a technique, pilots should predetermine 60 to 75 degrees DA ranges for HAT and mark this on the HUD with a dry erase marker. In urban environments, manage aircraft positioning to achieve a DA of approximately 80 degrees DA.

9.8.1.4 Communication. Options in priority order—Clearcomm, Strike Bridge (VOSIP), and ARC-210/WAVE.

9.8.1.4.1 Preplanned Formation. Use the FROTIES format per the flight brief. See **Chapter 8**, “MQ-9 Multiship/Formation,” for FROTIES examples.

9.8.1.4.2 Ad Hoc Formation. Despite a lack of prior coordination, condense the FROTIES brief down for an ad hoc shooter/buddy MTE scenario by first communicating roles and ordnance then address positioning/deconfliction. Normally the lead aircraft would be responsible for setting deconfliction. Either designate a lead aircraft for the engagement duration or be clear in setting expectations for deconfliction. If there is confusion amongst the aircraft due to unfamiliarity with FROTIES expectations, do not hesitate to use “plain English.”

9.8.1.4.2.1 Regardless of preplanned or ad hoc, address sorting contacts for post Splash contingency with Squirters.

9.8.2 Hold. Establish hold in this chapter. Execute pre-attack checks per SAT in **Chapter 7**, “Single-Ship Surface Attack Tactics.” Call “TARGET READY” per **Chapter 8**, “MQ-9 Multiship/Formation.” Formation contracts or based upon briefed contracts from the previous phase. Unless the shooter is DEADEYE, plan to establish an AVT per single-ship MTE section as a contingency.

9.8.3 Execution. Trigger to commence the attack is immediately following the shooter's "TGT RDY" call. If delayed, inform buddy lase asset of ETA.

9.8.4 Egress. Post Splash, maneuver in shortest direction for a reattack in the event of Squirters.

9.8.5 Shooter/Goalie. Shooter/goalie is a formation reserved for niche situations such as a urban MTE scenario. Shooter/buddy or shooter/collateral are normally better uses of two assets than the shooter/goalie formation. However, in a dense urban MTE scenario where there is a high probability of target masking from buildings, a shooter/goalie option is useful with the shooter and goalie offset 90 degrees from each other to cover the target in case of masking with the missile in flight. Because of the positioning required in this environment, shooter/goalie may alternate between a shooter/buddy and vice versa as the aircraft experiences masking. The shooter must ensure a minimum of 70 degrees IA while ideally looking for 80 degrees IA. An 80-degrees IA will be required to clear up to five story buildings in two to three lane streets.

9.8.5.1 Goalie Execution. The goalie option is a contingency requiring MQ-9 crews to execute timely clear, concise, correct communication and actions to have a chance of salvaging an engagement. Since it is a contingency, the flight lead does not have time to address the specifics covered in this section during execution; therefore crews need to familiarize themselves with **Table 9.7**, Goalie Execution Actions, to enable goalie role assignment during the FROTIES brief. The flight lead should assign the goalie role whenever execution involves two or more MQ-9s and collateral roles do not take precedence. For urban environment MTE with two MQ-9, the shooter should plan to have the goalie role in shooter/buddy scenarios. In a prebriefed/coordinated two-ship with both aircraft having uninterrupted feed status and ClearCom with each other, it is an easier task to execute. With a delayed feed status and/or delayed comms, the chance of successful goalie execution decreases. In all cases, goalie execution should be initiated with greater than 5-second TOF remaining. Approaching 5-second TOF, the original designator should complete the engagement themselves. Communication options in priority order are ClearCom, Strike Bridge (VOSIP), ARC-210/WAVE.

9.8.5.2 Shooter Active Goalie. Only use this tactic in preplanned formations with aircrew that have prebriefed together. Additionally, strongly consider only using when the formation is in the same squadron. In a shooter/buddy engagement, with a stable track built on the target vehicle, the shooter should swap the laser code approaching 10-second TOF remaining, to the guidance PRF in order to increase the chance of a successful goalie option execution should the buddy aircraft have any issues. The shooter should call out "ACTIVE (guidance PRF)" over the primary communication channel when this has been accomplished for buddy aircraft SA. The probability of the HF guiding/correlating to a second laser fired on the same PRF at the same DPI after the HF has locked onto the first laser is minuscule. If the shooter is unable to establish a track on the target, they should maintain lasing on the non-guidance PRF. If the buddy experiences a track break or system malfunction (laser, target pod) after hearing the "ACTIVE (guidance PRF)" call from the shooter, they should automatically turn off laser to enable the HF to guide onto the shooter's laser as the active goalie option. In this situation, the buddy should call out "[C/S], BROKEN" so the shooter has situational awareness that terminal guidance has been transferred to laser. The active goalie TTP should be established as a contract in the FROTIES brief via modification to the roles section, for example, "this will be a shooter/buddy with active goalie option." Due to the precise timing and communication language, it should not be assumed to be a default unless precoordinated.

Table 9.7 Goalie Execution Actions.

Criteria	Authority	Communication	Action
Track breaks/Laser malfunction with additional asset available and greater than 5 seconds TOF remaining	Original designator	"GOALIE, GOALIE, GOALIE"	Original designator maintains laser on and keeps fighting to get track built and/or works manual track. Original designator does not cease lasing and/or supporting terminal guidance to target.
Additional asset has track built on target and after hearing GOALIE x3 call, turns on laser and has good indications	Secondary asset	"LASING (GUIDANCE PREF)"	Original designator ceases laser and responds with call sign as acknowledgment that responsibility for terminal guidance has been transferred.

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CHAPTER 10

TACTICAL TOOLS

10.1 Introduction. Tactical data links (TDL) are a combination of radio and landline signals that send tactical information around the battlefield. They are a communication system that supports the exchange of near-real-time tactical data between participants using a variety of free- or fixed-format messages, which are characterized by unique transmission characteristics, protocols, and standardized message structure. Link 16 and situational awareness data link (SADL) are the two primary TDLs the MQ-9 communicates with. Link 16 and SADL provide fighter-to-fighter and command, control, communications and intelligence (C3I) messages to fighter via digital communication. These communications can be used for navigation, identification and targeting between equipped platforms. Data link displays can enhance situational awareness, reduce workload in dense targeting environments, lower reliance on voice communications and increase C3I SA and effectiveness. This chapter will outline baseline TDL architecture and systems integration as it applies to the MQ-9. Refer to HQ ACC/DOYJ, *Understanding Link 16, (UNCLASSIFIED) A Guidebook for USAF Operations*, September 2008, for Link 16 detailed information and its interoperability, and AFTTP 3-3.IPE, Attachment 7, "Tactical Data Link Employment Standards." Tactical integration of TDL into MQ-9 missions is discussed throughout AFTTP 3-1.MQ-9.

10.2 Tactical Data Links Basics. Link 16 is the NATO common term for TADIL-J, which is a common message format defined by MIL-STD-6016F. Link 16 is a time-division, multiple access (TDMA) fixed format message (FFM) network used to transmit tactical information to multiple users. It is a high-capacity, multifunctional, secure and jam-resistant link operated within UHF line-of-sight and capable of relays to allow for over-the-horizon connectivity. SADL is functionally similar and uses the same J-series message set.

10.2.1 Active Participants. Each active Link 16 participant is called a joint tactical information distribution system (JTIDS) unit (JU) and contains a multifunctional distribution information system (MIDS) terminal and is assigned a specific address known as a JU address. Active participants are highly interoperable within the Link 16 network and are information limited by network participation groups (NPG) and MIDS terminal capabilities.

10.2.2 Passive Participants. Passive participants lack Link 16 terminals and receive Link 16 information through a joint range extension (JRE). Passive participants and any object on the Link 16 network (e.g., group reference point, and threat) are labeled as a specific type of track and assigned a unique track number (TN). The TDL network lacks large pools of TNs that can be readily accessed on demand and, therefore, assigns a block of TNs for use on the network to each group of TDL players (e.g., each MQ-9 squadron) to mitigate this limitation. Passive participants require a server linked to the JRE gateway and a tactical display framework (TDF) software (e.g., Zeus) that displays TDL data to the crew.

10.2.3 J-Series Messages. Each track displayed on the Link 16 or SADL network is actually a set of grouped information that is encoded and formatted in a specific pattern and is referred to as J-series messages. Each J-series message has a label and a sublabel, as well as a specific definition and function. For example, in the J12.6 Target Sorting message, the "J" indicates the Link 16 message set, the "12" is the message label, and the "0.6" is the message sublabel. See **Table 10.1**, MIL-STD-6016F Messages, for all Link 16 J-series messages. The specific

J-series messages a TDL-capable platform can receive, transmit, and display is dependent on the mission of the platform as well as terminal capabilities and network design. For a breakdown of what J-series messages specific platforms can transmit and receive reference the MQ-9 Link 16 Handbook.

10.3 Tactical Data Links Components. This section describes basic components of the TDL network as they relate to MQ-9 operations. MQ-9 related TDL components consist of a JRE, a joint range extension application protocols (JREAP) and a multi-source correlator-tracker (MSCT).

10.3.1 Joint Range Extension. The JRE functions as the host server for TDL operations. Once connected to a Link 16 or SADL terminal, the JRE provides multipoint interoperability for BLOS data link connectivity. The JRE also serves as the gateway for tactical data exchange between different TDLs (e.g., Link 16 and SADL). JREs are generally located at theater AOCs and forward-deployed CRCs.

10.3.2 Joint Range Extension Application Protocols. JREAP are designed to support BLOS operations over most communications media (JRE media). JREAP is the medium through which BLOS entities communicate with the JRE. There are currently three JREAP protocols.

- JREAP A uses military UHF satellite and terrestrial RF communications.
- JREAP B uses military superhigh-frequency (SHF) SATCOM, landlines (telephone lines), or field wire.
- JREAP C uses Internet Protocol (IP) as well as transmission control protocol (TCP) to exchange messages over wide and local area networks. MQ-9 operations use JREAP C.

10.3.3 Multi-Source Correlator Tracker. MSCT is a collection of software modules that make up a three-tiered, correlation and tracking system. In the first tier, various inputs are introduced into the system. These inputs can be radar feeds, TDLs, or MQ-9 exploitation support data (ESD). In the middle tier, a series of complex algorithms takes the various data streams and fuzes them into a single integrated picture. The final tier is the output of the integrated track picture to numerous formats, including Zeus, or JRE. **Figure 10.1**, Notional MQ-9 Link 16 Architecture.

10.3.3.1 The MSCT connects the MQ-9 aircrew's TDF (e.g., Zeus) to the JRE via JREAP C. See **Figure 10.2**, Three-Tier Multi-Source Correlator Tracker Process, depicts the three-tier MSCT process.

10.3.3.2 Correlator Tracker Track Number. A CTTN is a track which is created on the MSCT network but is not yet pushed to the TDL network. The CTTN track is visible by all other Zeus clients connected to the same MSCT, but is not visible to Link 16, SADL players, or other Zeus users connected to a different MSCT until published to the link.

Table 10.1 MIL-STD-601D Messages.

NETWORK MANAGEMENT		ANTISUBMARINE WARFARE		PLATFORM AND SYSTEM STATUS	
J0.0	Initial Entry Message	J5.4	Acoustic Bearing/Range Message	J13.0	Airfield Status Message
J0.1	Test Message	**INTELLIGENCE**		J13.2	Air Platform and System Status Message
J0.2	Network Time Update Message	J6.0	Amplification Message	J13.3	Surface Platform and System Status Message
J0.3	Time Slot Assignment Message	**INFORMATION MANAGEMENT**		J13.4	Subsurface Platform and System Status Message
J0.4	Radio Relay Control Message	J7.0	Track Management Message	J13.5	Land Platform and System Status Message
J0.5	Repromulgation Relay Message	J7.1	Data Update Request Message	**ELECTRONIC WARFARE**	
J0.6	Communications Control Message	J7.2	Correlation Message	J14.0	Parametric Information Message
J0.7	Time Slot Reallocation Message	J7.3	Pointer Message	J14.2	EW Control and Coordination Message
J1.0	Connectivity Interrogation Message	J7.4	Track Identifier Message	**THREAT WARNING**	
J1.1	Connectivity Status Message	J7.5	IFF/SIF Management Message	J15.0	Threat Warning Message
J1.2	Route Establishment Message	J7.6	Reserved for NATO use	**MISSION SUPPORT**	
J1.3	Acknowledgment Message	J7.7	Association Message	J16.0	Image Transfer Message
J1.4	Communicant Status Message	J8.0	Unit Designator Message	J16.1	Route Change Message
J1.5	Net Control Initialization Message	J8.1	Mission Correlator Change Message	J16.2	GARS
J1.6	Need Line Participation Group Assignment Message	**WEAPONS COORDINATION AND MANAGEMENT**		**NATIONAL USE**	
PRECISE PARTICIPANT LOCATION AND IDENT		J9.0	Command Message	J28.0	U.S. National 1 (Army) Message
J2.0	Indirect Interface Unit PPLI Message	J9.1	Engagement Coordination	J28.1	U.S. National 2 (Navy) Message
J2.2	Air PPLI Message	J10.2	Engagement Status Message	J28.2	U.S. National 3 (Air Force) Message
J2.3	Surface PPLI Message	J10.3	Handover Message	J28.2(0)	Text Message
J2.4	Subsurface PPLI Message	J10.5	Controlling Unit Report Message	J28.3	U.S. National 4 (Marine Corps) Message
J2.5	Land Point PPLI Message	J10.6	Pairing Message		
J2.6	Land Track PPLI Message	**CONTROL**			
SURVEILLANCE		J12.0	Mission Assignment Message		
J3.0	Reference Point Message	J12.1	Vector Message		
J3.1	Emergency Point Message	J12.2	Precision Aircraft Direction Message		
J3.2	Air Track Message	J12.3	Flightpath Message		
J3.3	Surface Track Message	J12.4	Controlling Unit Change Message		
J3.4	Subsurface Track Message	J12.5	Target/Track Correlation Message		
J3.5	Land Point/Track Message	J12.6	Target Sorting Message		
J3.6	Space Track Message	J12.7	Target Bearing Message		
J3.7	Electronic Warfare Product Information Message	J17.0	Weather Over Target		

Figure 10.1 Notional MQ-9 Link 16 Architecture.

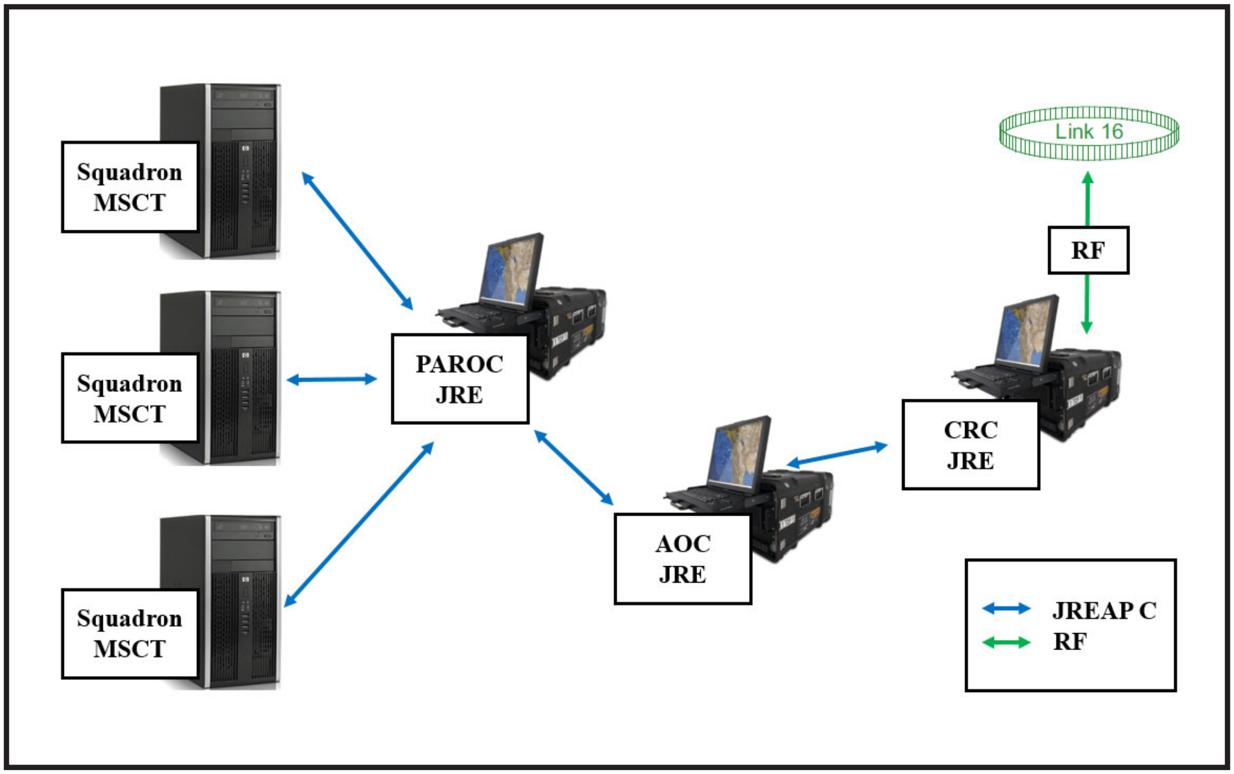
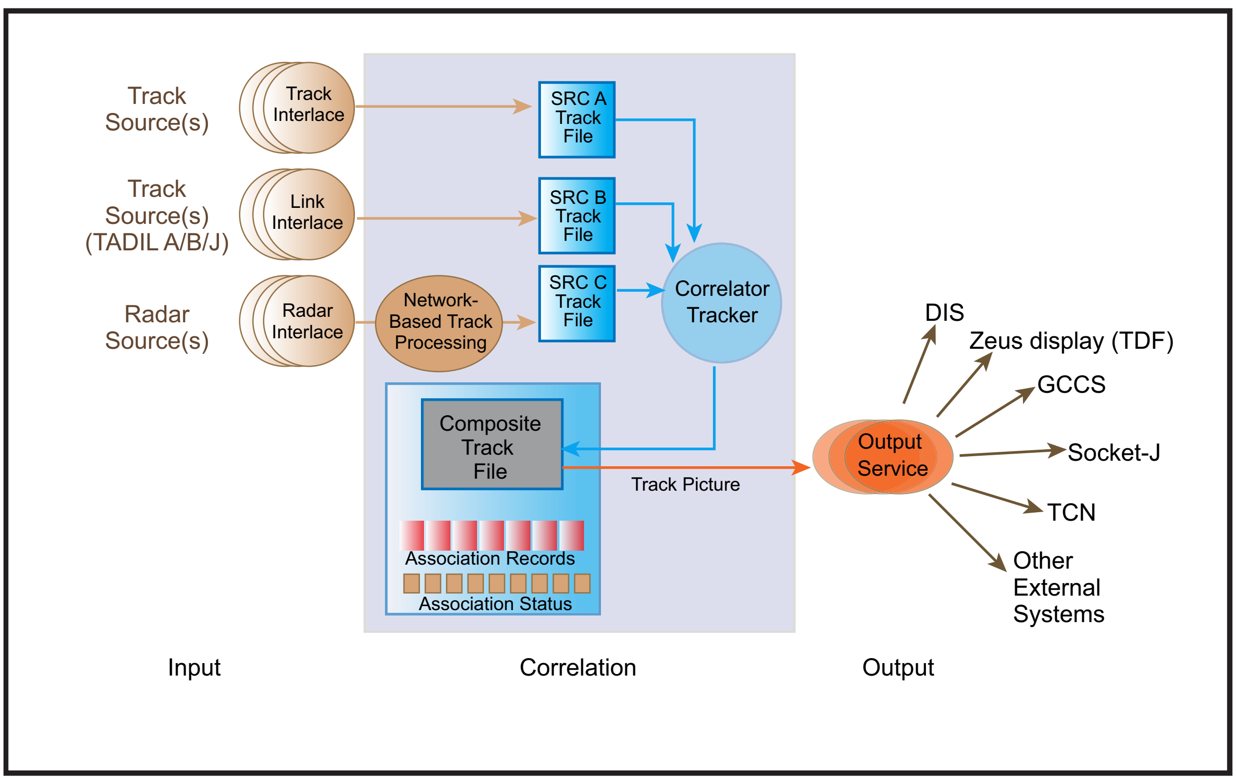


Figure 10.2 Three-Tier Multi-Source Correlator Tracker Process.



10.3.4 MQ-9 Applicable J-Series Messages. There are 256 possible message combinations within the J-series message set. MQ-9 TDL setup and passive participation role limits which messages are displayed to the TDF (received) and which messages can be pushed to the TDL network (transmitted). Common message sets which the MQ-9 can transmit and receive are listed below.

10.3.4.1 J2.0 Indirect Interface Unit Precise Participant Location and Identification (PPLI) (Zeus 2.2.4 Transmit/Receive). Indirect PPLI represent platforms that are not directly participating in the JTIDS/MIDS network. They often represent Link 16 JUs being forwarded from a different network (e.g., a JREAP player). MQ-9s are only able to transmit this message type when the squadron has been assigned multiple JU numbers on the operational tasking link (OPTASKLINK). Zeus 2.2.4 will only allow users to publish a J2.0 when the aircraft is in radar coverage. This issue has been resolved in Zeus version 2.6.6. Transmitting a J2.0 is required in order to publish a J12.6.

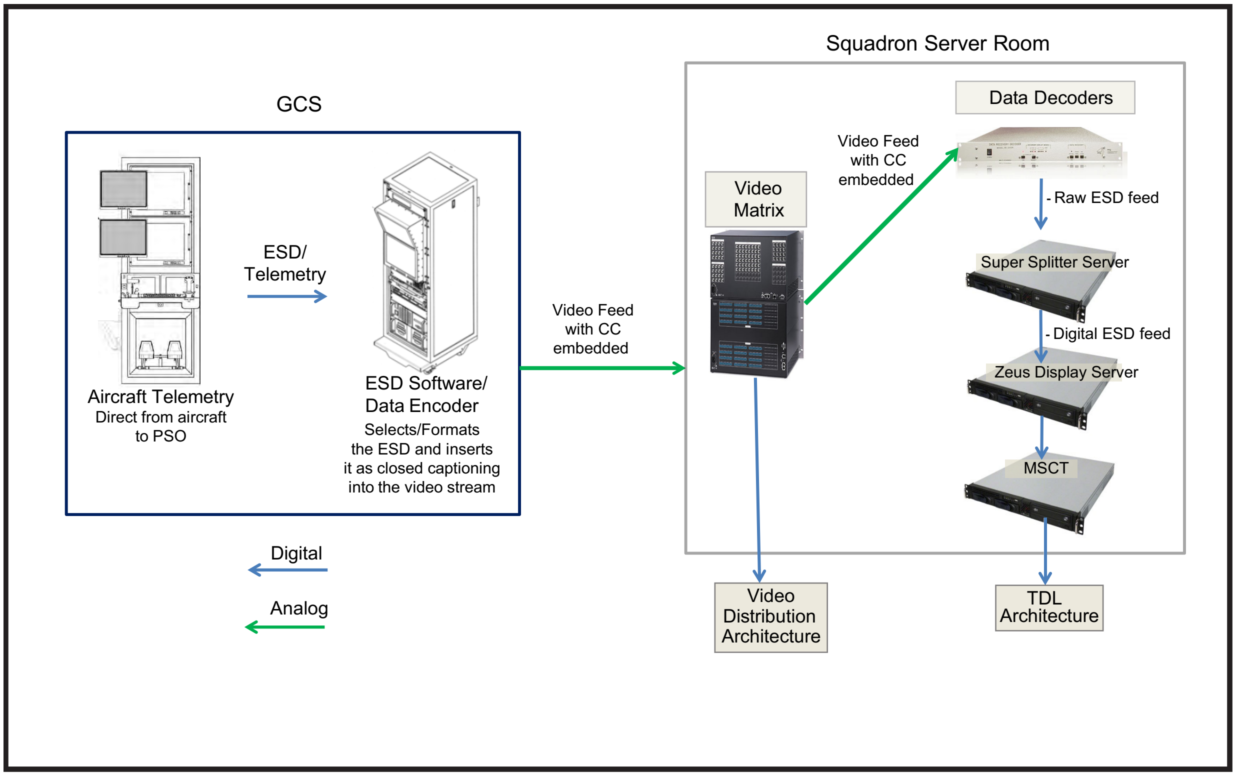
10.3.4.2 J3.1 Emergency Point (transmit/Receive). The J3.1 Emergency Point is used to report various emergency situations requiring search and rescue (SAR). The specific type, downed aircraft, man in water, ditching, bailout, and other can be reported. These messages can also contain the number of personnel, position, and time of report. Prior to transmitting this message, crews should ensure they reference theater SPINS for specific guidance.

10.3.4.3 J3.2-Air Track (Transmit/Receive). The MQ-9 ESD is translated into a J3.2 message to indicate position and aircraft information. To transmit a J3.2, the MSCT pulls the ESD from the cockpit, builds a surveillance track with the data, assigns a track quality of 14 to it and transmits it on the TDL network. See **Figure 10.3**, MQ-9 J3.2 Message Transmission, for this depiction. The air track number is pulled from the track block assigned to the publishing JU. The TDF displays received J3.2 messages for the aircrew. Active users publish the position and aircraft information via the J2.2 Air PPLI message.

10.3.4.4 J3.3-Surface Track. This message set is primarily used for maritime naval targets. This track can be labeled to annotate many properties, including identification, location, and platform (e.g., hostile or friendly, cruiser, aircraft carrier, etc.). Surface track numbers are pulled from the track block assigned to the JU of the MQ-9 squadron. This is the primary method for MQ-9 crews to transmit information over the Link in a maritime environment. The TDF displays received J3.3 messages for the aircrew.

10.3.4.5 J3.5-Land Track (Transmit/Receive). The Reaper aircrew can transmit a J3.5 land track message on the TDL. This track can be labeled to annotate many properties, including identification, location, and platform (e.g., hostile or friendly, tank or SAM). Land track numbers are pulled from the track block assigned to the JU of the MQ-9 squadron. This is the primary method for MQ-9 crews to transmit information over the Link. The TDF displays received J3.5 messages for the aircrew.

Figure 10.3 MQ-9 J3.2 Message Transmission.



10.3.4.6 J12.6-Target Sorting Message (Zeus 2.0-Receive Only, Zeus 2.26- Send/Receive if publishing a J2.0 and in radar coverage). This message allows non-C2 JUs to share target information with each other. For example, some fighters use J12.6 POINT and MARK POINT messages to quickly coordinate attacks against multiple targets. Current versions of the TDF may display J12.6 POINT messages through the use of a C2 "Backlink." This data is displayed as a CTTN located at the referenced target position. As a result fighter published MARK POINTS are not be labeled correctly on the Zeus display. MQ-9 crews should use additional methods to verify MARK POINT location (i.e., Bullseye, MGRS Grid, etc.), as required to avoid confusion.

10.3.4.7 J28.2-Text (Transmit/Receive). This message allows capable JUs to pass alphanumeric text information. MQ-9 crews have the ability to transmit J28.2 messages to all platforms capable of receiving J28.2 messages. Platform specific J28.2 formatting requirements should be understood and/or coordinated between the MQ-9 and receiving asset to ensure the message is displayed effectively and efficiently to the intended receiver. Formatting requirements should be addressed in mission planning.

10.4 Link 16 Mission Planning.

10.4.1 Mission Planning. Detailed TDL mission planning is required to ensure the information displayed properly and as expected by all participants. Aircrew must be aware of assigned TDL data through the operational tasking data link (OPTASKLINK) message, understand the TDL capabilities of other integrated assets and establish required contracts during the planning process.

10.4.1.1 Operational Tasking Data Links. The OPTASKLINK is the official participant message that indicates network information. Similar to an ATO for data links. It includes participating units and assigned JUs and track blocks (i.e., TN; e.g., 16,929 to 16,949). All players operating on a given network will be found in the OPTASKLINK message. The OPTASKLINK may be found through the joint interface control cell (JICC) at the theater air operation center (AOC). For description on how to read the OPTASKLINK, reference the *MQ-9 Link 16 Handbook*.

10.4.1.2 Message Sets. Since TDL transmit and receive capability varies from participant to participant, crews must be familiar with the capabilities of other assets. Chapter 6 of the Understanding Link 16 **document** describes capabilities of Link 16 players by platform. The *MQ-9 Link 16 Handbook,* and Captain Nicholas Pederson's Weapons School paper, *Integrating MSCT to Enhance MQ-1/9 Link 16 Operations*, also lists message sets by MDS.

10.4.1.3 Data Link Contracts. Due to the wealth of information that may be passed over TDLs, aircrew should coordinate and develop contracts with other participants for data transmission and receipt. Some TDL contracts may be found in theater SPINS and the OPTASKLINK, while others may need to be developed between assets for specific missions. Tactical data links can be SA enhancing and can increase the speed and accuracy of information transfer when properly integrated. It is important to remember that other means may be quicker or more effective, such as a timely radio call. Reference the *MQ-9 Link 16 Handbook* for a listing of Link 16 contracts by mission set.

10.4.1.4 MQ-9 Link 16 Mission Planning Cell (MPC) Data Sheet. **Attachment 3**, "MQ-9 Link 16 MPC Data Sheet," provides a quick reference of MQ-9 Link 16 capabilities for crews attending an MPC. Pilots should reference the theater's OPTASKLINK and fill out the squadron/call sign JU numbers and assigned track blocks prior to the start of the MPC.

10.5 Execution.

10.5.1 Zeus Fence.

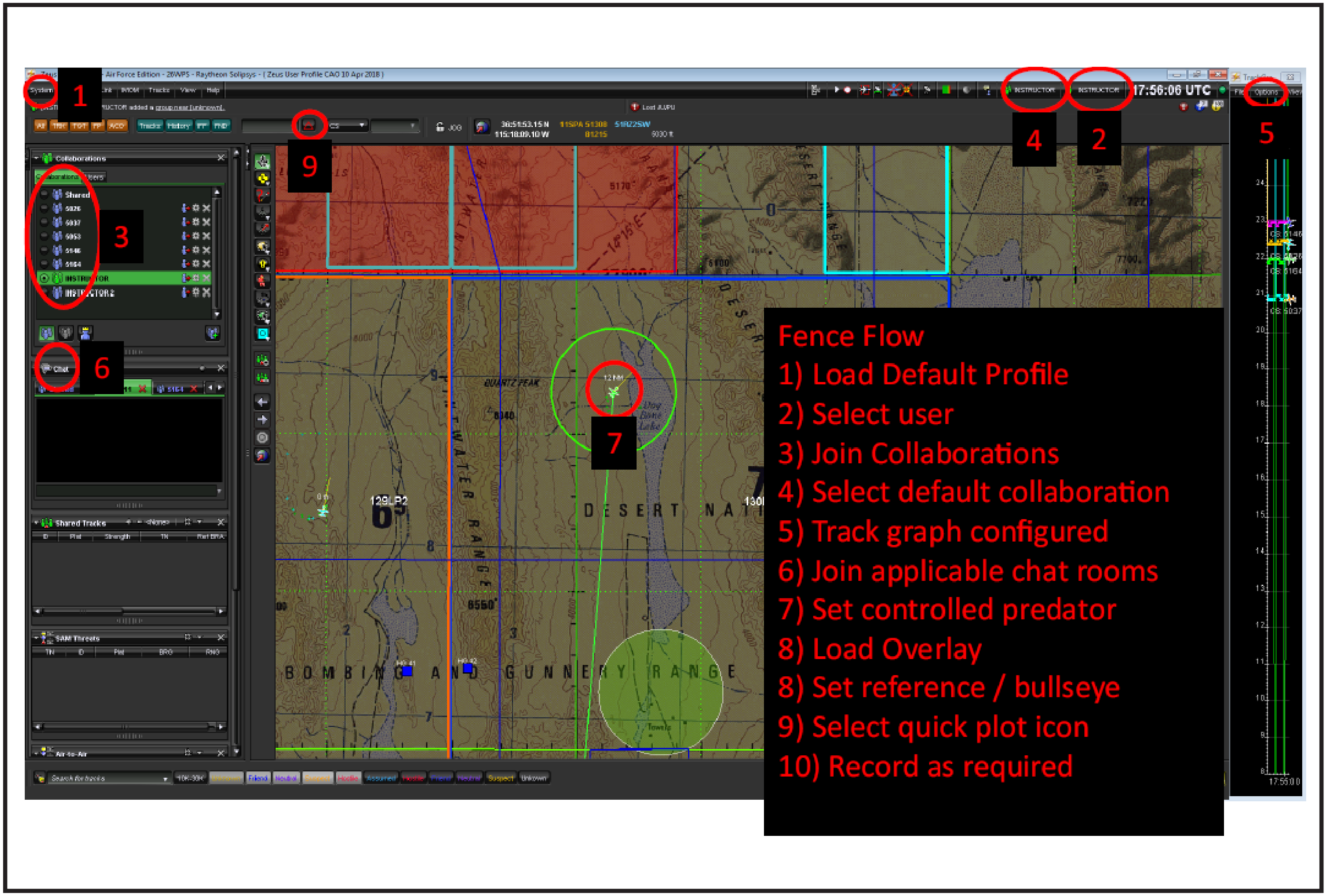
10.5.1.1 Zeus fence flow IAW **Figure 10.4**, Zeus 2.2.4 Fence Flow.

10.5.1.1.1 Load Default Profile Select User (version 2.2.4 or greater).

10.5.1.1.2 Select a user IAW local standards using the drop-down menu in the upper right corner of the Zeus display adjacent to the GMT clock. Selecting a user ensures the appropriate permissions are set for that Zeus client. It can also be set up to auto join specific collaborations.

10.5.1.1.3 User profiles are managed by squadron weapons (DOW) shops.

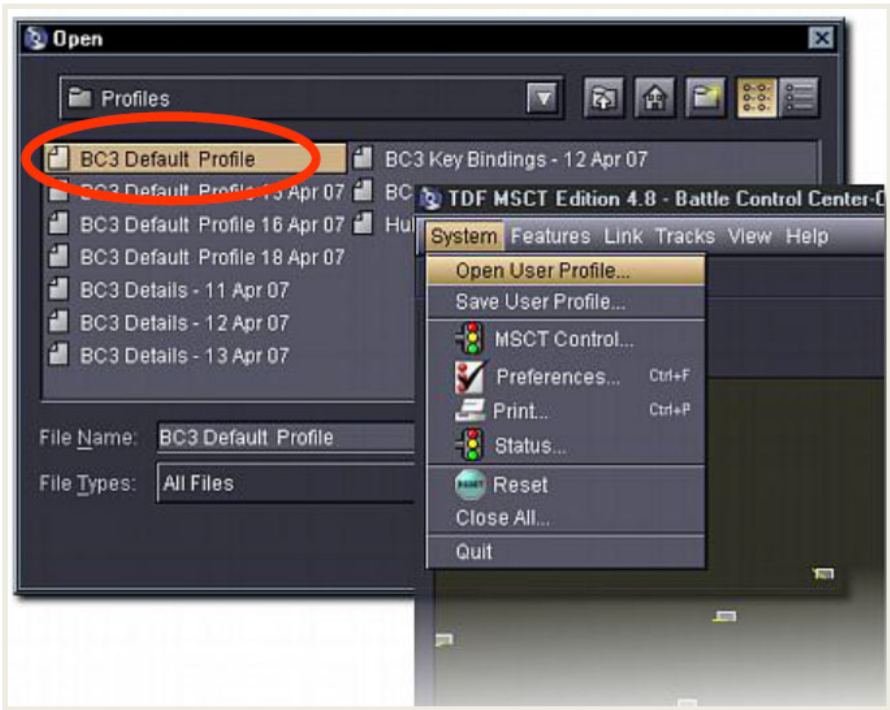
Figure 10.4 Zeus 2.2.4 Fence Flow.



10.5.1.2 Load Default Profile .

10.5.1.2.1 Load the user profile by following the path depicted in Figure 10.5, Zeus User Profile. Then locate the appropriate user profile to load IAW local standards.

Figure 10.5 Zeus User Profile.



10.5.1.3 Collaboration (Version 2.2.4 or Greater).

10.5.1.3.1 Select default collaboration IAW local standards by using the drop down menu in the upper right corner of the Zeus display adjacent to the user drop down. Setting default collaboration means that all overlay plots will be saved to that folder.

10.5.1.3.2 Join additional collaborations as required. Joining additional collaborations will allow viewing plots made by that collaboration. This is useful for multiship operations.

10.5.1.4 Track Graph.

10.5.1.4.1 To display the track graph, select tracks > track graph. Once the track graph is displayed the following sections of the tool should be set for the current mission.

10.5.1.4.2 Altitude restrictions should be set as required to maintain situational awareness of other aircraft in the stack. At a minimum aircrew should have ± 5,000 feet of current altitude displayed. Another option is to set the bounds of the track graph to encompass the current stack ± 1,000 feet.

10.5.1.4.3 Lateral restrictions should be limited to the current working airspace overlay.

10.5.1.5 Join Applicable Chat Rooms.

10.5.1.5.1 To join chat in a room, select the "+" symbol on the dashboard chat window. Then select users, collaborations, or JUs (J28.2) to open the desired chat tabs. Click + drag to move chat tabs around the screen.

10.5.1.6 Set Controlled Predator.

10.5.1.6.1 Select the controlled predator by finding the aircraft's J3.2 on the Zeus display, right click the aircraft icon and select set as controlled predator.

10.5.1.7 Load Overlay.

10.5.1.7.1 To fence in overlays, navigate to the overlay window (Ctrl +O). Find the appropriate folder to select as the default group IAW local standards. Select that folder and middle mouse click (or right click, set default group). The text on the name of that folder should turn BOLD indicating it is the selected default group.

10.5.1.7.2 To load a mission overlay, navigate to the overlay window (Ctrl +O). Then right click on the desired folder and select "import from object file." Navigate to the location of the overlay file and select open.

10.5.1.8 Set Reference/Bullseye.

10.5.1.8.1 Find or plot the desired bullseye on the Zeus display. Primary hook that overlay item and set to reference by pressing "R" or right click, set as reference.

10.5.1.9 Select Quick Plot Icon.

10.5.1.9.1 Select the appropriate quick plot (Shift + T) icon by clicking on the quick plot icon shown on **Figure 10.6**, Selecting a Quick Plot Icon, and selecting a new icon IAW local standards.

10.5.1.10 Record, as required.

10.5.1.10.1 Zeus should be set to record as required for debrief purposes. To do this hit the record button and save IAW local standards.

10.5.2 Basic Execution Tools. The following covers the most commonly used Zeus tools. Most of them employ the use of "hot key" or "keybinds" to simplify usage. A complete list of Zeus hot keys can be found in **Table 10.2**, Zeus Hot Keys.

10.5.2.1 Range and Bearing Tool.

10.5.2.1.1 Middle Click and Drag. This tool is useful to quickly assess the range and earing between two points. For example, verifying distance and direction from the target to nearest friendly force element. **Figure 10.7**, Range and Bearing Line, displays a middle click drag range and bearing line.

10.5.2.1.2 Persistent Range/Bearing (b). This tool is useful to assess distance and direction between moving link tracks. For example, the distance and direction from the aircraft to the nearest air-to-air threat track. To do this primary hook one track (left click) and secondary hook the other track (middle click). Then press 'b'. To remove that line execute those steps in reverse order. **Figure 10.8**, Persistent Range and Bearing Line, provides a visual depiction of this tool.

Figure 10.6 Selecting a Quick Plot Icon.

10.5.2.2 Overlay Plots.

10.5.2.2.1 Targets.

- Target-Point Entry Panel.
- Quick Plot at SPI (Shift +T). See **Figure 10.9**, Quick Plotting.
- Quick Plot at location by typing the location in the dialog container to the left of the quick plot icon. For a list of all acceptable coordinate and grid formats right click in the text field and select "Valid Coordinate formats."
- Quick Plot at cursor: Red Triangle (T then click), Red X (Alt + T) then click.

10.5.2.2.2 Friendlies.

- Quick Plot at cursor: Blue IP (F then click), Blue Square (Alt + F) then click.

Table 10.2 Zeus Hot Keys.

Key	Action	Description
Space Bar	Orient Map North Center Display on Controlled Predator Center/Zoom mode	For when your Zeus display is not behaving like you expect it to
1-4	Save View	When pressed and held; saves the current Zeus map field of view When pressed; slews the map to the saved FOV
=		Adds the currently hooked track to the preferred track list
-		Removes the currently hooked track to the preferred track list
c	Copy pointer position	Copies the position of your mouse cursor in MGRS
Shift + c	Copy pointer position	Copies the position of your mouse cursor in LAT/LONG DDMMSS.sss
d	Toggle dashboard	
e	Edit Overlay Track Properties	Brings up the edit overlay window for the currently selected overlay item Brings up the track properties window for the currently hooked link track
f	Blue IP	Plots a Blue IP at the next location place on the map you click
Alt + f	Blue Square	Plots a Blue square at the next location place on the map you click
t	Red Triangle	Plots a Red triangle at the next location place on the map you click
Alt + t	Red X	Plots a Red X at the next location place on the map you click
Shift + t	Quick Plot at SPI	Places the currently selected quick plot icon at the SPI of the controlled predator
m	Reposition Track	Selects the reposition track tool. Only usable on J3.5s or CTTNs
r	Set Reference	
s	Land Point (J3.5)	Drops a CTTN at the next location place on the map you click Launches the track properties window
Shift + s	Convert to J3.5 send to Cross Tell	Converts the currently selected overlay plot to a CTTN Converts the currently selected CTTN to a J3.5
delete	Delete overlay drop track	Works on currently selected overlay item
b	Toggle persistent range bearing line	

Figure 10.7 Range and Bearing Line.

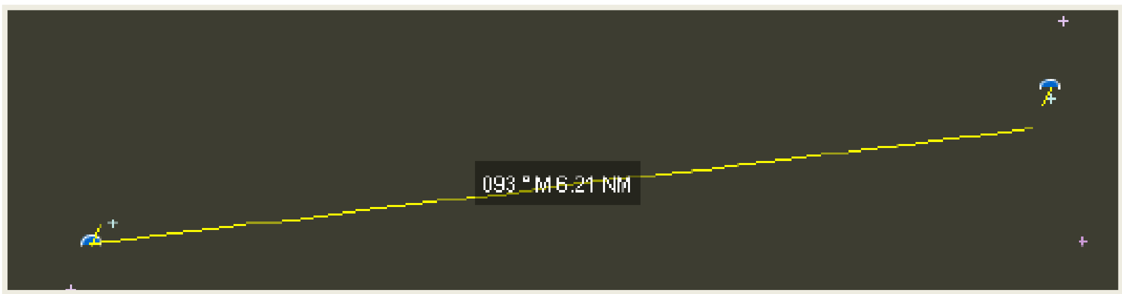
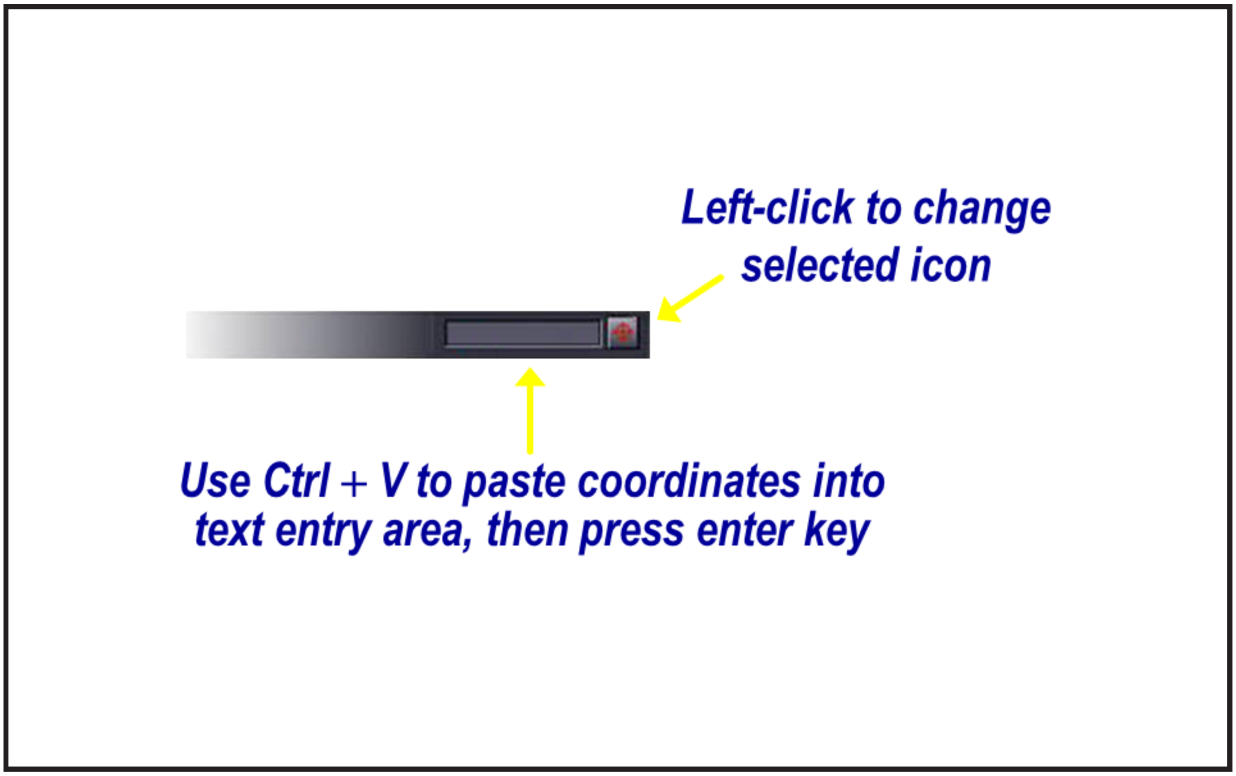


Figure 10.8 Persistent Range and Bearing Line.

Figure 10.9 Quick Plotting.



10.5.2.2.3 Circle. The circle overlay can be useful for plotting circular objects such as ROZs, threats, etc. To plot a circle select the circle tool from the overlay toolbar, then click and drag on the map at the desired location. Once an initial circle is plotted select the circle by left clicking it. Then press (E) to bring up the edit overlay window shown in **Figure 10.10**, Overlay Editor Circle Tool. In the edit overlay window choose a center point, enter a radius/diameter, and manipulate the appearance of the circle (fill color and transparency/outline color and weight).

10.5.2.2.4 Lat Long Box. The lat long box overlay can be useful for plotting square or rectangular objects such as approved airspace, closed or open kill boxes, etc. To plot a lat long box select the lat long box tool from the overlay toolbar, then click and hold on the most Northwest point and drag to the most Southeast point. Once an initial lat long box is plotted select it by left clicking. Then press E on the keyboard to bring up the edit overlay window shown in **Figure 10.11**, Overlay Editor Lat/Long Box. In the edit overlay window, choose a center point, and manipulate the appearance of the Lat Long Box (fill color and transparency/outline color and weight). Additionally, when the edit overlay window is open click and drag on the Lat Long Box to manipulate its position and size. **Figure 10.12**, Lat/Long Box Display on Map, shows a way to depict restricted airspace using a Lat/Long Box.

Figure 10.10 Overlay Editor Circle Tool.

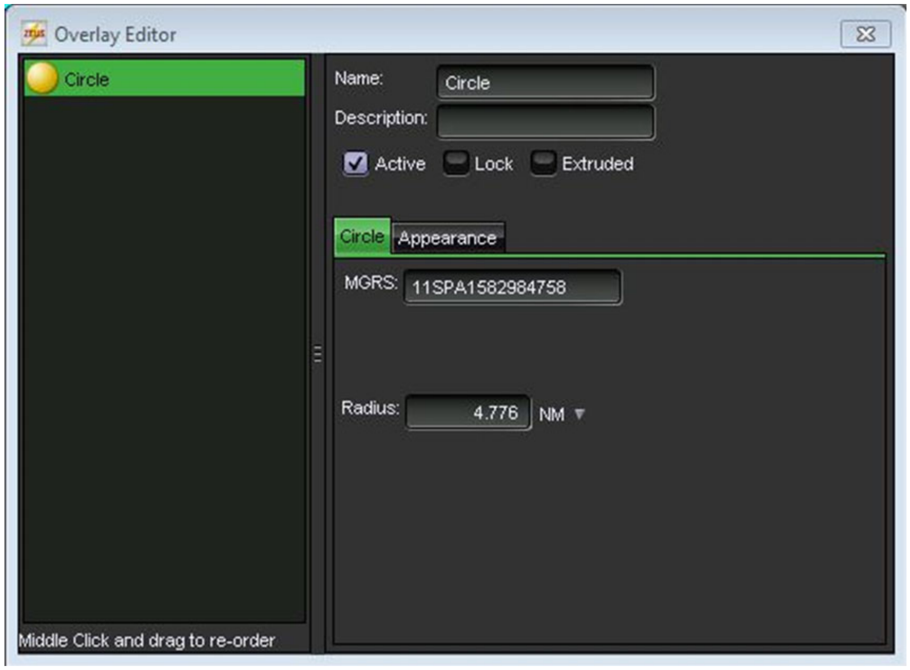


Figure 10.11 Overlay Editor Lat/Long Box.

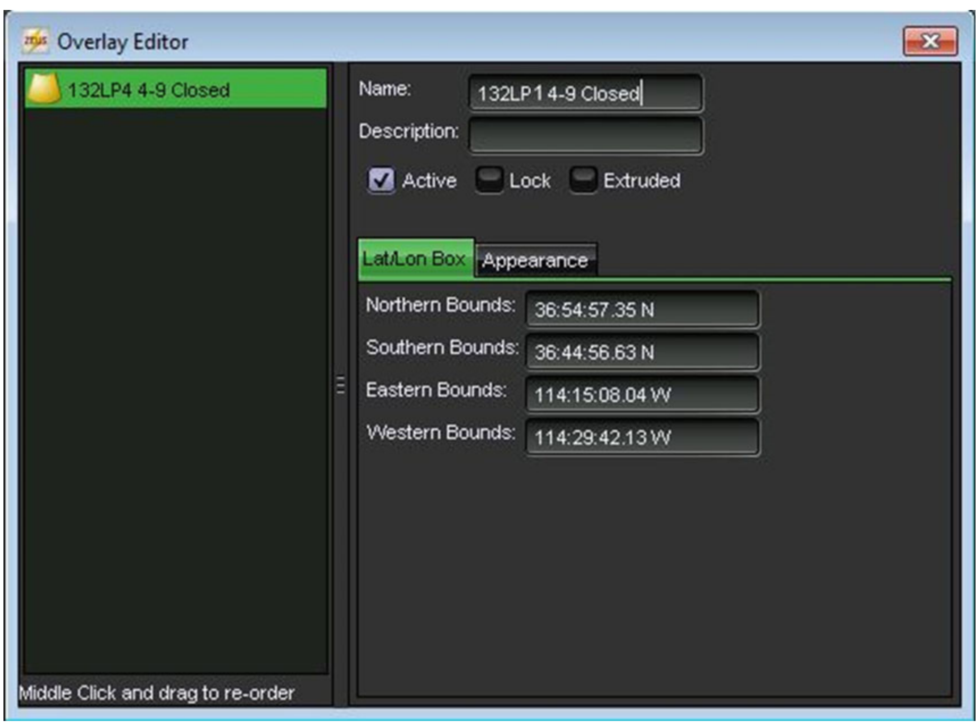
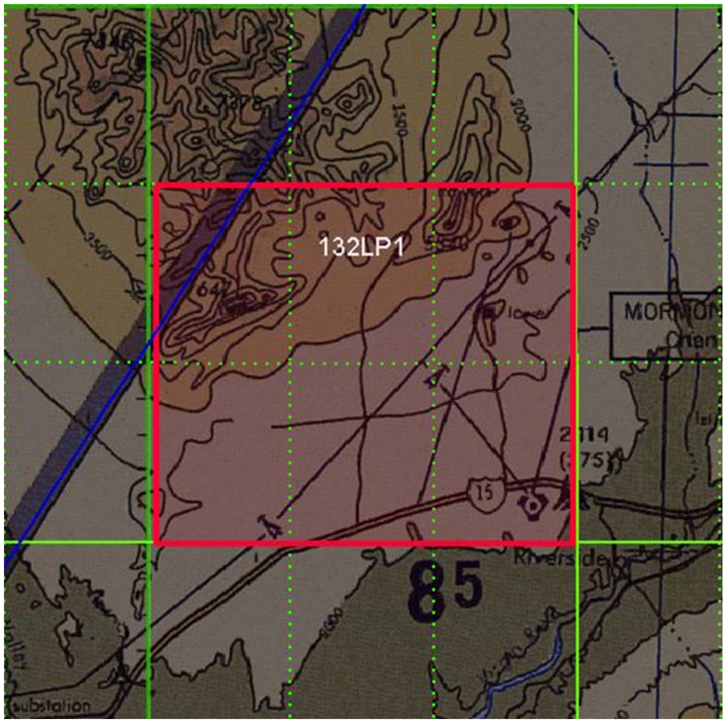


Figure 10.12 Lat/Long Box Display on Map.



10.5.2.2.5 Polyline. The Polyline tool can be useful to plot linear or irregularly shaped objects. To plot a Polyline, select the Polyline tool from the overlay toolbar, then click at the desired location of the first point. Each time you left click on the map an additional Polyline point will be plotted at that location. To finish the Polyline and stop plotting points middle mouse click. This will automatically bring up the edit overlay window. In the edit overlay window, input specific locations for each point, delete points, and manipulate the appearance of the line (color and weight). See **Figure 10.13**, Building a Polyline, for a depiction of how to use the Polyline tool.

10.5.2.2.6 Tellestrator (Zeus 2.2.4). The Tellestrator tool can be useful to quickly draw an object on the Zeus display when precision is not required. The tellestrator feature operates similarly to a draw tool in MS Paint. See **Figure 10.14**, Using the Tellestrator Tool, for a depiction of how to use the Tellestrator.

Figure 10.13 Building a Polyline.

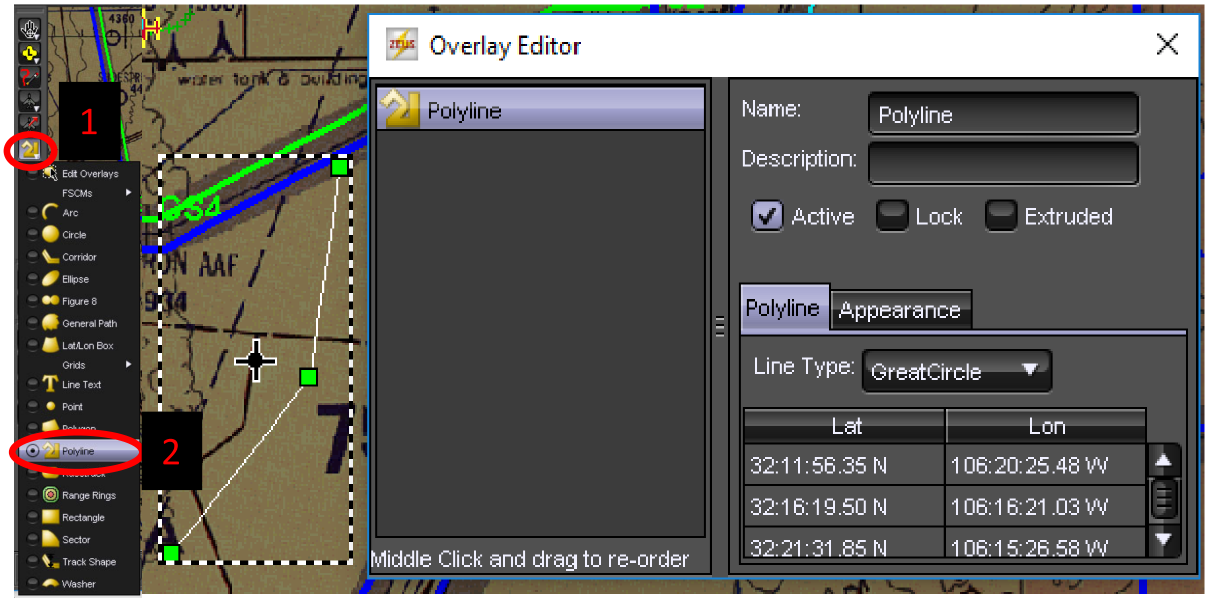
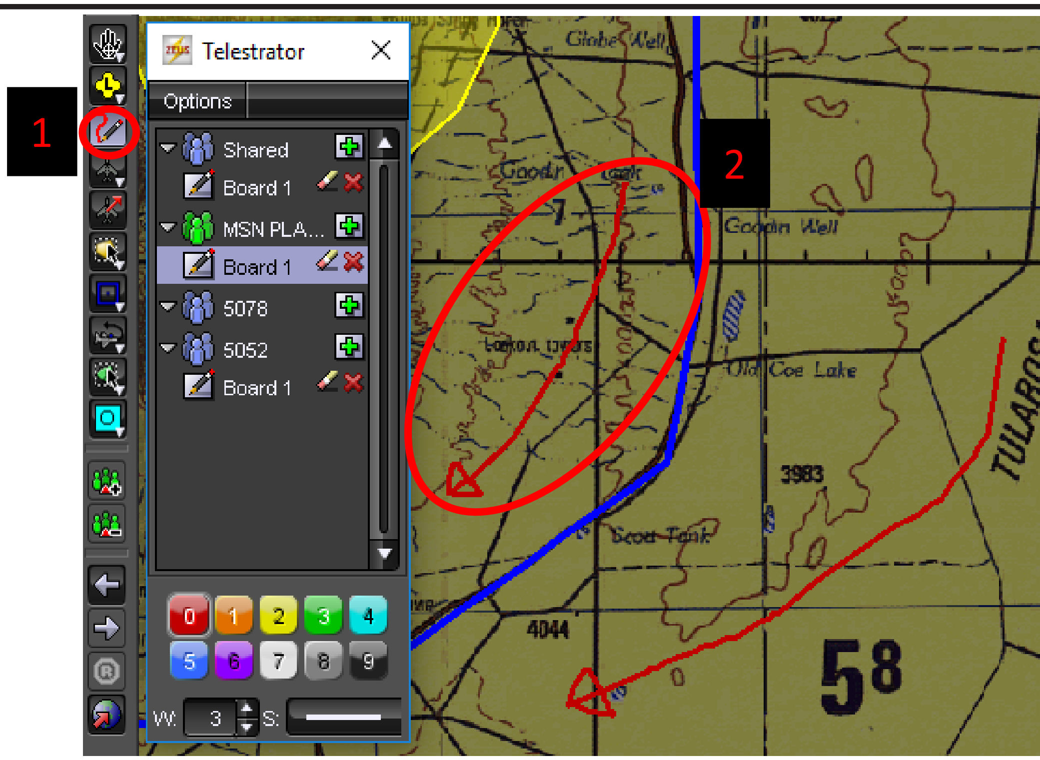


Figure 10.14 Using the Tellestrator Tool.



10.5.2.3 Constrained Shapes. Constrained shapes can be useful for highlighting own aircraft when the Zeus TacSit is cluttered. There are two types of constrained shapes; local and shared. Only use local constrained shapes unless tactically relevant to use shared constrained shapes. Local constrained shapes are only visible on that specific users Zeus display. Because constrained shapes are not visible to the entire crew and are difficult to change or remove, they are not useful for plotting DRPs/standoffs or threats. To plot a constrained shape right click on the track or overlay point you would like the constrained shape built on. Select constrained shape and then select the desired diameter or radius of that shape. This process is shown in **Figure 10.15**, Constrained Shape Setup. Once complete the constrained shape will follow the track it was placed on as depicted in **Figure 10.16**, Constrained Shape Editor/Map Visual. To remove a constrained shape, right click on the associated track and select "Remove Constrained Shape."

10.5.2.4 Hook Panel. The hook panel, shown in **Figure 10.17**, Hook Panel, is useful when passed a JTN to search for. To use the hook panel to search for a JTN select JTN IAW **Figure 10.17**, Hook Panel. Then type the JTN being searched for in the adjacent container and press enter. If that JTN exists the Zeus display will hook and center on that JTN.

Figure 10.15 Constrained Shape Setup.

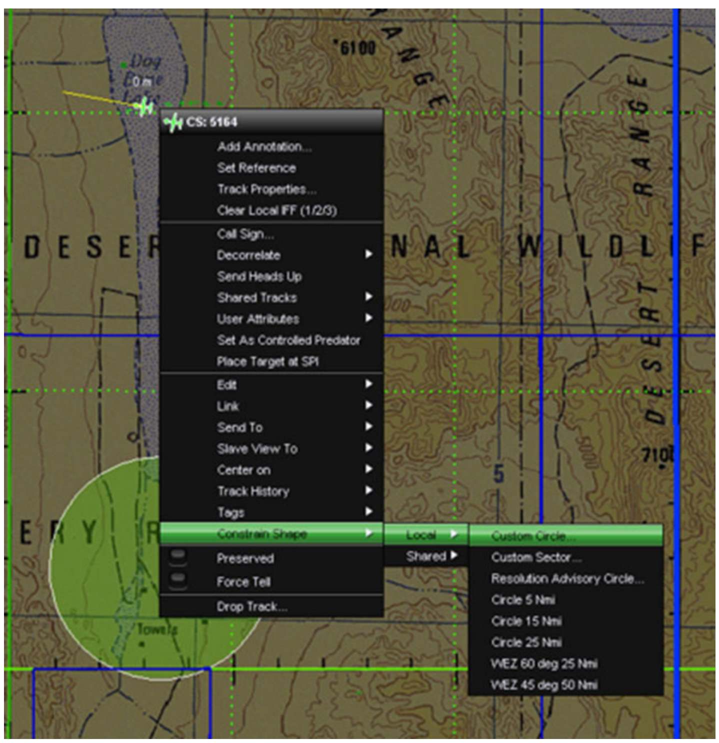


Figure 10.16 Constrained Shape Editor/Map Visual.

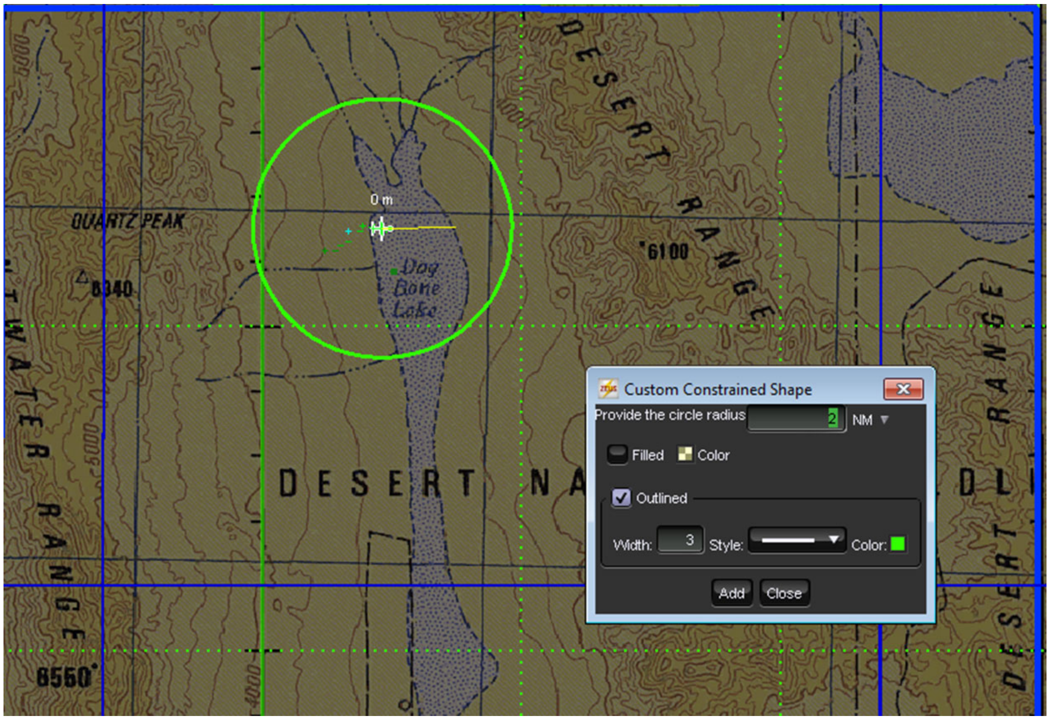


Figure 10.17 Hook Panel.

10.5.2.5 Copy Cursor Location. Copying the cursor location as a grid and then pasting that information into mIRC, 28.2, or Zeus chat can expedite sending information. To copy the MGRS location of the cursor position press 'C.' To copy the Lat Long DD MM SS.ss location of the cursor position press 'Shift + C.' Use 'Ctrl + V' to past that grid or coordinate.

10.5.2.6 Saving a Zeus Field of View. To save a Zeus map field of view hold down one of the number keys (1 through 4) for approximately 5 seconds. Any time that number key is pressed again the Zeus map will return to that zoom level centered on the same location. Up to 4 fields of view can be saved at a time.

10.5.2.7 Spotlighting Toolbar (Zeus 2.2.4). The Spotlighting Tool is useful to draw attention to groups of tracks on the TacSit. To choose a group to spotlight, select the drop down shown in **Figure 10.18**, Spotlighting. Once a group is selected, click the flashlight icon and it will produce a yellow outline around all tracks in that group. Additionally, it will make everything else on the TacSit darker.

Figure 10.18 Spotlighting.

10.5.2.8 Terrain Mode. The Terrain Analysis tool, shown in **Figure 10.19**, Terrain Analysis, is a function of the range and bearing line and is useful in mission planning to get a rough estimate of terrain in the area and assess LOS to the target based on the DTED loaded into Zeus. It is the most useful in mountainous or low altitude environments. To use, plot the target on the TacSit, the elevation will automatically be set for the DTED elevation at its location. Then plot a blue IP to represent the aircraft. Set the elevation for the Blue IP at the planned operating altitude, and adjust location for the planned holding distance. Use the range and bearing tool by middle clicking and holding starting at the target. Then drag the line through the blue IP representing the aircraft. A line depicting LOS to the target will be depicted.

10.5.2.9 Flightpath. The flightpath tool is useful for fuel planning and making timing calculations for long travel routes. To use the flightpath tool select it on the overlay toolbar, as shown in **Figure 10.20**, Opening the Flightpath Tool, and plot it on the Zeus display similarly to the polyline tool. Then right click one of the flightpath points and select edit, as shown in **Figure 10.21**, Opening the Flightpath Editor. This will bring up the flightpath editor as shown in shown in **Figure 10.22**, Editing a Flightpath. First enter the current date and time, start fuel (current fuel), holding and default burn rates, and recovery fuel. Next enter scheduled handover time in order to determine Joker fuel. Finally, open the points table and update expected true airspeed, and forecasted wind speed/direction along the routing. Once that data is entered reference the Joker and Bingo sections the respective RTB times.

Figure 10.19 Terrain Analysis.

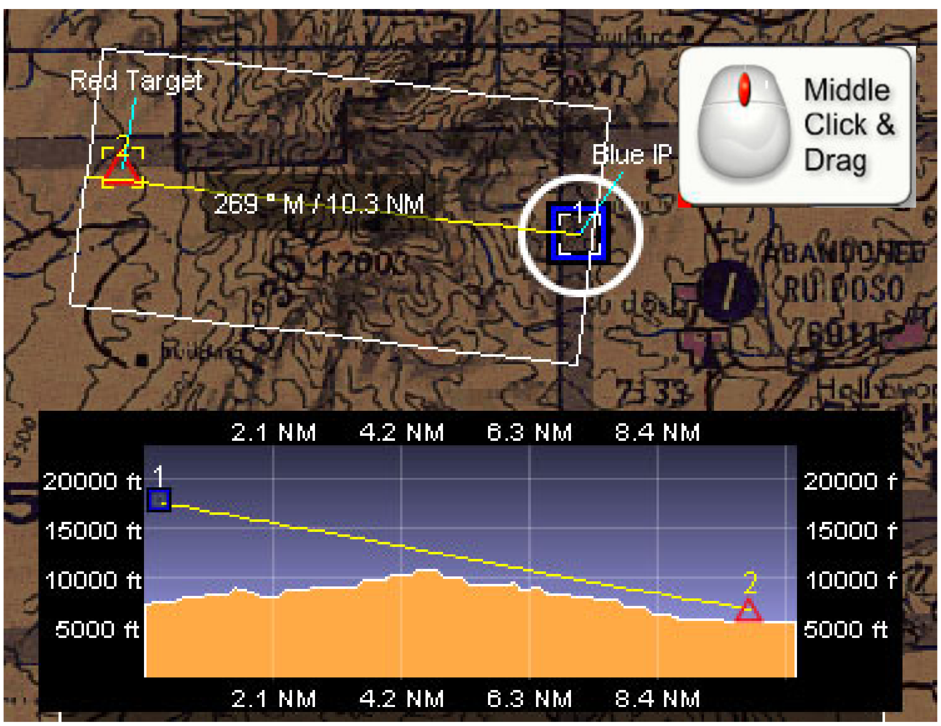


Figure 10.20 Opening the Flightpath Tool.

Figure 10.21 Opening the Flightpath Editor.

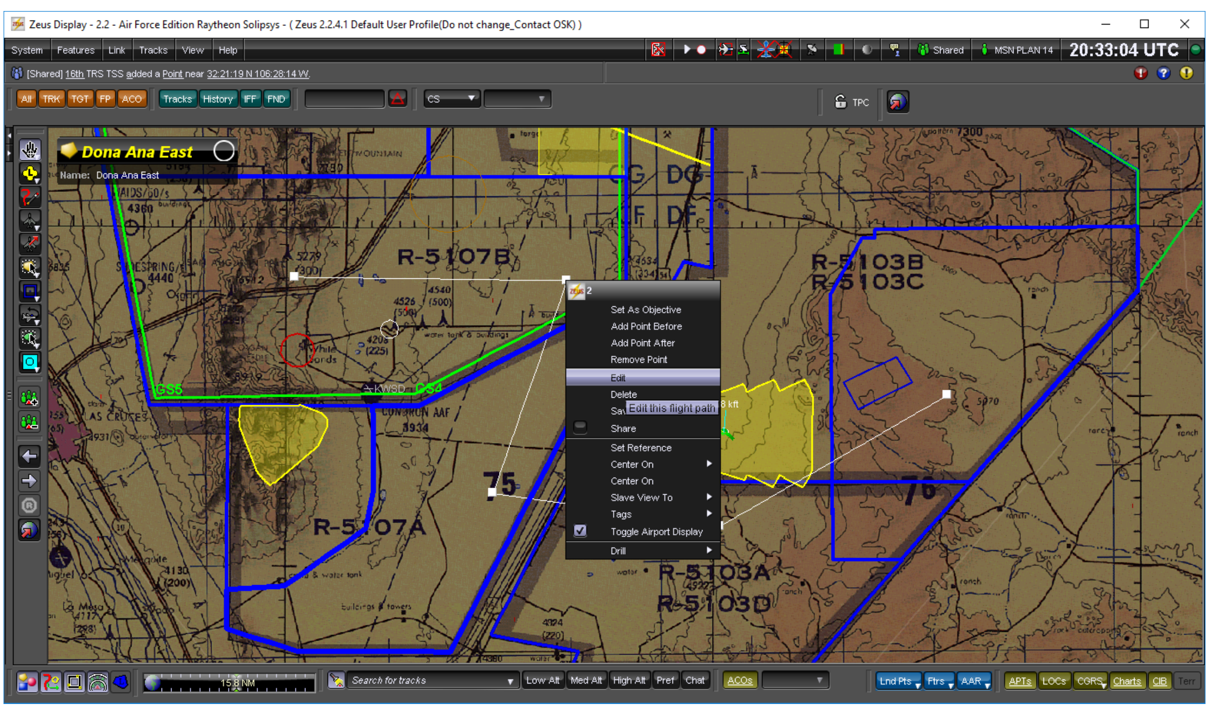
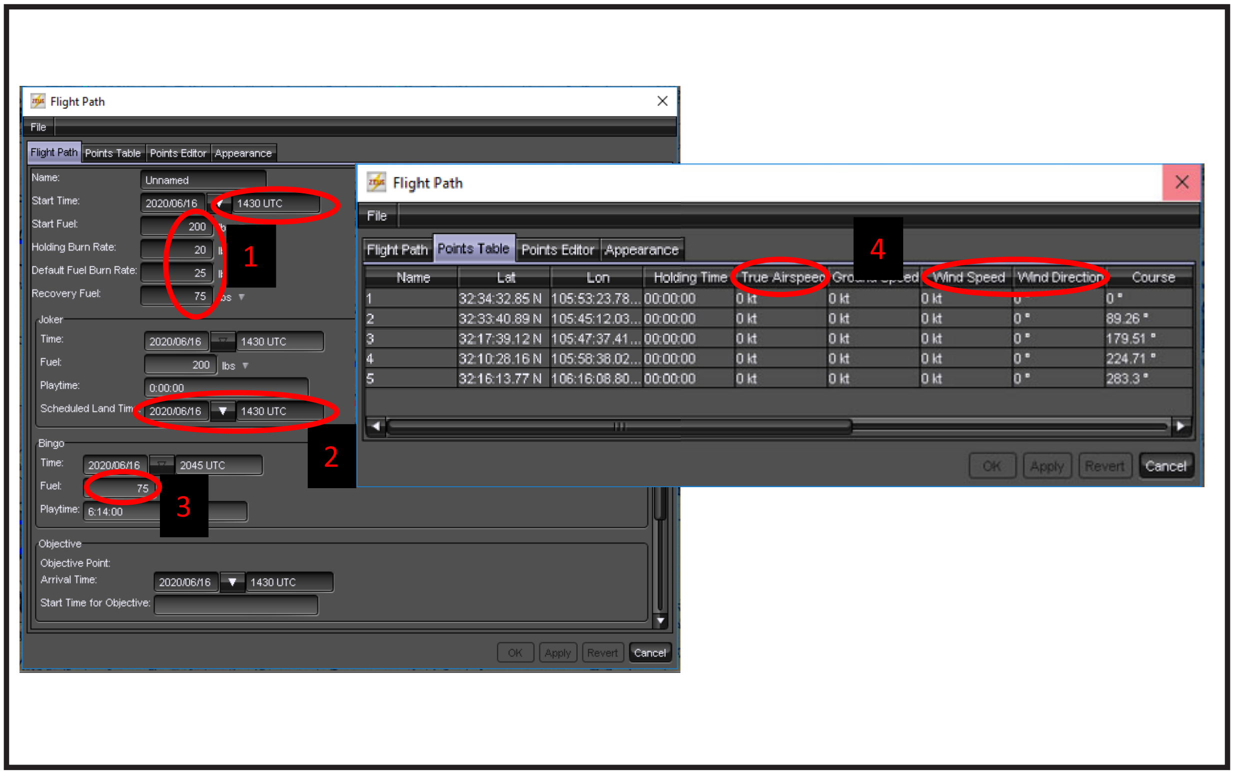


Figure 10.22 Editing a Flightpath.



10.5.2.10 Magnifier. The magnifier, shown in **Figure 10.23**, Magnifier Display, allows you to bring up a second map/imagery display. It is useful for maintaining situational awareness of the target area (zoomed in to imagery) while simultaneously using the TacSit (zoomed out) to maintain situational awareness of aircraft positioning. To display the magnifier select “features > magnifier.”

- Overlays on the magnifier and TacSit are controlled independently. To “pencil on/out” overlay items select “view > magnifier” on the overlay window.

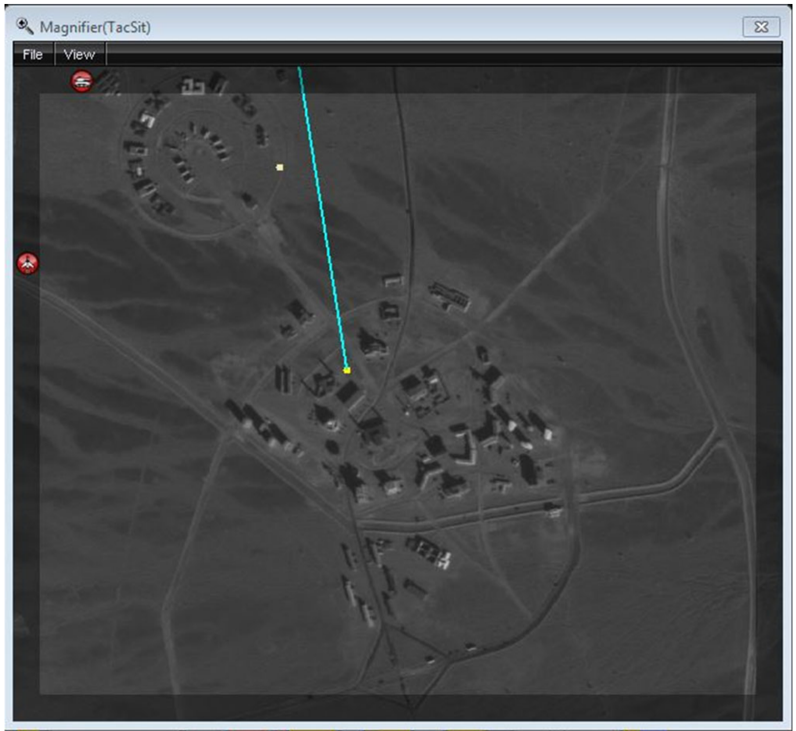
10.5.3 Aircraft Identification. Aircraft will be identified by the JU (shown as JTN on the display) or call sign. For example, Hog 01 flight, a two-ship of A-10s, arriving in the AO will be represented on the link by a notional JU of “12410” and a call sign of “HG01.” MQ-9s will be represented with the following:

10.5.3.1 JU Number. Due to the MQ-9 data link architecture, all MQ-9s using the same MSCT will have the same JU number. (Zeus 2.2.4 and later) if assigned multiple JUs in the OPTASKLINK each aircraft can publish a J2.0 with the JU number. However, sending or receive J28.2 messages will still be from the squadron MSCT JU. Use of specific call signs in messages is required to minimize confusion.

10.5.3.2 TN. Each MQ-9 aircraft may be represented by a J3.2 air track. If not pushing a J2.0, the MSCT will assign each aircraft a TN from assigned track block chronologically.

10.5.4 Publishing J-Series Messages. The following subsections describe how to transmit and receive common J-series messages through Zeus. See **Figure 10.24**, Zeus Data Link Symbology, for depictions of J-series messages.

Figure 10.23 Magnifier Display.



10.5.4.1 J2.0 Indirect PPLI Message. MQ-9s can be published on the TDL network as a J2.0 through the MSCT. In order to accomplish this the squadron must be assigned multiple JU numbers on the theater OPTASKLINK, and those numbers must be loaded into Zeus. For a more in-depth review of the J2.0 message set see **paragraph 10.3.4.1**, J2.0 Indirect Precise Participant Location and Identification. Publishing a J2.0 requires the aircrew to accomplish the following four steps.

- Select Predator Feeds (Zeus 2.0.6 and earlier) or UAV feeds (Zeus 2.2.4) from the Zeus Tracks pull-down menu.
- Select call sign of aircraft to be published as J3.2.
- Select the appropriate link interface under the Link Transmit: pull-down menu.
- Select the appropriate JU under the JU: pull-down menu. See **Figure 10.25**, Publishing a J2.0.

10.5.4.2 J3.1 Emergency Point. To transmit a J3.1 Emergency Point on the left hand side of the Zeus display. The user can then select either "Bailout Link Point" or "Downed Aircraft Link Point." The second step is to either click on the desired point or input the coordinates into the position box. Crews should fill out the remainder of the data fields IAW theater directives. See **Figure 10.26**, Publishing a J3.1, for a graphic depiction of this process.

Figure 10.24 Zeus Data Link Symbology.

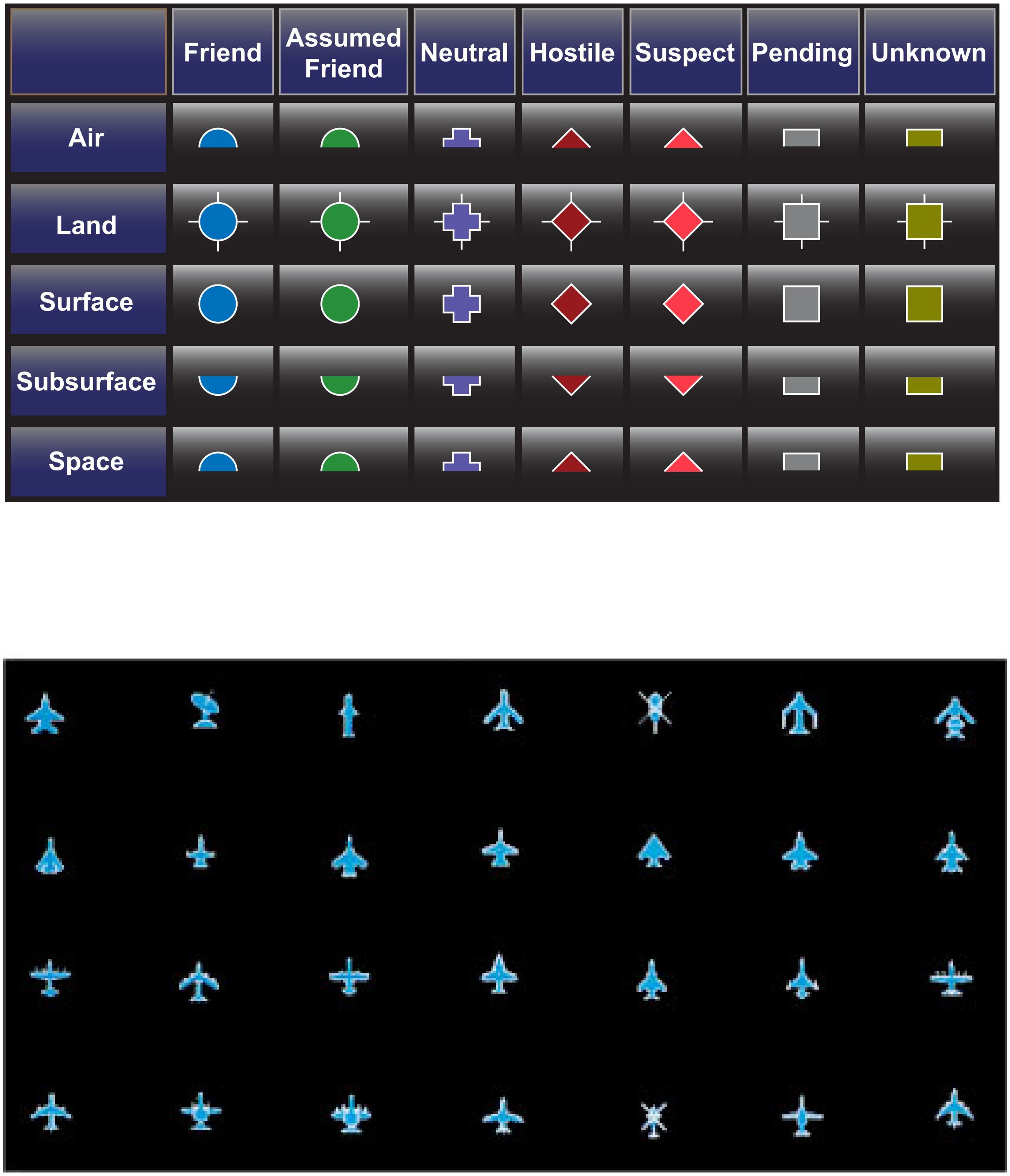


Figure 10.25 Publishing a J2.0.

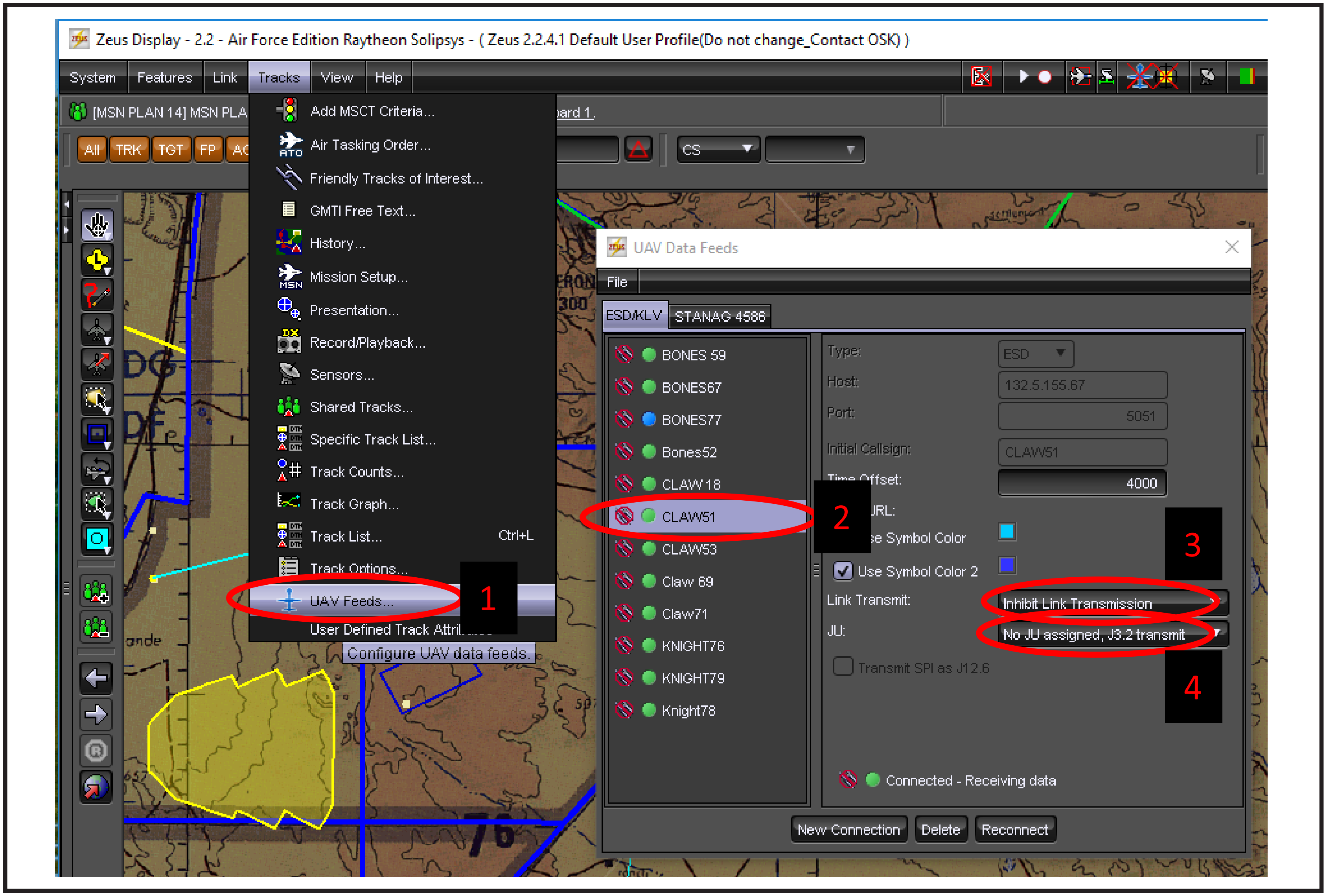
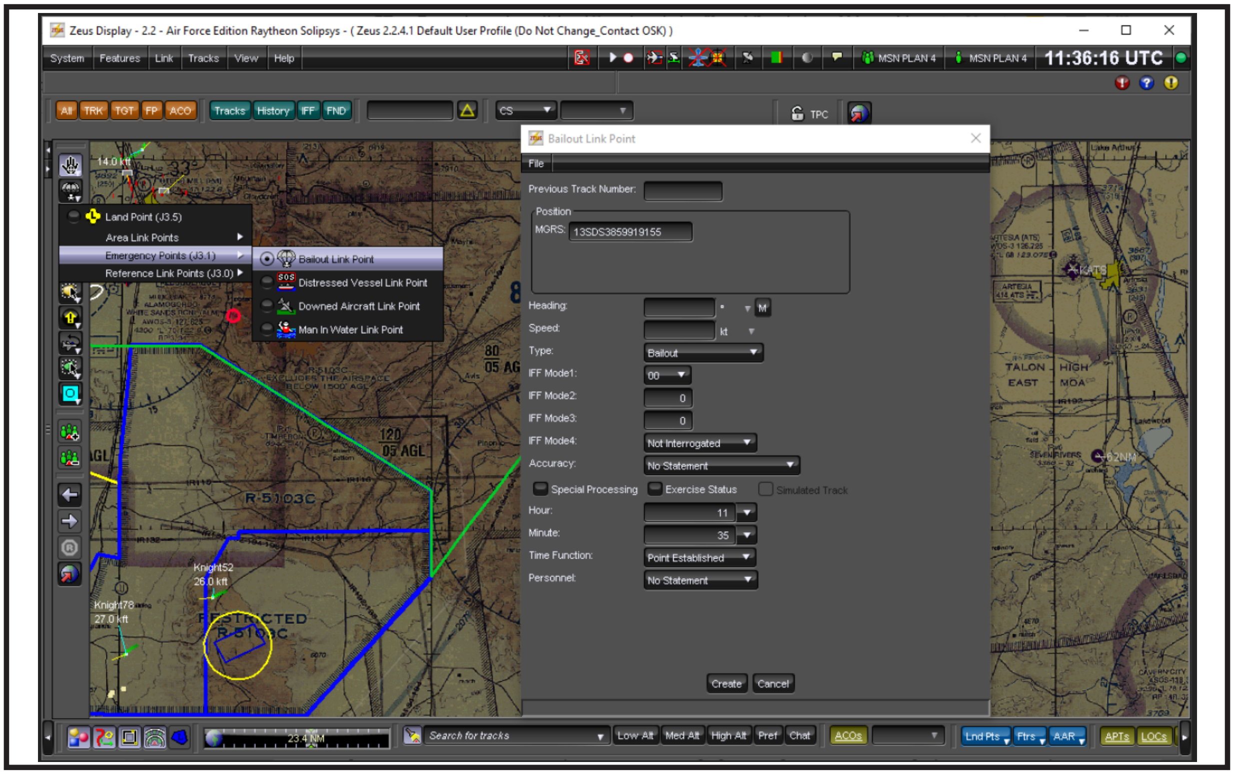


Figure 10.26 Publishing a J3.1.



10.5.4.3 J3.2 Air Track Message. MQ-9s can be published on the TDL network as a J3.2 air tracks through the MSCT. In order to ensure that the aircraft's J3.2 track is actively updated on the link, the aircrew must accomplish the following three steps.

- Select UAV feeds (Zeus 2.2.4) from the Zeus Tracks pull-down menu.
- Select call sign of aircraft to be published as J3.2.
- Select the appropriate link interface under the Link Transmit: pull-down menu. See Figure 10.27, Publishing a J3.2.

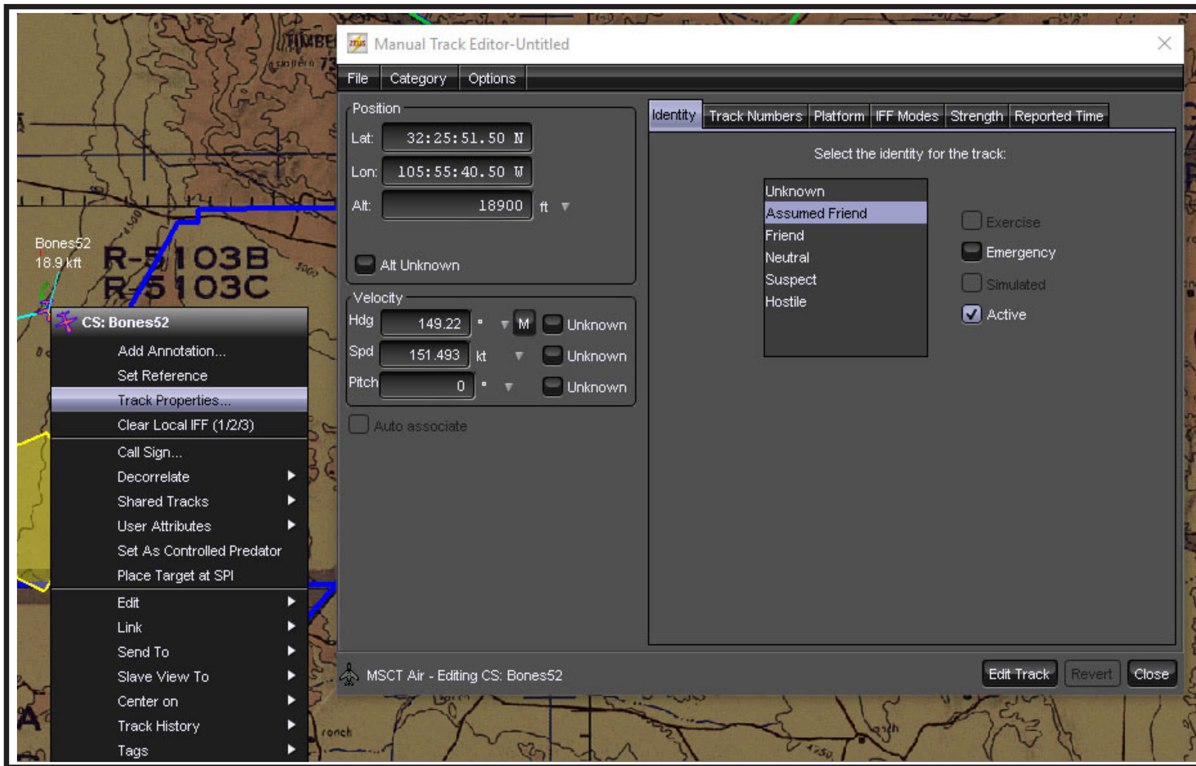
10.5.4.3.1 If the desired aircraft call sign is not present on the Predator Data Feeds window, select Load from FalconView MPF File under the File pull-down menu in the same window.

NOTE: This will reset all J3.2s being transmitted by the MSCT to "Inhibit Link Transmission." All J3.2s will have to be reenabled.

10.5.4.3.2 To change J3.2 properties, right click on the aircraft and select Track Properties. The PIC must ensure the call sign and IFF modes of the J3.2 match those that are in the aircraft. The IFF codes can be changed in the IFF modes tab, while the call sign can be changed in the Track Numbers tab. See Figure 10.28, Changing J3.2 Properties.

Figure 10.27 Publishing a J3.2.

Figure 10.28 Changing J3.2 Properties.



10.5.4.4 J3.3 Surface Track Message. MQ-9 aircrew may publish J3.3 Surface tracks to mark friendly position, targets, or objects of interest in a maritime environment. It is extremely important to remember to maintain and/or delete created tracks. Track location must be kept up-to-date in order to ensure an accurate link picture. Creating and maintaining J3.3s can be task saturating; therefore, aircrew must task-manage data link and all other cockpit tasks and not attempt to maintain too many link tracks to prevent unnecessary link data from being transmitted over the TDL network. See **Figure 10.29**, Publishing a J3.3 for visual depiction. To finish publishing a J3.3 see next paragraph.

10.5.4.5 J3.5 Land Point/Track Message. MQ-9 aircrew may publish J3.5 land points/tracks to mark friendly position, targets, or objects of interest. It is extremely important to remember to maintain and/or delete created tracks. Track location must be kept up-to-date in order to ensure an accurate link picture. Creating and maintaining J3.5s can be task saturating; therefore, aircrew must task-manage data link and all other cockpit tasks and not attempt to maintain too many link tracks to prevent erroneous link data from being transmitted over the TDL network.

10.5.4.5.1 To inject a J3.5 land track, first create a CTTN. To do this, left click the "Land Point (J3.5)" button on Zeus and then click on the desired map location for the J3.5. A Manual Track Editor window will then pop-up. See **Figure 10.30**, Creating a CTTN.

Figure 10.29 Publishing a J3.3.

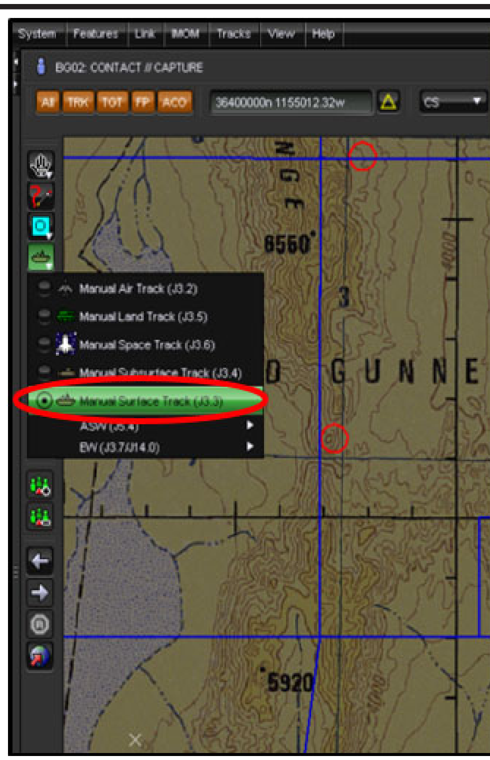


Figure 10.30 Creating a CTTN.

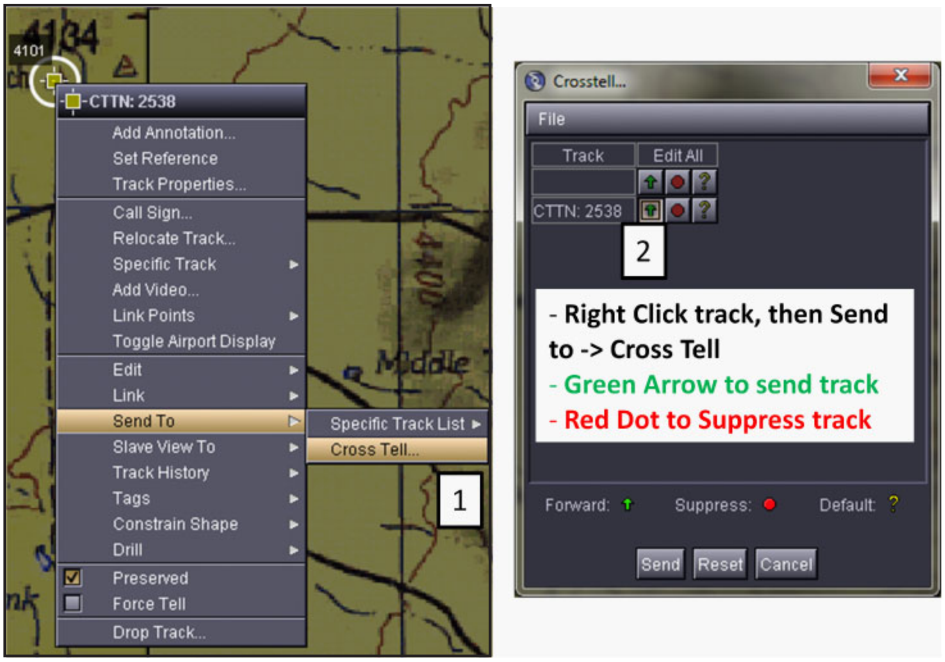
10.5.4.5.1.1 To create a CTTN more efficiently press the "S" key when the Zeus display is selected. Then mouse click on the map at the location you would like the track to populate. Then, J3.5. A Manual Track Editor window will then pop-up.

10.5.4.5.1.2 J3.5s must, at a minimum, contain identification, position (location), platform, and contain the call sign of the owning aircrew. For example, a Roland could be identified as hostile, with precise location determined from the TGP, and platform set to Roland. Theater SPINS will contain further guidance on identification and platform. After the appropriate data is input in the Manual Track Editor, select Create Track. The land point should now be present on the Zeus display as a CTTN. Finally, right click on the point and select Add Annotation to input the call sign of the owner of the track.

10.5.4.5.2 The CTTN will only be visible to users of the same MSCT. If the aircrew desires to make the track available to all participants of the TDL network they need command the MSCT to publish the track. Right click on the CTTN, highlight Send To, and select Crosstell. This will bring up the Crosstell window, where the user can press the green arrow to publish the track to the TDL. The CTTN should then transition to a J3.5 message with a JTN. See **Figure 10.31**, Publishing a J3.5.

- To publish a J3.5 to Link 16 more efficiently, primary hook the CTTN and press "Shift+S," which will bring up the Crosstell window.

Figure 10.31 Publishing a J3.5.



10.5.4.5.3 The aircrew should remove Land Tracks when they are no longer tactically relevant, such as at mission completion or if the track can no longer be accurately maintained. The aircrew have two options; suppressing a track or DROPPING a track. To suppress a track, depress the red circle button in the Crosstell window. This will remove the track from the TDL network but maintain it on the MSCT as its original CTTN. See Figure 10.31, Publishing a J3.5, for a reference to the Crosstell window. To remove a track completely from the TDL network and the MSCT, the user must DROP the track. To DROP a track, primary hook the track and press “delete” (or right click on the track, uncheck Preserved, and select Drop Track). See Figure 10.32, Dropping a J3.5.

Figure 10.32 Dropping a J3.5.

10.5.4.6 J12.6 Target Sorting Message. To publish a J12.6 the MQ-9 must be transmitting a J2.0 Indirect PPLI. For more information regarding J2.0 messages see **paragraph 10.3.4.1**. In order for other Link 16 players to see the J12.6, the JU associated with the J2.0 must be "Donarized" by the receiving asset. This contract should be established during mission planning if required for mission execution. To publish a J12.6 follow the steps detailed in **paragraph 10.5.4.2**. Once the aircraft is pushing J2.0 select the box labeled "Transmit SPI as J12.6." For a visual depiction of this process see **Figure 10.33** Publishing a J12.6.

10.5.4.7 J28.2 Text Message. The J28.2 message is a free format alphanumeric text option to communicate with J28.2 capable assets. It is essential to know the receivers display capability prior to sending any J28.2 messages. For example, an A-10 can only display 28 characters per line. Any text beyond the 28th character will not wrap around to the next line on the MFD or be displayed. Reference Theater SPINS for further guidance on J28.2 usage.

10.5.4.7.1 To send a J28.2 text message with Zeus 2.0.6, first open the JChat window by double-clicking on the "JChat Indicator" button. See **Figure 10.34**, J28.2 Message Example. Select the JU number of the asset to be messaged. The available JU numbers will be displayed on the left side of the JChat window. To determine the JU number of an asset, either reference the expanded data by clicking on that asset in Zeus, reference the mission cord card, or look it up in OPTASKLINK.

Figure 10.33 Publishing a J12.6.

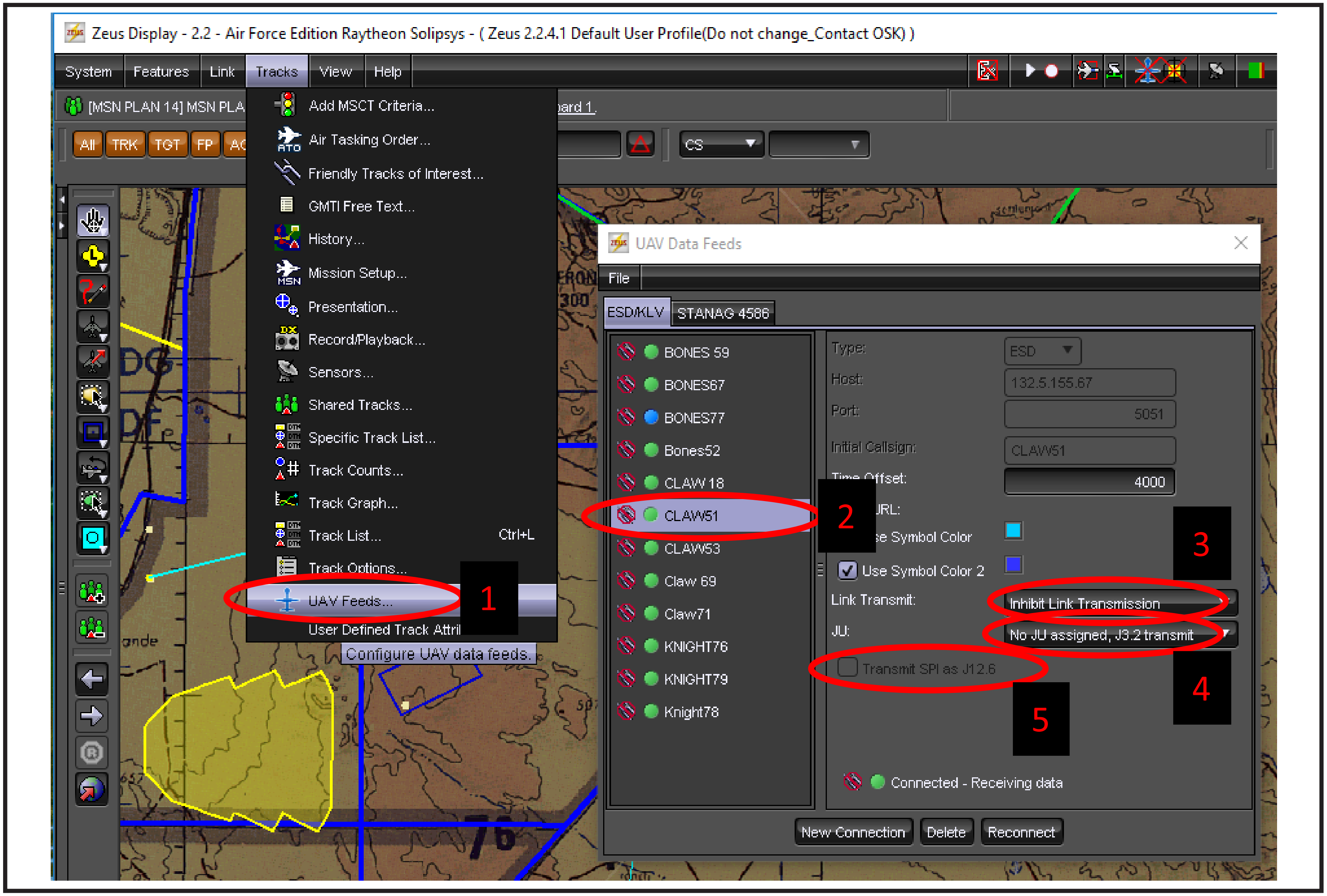
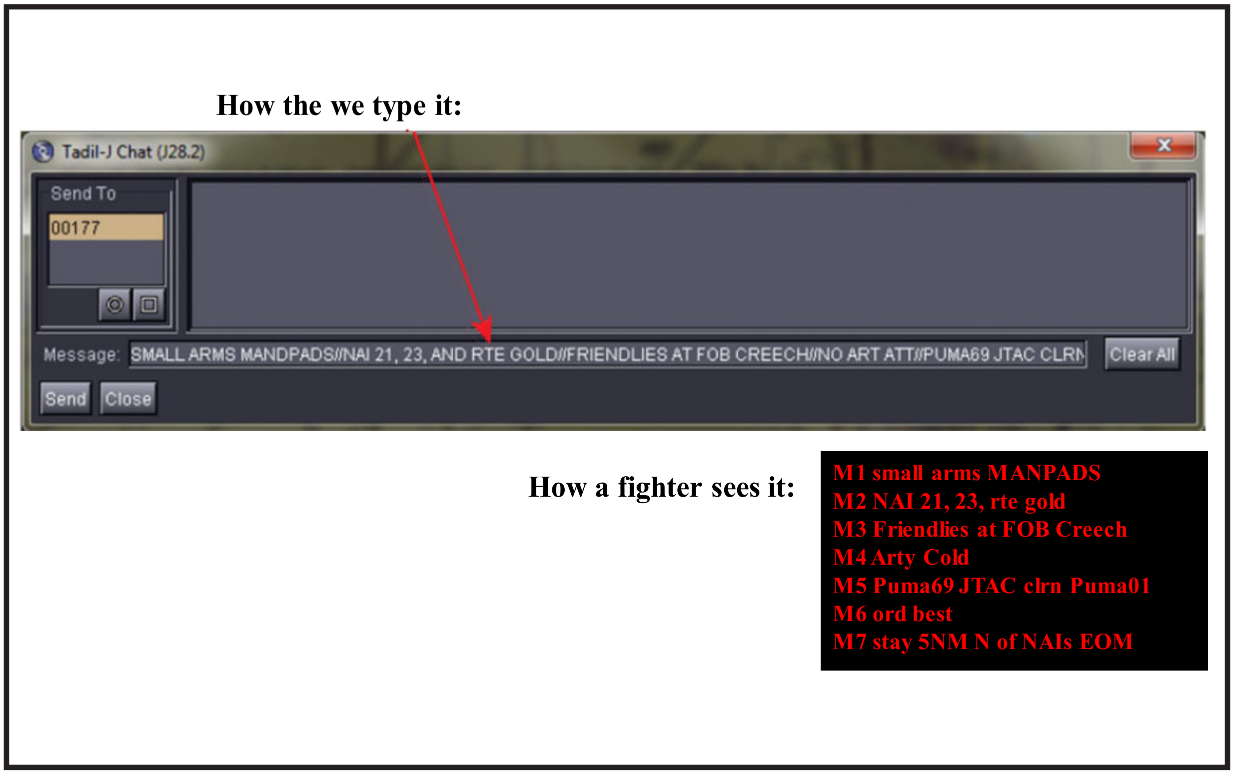


Figure 10.34 J28.2 Message Example.



10.5.4.7.1.1 To send a J28.2 text message with Zeus 2.2.4, select the JU number of the asset to be messaged in the chat window shown in **Figure 10.35**, Chat Window. See **Figure 10.34**, J28.2 Message Example, for limitations of other 28.2 capable platforms. The available JU numbers will be displayed on the chat window once clicking the '+.' To determine the JU number of an asset, either reference the expanded data by clicking on that asset in Zeus, reference the mission cord card, or look it up in OPTASKLINK.

10.5.4.7.2 When using a J28.2 it is important to format the message in a way the receiving platform can display and is easy to read on a small screen. A good rule of thumb is to pass less characters and more lines to avoid text wrapping. Label each line of the message. For instance, if sending a description, location, elevation, remarks (DLER) target message label each line. The last line of the message should end with the acronym EOM (end of message) to signify that all data has been passed. By labeling each line of the message, the receiving platform can easily determine if they have received the entire message or if some lines are missing.

10.5.4.7.3 Different platforms have different capabilities when it comes to sending and receiving J28.2 messages. See **Table 10.3**, 28.2 Character per Line Limitations, for limitations for the most common assets with limitations.

10.5.4.7.4 Type the message in the Message container. To begin a new line, users must type "//." See **Figure 10.34**, J28.2 Message Example. When the message is complete, press the "Send" button to transmit.

Figure 10.35 Chat Window.

Table 10.3 Character Per Line Limitations.

MDS	Character Per Line
F-15E	44
F-16	36
A-10C	28
HH-60	15
B-1	1,000
B-52	13,000
HC-130	No limitations
JTAC	No limitations

10.5.5 TDL Brevity. Use the terms described in **Table 10.4**, TDL Brevity Terms, when communicating with other data link players. See AFTTP 3-2.5, *Brevity*, for further information.

Table 10.4 TDL Brevity Terms.

Brevity	Definition
CHECK TIDS	Directive/descriptive call to reference data link display and may be followed by amplifying information.
CONTACT	Acknowledges sighting of a specified reference point either visually or via sensor. In this case data link info.
DATA (object, position)	Standby for data link message concerning object at stated location.
DIRTY	Link is not encrypted.
DONORIZE (D)	Aircraft data has been input into the host aircraft as a flight, team, or donor to enable target/data sharing among tactical data link participants.
DROP(PING)	(TRACK___) Remove (Removing) the emitter/target from tactical picture/track stores.
HOLLOW	Any data link message not received.
(expect) HOLLOW	A condition that will likely exist limiting video data link reception (e.g., maneuvers, terrain).
HOOK (descriptor)	Data link directive call to cue sensors to described point (e.g., point of interest, SAM, markpoint, or TN, etc.).
INDEX	Unique number assigned to a tactical data link J12.6 message to differentiate between more than one POINT or MARKPOINT.
MARKPOINT	Data link nondesignated geographic point of interest (J12.6 SID 9 message).
(type) POINT	Data link sensor point/track of interest, such as the J12.6 SID 10 data link message.
CONTACT POINT	Indicates the fighter has acquired the TOI track number on their data link.
DROP POINT	Data link target sorting message is no longer needed/desired.
HOLD POINT	Maintain weapons quality track data
TARGET POINT	Target the referenced data link target sorting message. (example, "*IRON FOUR, TARGET IRON ONES **POINT***")
TIMBER	Link 16 network
TIMBER CHANNEL	Stacked net within a Link 16 Network.
TRACK NUMBER (#)	Data link information file.
ROVER	Platform is video downlink capable
(system) SILENT	Data link is, or should be placed, in receive only.
(link name) SWEET	Confirms receipt of data link information (e.g., TIMBER SWEET).
(link name) SOUR	Potential problems with net entry; initiates link troubleshooting
ZAP	Request for data link information (e.g., "ZAP POINT," "ZAP DATA")

10.6 Link 16 Resources.

- *Understanding Link 16: A Guidebook for USAF Operations* (September 2008). Copies are available through the AF Link 16 Network Design Facility, HQ ACC/A3YJ. Contact unit Weapons Officers for access.
- USAF Weapons School Papers. Refer to *Integrating MSCT Into MQ-1/9 Link 16 Operations,* by Captain Nicholas Pederson, Class 10A, June 2010; *MQ-9 Digitally Aided SCAR,* by Captain Timmy T. Wang, Class 17A, June 2017; and *MQ-9 Link 16 Handbook,* by Captain Garrett J. Wheeler, Class 19B, June 2020.
- AFTTP 3-3.IPE, Attachment 7, "Tactical Data Link Employment Standards," April 2020.

10.7 Improved Many on Many. Improved many on many (IMOM) provides electronic warfare modeling for the user. It is a plug-in application for Zeus that provides functionality for analysis during mission planning and near real time processing of data link messaging during execution for the purpose of the following.

- Radar coverage analysis constrained by parametrics, terrain, and aircraft RCS.
- The radar detection feature of IMOM will automatically populate threat rings on J3.5 Link 16 tracks that have the "specific type" track property populated.
- Weapon system threat envelopes.
- Acoustic detection capabilities.
- Mission plan against listening posts, visual observers, and residents to determine audible detectability at various altitudes.

10.7.1 IMOM Server Setup. The IMOM TDF server is installed on the Zeus display-server computer and publishes settings to all the clients connected to that server. Server setup should only be accomplished by a qualified technician or IMOM SME.

10.7.2 Aircrew IMOM Setup. Prior to opening the Zeus client launch IMOM using the desktop shortcut. This will launch the window displayed in **Figure 10.36**, IMOM TDF Server, and attempt to connect to the IMOM server. Once that window displays two green "connected" containers launch the Zeus client.

10.7.2.1 Once you have launched and fenced in all other features of your Zeus client open the IMOM analysis properties window, as shown in **Figure 10.37**, IMOM Setup. Then select the "Altitudes" tab and ensure you planned or current altitude is displayed and press OK.

10.7.2.2 Once that is complete, reference the IMOM toolbar shown in **Figure 10.38**, IMOM Toolbar. The IMOM Toolbar should be displayed in the bottom right of the TacSit. On the IMOM Toolbar select planned or actual aircraft altitude using the drop down menu. Then select which IMOM feature to use by highlighting one of the four square containers on the IMOM toolbar.

10.7.2.3 IMOM Features. For additional information on IMOM and how to use the acoustic and line of sight features, refer to Capt Bradford "Crush" Wade's Weapons School paper, *RPA Integrations of Improved Many on Many*, on the USAFWS SIPR website.

Figure 10.36 IMOM TDF Server.

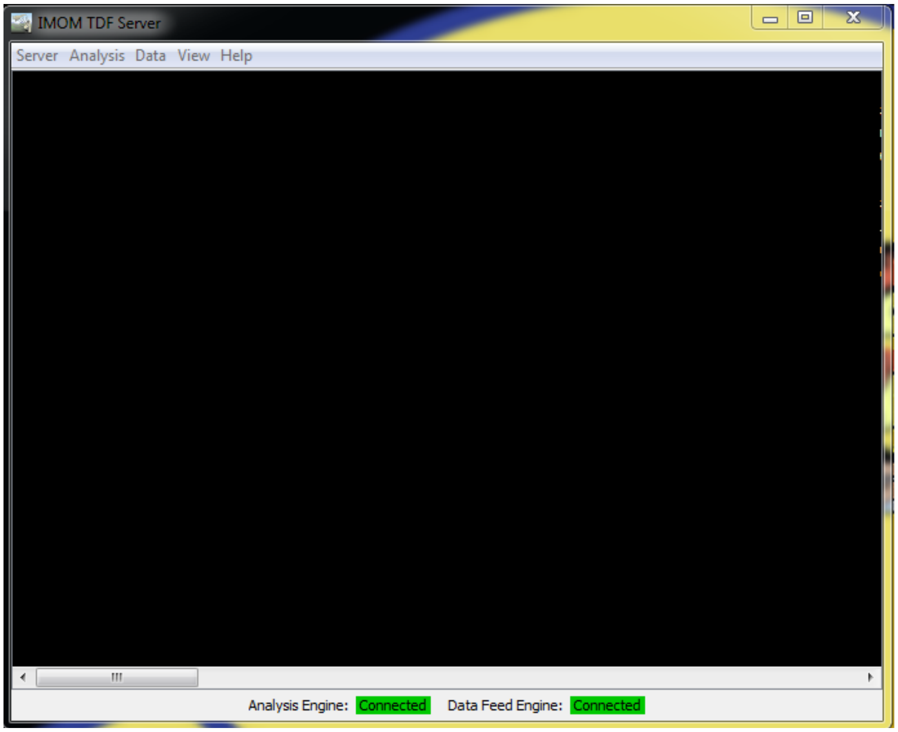


Figure 10.37 IMOM Setup.

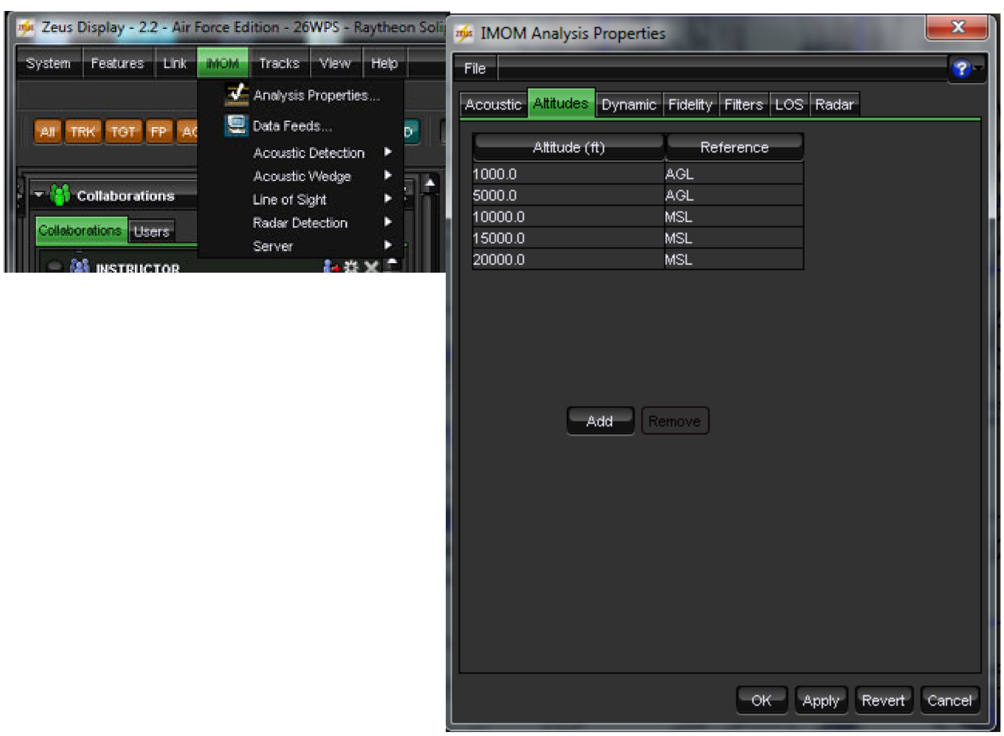


Figure 10.38 IMOM Toolbar.

10.8 Debrief.

10.8.1 Fence.

10.8.1.1 Zeus should be fenced in for debrief IAW the Zeus Fence section from earlier in the chapter.

10.8.1.1.1 Additionally, select features > playback to display the playback window in **Figure 10.39**, Zeus Playback.

10.8.1.1.2 To view history trails hook the desired track after playback has started and click the blue history button. See **Figure 10.40**, Track Display Options.

10.8.1.1.3 Recommended playback speed for debrief is 10x.

10.8.1.1.4 To play/pause playback use the pause button. Using the stop button will cancel the current playback, requiring to reload the playback file.

10.8.1.1.5 Seek: seek to a time in playback in two different ways, actual (A) or relative (R). Seeking to an actual time seeks to the Zulu time. Seeking to a relative time seeks to that number of hours/minutes/seconds into the recording (time from when the record button was pressed).

Figure 10.39 Zeus Playback.

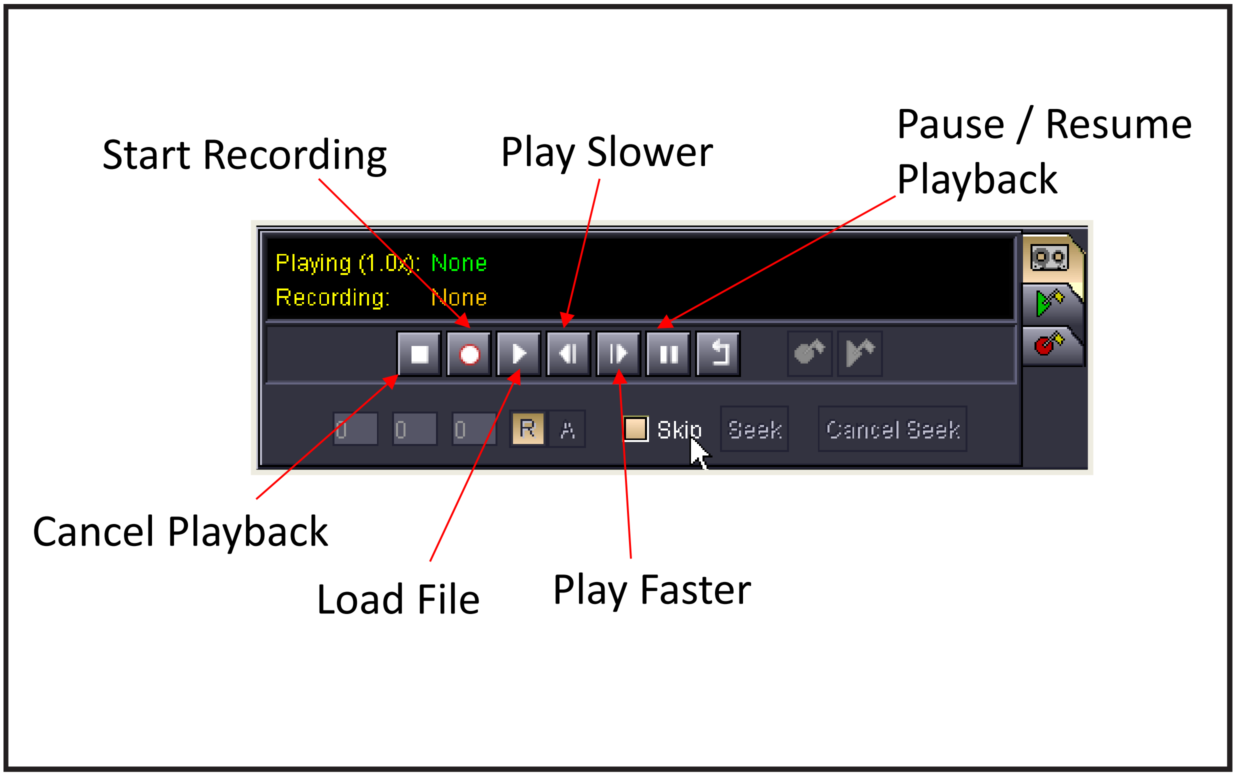


Figure 10.40 Track Display Options.

10.9 Internet Relay Chat. mIRC is an Internet relay chat (IRC) client software. mIRC gives the user near real time (NRT), text based, multi-participant means of communicating. mIRC allows for predominantly jam-free communications, similar to encrypted radio-voice communications, such as KY100. mIRC is employed by C2ISR assets, control and reporting centers (CRC), AOCs, strike cells, and RPAs.

10.9.1 mIRC Servers. mIRC works by relaying inputs from all users through a central server. Most combined commands (COCOM) have at least one server for communication, however, it is possible to have several servers in one theater of operations.

10.9.2 mIRC Terminology.

10.9.2.1 Channels. Most communication on mIRC is passed in windows with multiple people in them, referred to as channels by the software.

10.9.2.2 Private Messages/Whispers. It is possible to open a window with only yourself and one other user, called a "private message," or "whisper." A whisper can be opened by double clicking a user's nickname or using the /MSG command. This whisper will not be seen by any other users other than the user you are messaging, therefore, information that directly impacts the mission should not be whispered.

10.9.2.3 Nicknames/Call Signs. Your nickname is the series of letter and numbers that identify you in mIRC. Nicknames cannot begin with a number and cannot have symbols. Nicknames can be changed by typing the /nick command in any open chat room. For MQ-9 operations, the pilot will use call sign XX.P, and the sensor operator will use call sign XX.SO.

10.9.3 mIRC Operations. mIRC offers a number of commands that alter the use and function of the program.

10.9.3.1 Options Window. The options window controls a large number of the program options available. It consists of a menu tree on the left and various options on the right. To bring up the options window, do the following:

- Keyboard: Alt+O.
- Toolbar: Hammer+folder button.
- Menu Option: Tools, Options.

10.9.3.2 Command Line. Commands are words and symbols that can be typed into the "edit box" (the line at the bottom of a chat window that shows what you have typed before sending it). Commands will allow you to change the operation of the program. See **Table 10.5**, Common Command Line Functions, for more details.

10.9.3.3 Editing Text Appearance.

- Ctrl+B for bold text.
- Ctrl+U for underlined text.
- Ctrl+R for reversed text.
- Ctrl+K for colored text.
- Ctrl+O for normal text.

Table 10.5 Common Command Line Functions.

/JOIN# channel	Join a specific channel; example: /join#irchelp
/PART#channel	Leave a specific channel; example: /part#irchelp
/LIST[#channel][-MIN#][-MAX#]	Lists currently available channels. You can also tell mIRC to show only channels with a minimum and maximum number of people. If you specify a #channel, mIRC will only list results for that channel. If you specify wildcards, e.g., *MQ-9* mIRC will list all channels that contain the word "MQ-9." Placing asterisks on either side allows for variations in the preceding or following text; without asterisks, an exact match to "MQ-9" is required.
/MSG [nickname][message]	Sends a private message to the nickname listed without opening a query window. Example: /msg Reaper26 P say ready tasking
/NOTICE [nickname][message]	Sends a private message to the listed nickname's active window without opening a new dialog container. Example: /notice Reaper26 P avoid ROZ Tigers
/QUERY [nickname][message]	Opens a query window to the listed nickname and sends a private message (whisper). Similar to /MSG but forces a new dialog box to open.
/NICK [nickname]	Changes your nickname. Example: /nick Reaper26 P
/TOPIC [#channel][newtopic]	Changes the topic for a channel. You can also double click on the channel window and a dialog will appear. Example: /topic #26 WPS Mission

10.9.3.4 mIRC Abbreviations. Common abbreviations in mIRC are as follows:

- C: copy.
- Cip: check in please.
- Go: go ahead.
- n/s: nonstandard.
- pls: please.
- rgr: roger.
- ty: thank you.
- wspr: whisper.
- dr: disregard.

10.9.3.5 There are many ways to customize a mIRC profile to highlight text to the user. For example, bolding and changing the color of any line of text that contains your aircraft call sign. Settings should be customized based on mission requirements. Below is a list of recommended generic settings.call sign - light blue nickname and message.

- CFAC/JFAC (or applicable call sign)—magenta nickname and message.
- *HOT*—red, message only.
- *COLD*—blue, message only.
- *ECHO*, *TIC*, *SAFIRE*, *ROZ*—red, message only, case sensitive.
- *WPN*, *weapon*—yellow, message only.

10.9.3.6 Colors:

- mIRC Classic Theme.
- Nick text—lime green.
- Normal text—gray.
- Own text—light blue.
- ADDRESS BOOK.
- Sq (e.g., 26WPS)—turquoise.
- C2 call sign/airspace controllers—orange.
- *JTAC*—red.
- *SCR*, *DGS*—lime green.

10.10 Minotaur. The Minotaur System provides aircrew with real-time "Google Earth-style" maps displaying multi-source intelligence. Using the interactive map with 3D topographical plots, Minotaur automatically transports aircraft FMV to automatically detect and classify movement as well as display geographic information outside the current TGP field of view. The operator can input overlays, including markups and GRGs onto the maps. The map within Minotaur also supports cross-cuing like CLAW, discussed in **paragraph 10.10.5**, Cross-Cue. If the user clicks "F1" on the keyboard, it will bring up the help screen which displays all the hot-key options and the "Minotaur User Guide."

10.10.1 Start-Up. Before starting a mission, post-gaining handover, or the during the FENCE it is recommended that the user restarts the Minotaur software through the "Start (New Mission)" option. The "Start (New Mission)" option is necessary in order to end the previous mission and archive it for future use in "Mission Playback Mode," see **paragraph 10.10.1.1**. If Minotaur is currently active (map actively displayed on the screen/normal operations) right-click the map and mouse over "Software Restart," then click "Start new mission." If Minotaur has been shut down (black screen with the words "Minotaur" at the bottom right), click and hold the right mouse button on the black screen. Mouse over to the "Start Minotaur Ground Station," mouse over the drop-down menu to either "Start" or "Start (New Mission)." The option, "Restart Minotaur Software," does not archive the data and serves as a soft reboot of the system.

10.10.1.1 Mission Playback mode is a mode within Minotaur that allows the user to replay previously saved missions. Missions are saved whenever the user "Starts a New Mission."

This function can be used for quick debriefs within a cockpit or review of prior mission targets. In order to access this mode, the user will right-click the map (or the black Minotaur title screen if the system is powered off) and mouse over "Software Restart," and click the "Start In Mission Playback Mode" option to boot up the system in mission playback mode. After the system has booted up, the user can select a previous mission to replay. To do this the user must mouse over to the top left of the screen where the toolbar on the operator GUI lives. The user will then select the "Mission" tab and a drop-down should appear, allowing the user to choose the option "Mission Loader." After selecting this menu, the user can now select one of the previous missions that are stored in the minotaur system for playback. The missions are titled the date and time when the user created a new mission.

10.10.2 Minotaur Display Set-up. Minotaur has five displays that the user can manipulate. See **Figure 10.41**, Minotaur Display Layout. The Interactive Display (Main-Screen), Integrated Information Box (Bottom Toolbar), Quick Action Display Toggles (Right-Side Toolbar), Video Viewer (Bottom-Left Corner), and Operator GUI's (Left-Side Toolbar).

10.10.2.1 Interactive Display. Geographic Display Options consist of user-selectable map types, user-selectable map layers, user-selectable display units, street and pathway databases, background reference imagery, and terrain elevation databases. Real-time sensor display options are aircraft track, TGP full-motion video, VADER detections/tracks/contacts-of-interest, Video Moving Target Indicator (VMTI) detections/tracks/classifications, and user-selectable track histories with associated imagery. The User-Defined Markup Options are reference points, drawings, target projections, and alerts/highlights. Around the feed, a colored box will be present to indicate image stabilization and/or georeferenced (GEOREF). GEOREF means that the feed is located accurately where the grids are displayed, and image stabilization means the image from the feed matches the image on the map. A green box indicates good GEOREF and stabilization. A yellow box indicates either good GEOREF or stabilization. A red box indicates either GEOREF or stabilization is currently out of alignment. A fix to the yellow or red box around the feed is to zoom out a FOV; this allows Minotaur to take in more area for its GEOREF. When in fused or split-screen, the colored box will most likely be red and possibly yellow as it will struggle to either GEOREF or stabilize.

10.10.2.2 Integrated Information Box. See **Figure 10.42**, Integrated Information Box. The user can open/close the Action Menu. Inside the Action Menu, the operator can "Show Display Controls" expands the operator GUI's display, "Show TASR" enters tactical all-source replay (TASR) mode and displays TASR GUI, "Hide TASR" exits TASR mode and hides TASR GUI, and "Software Restart" can Restart Minotaur Software or Start New Mission. Inside the Options Menu, the operator can change Measurement Systems (Standard or Metric), and change Coordinate Notations (DMS-degrees:minutes:seconds, DMM-degrees:minutes:decimal minutes, Decimal degrees, and MGRS). It is recommended that the user swap these settings to represent what will be used during the mission, most likely metric and MGRS. A search box is also an option for the user. In the search box, the operator can type track number or track name, type coordinates, reference points, or type a Zulu time to find different information that the operator has imputed into Minotaur.

Figure 10.41 Minotaur Display Layout.

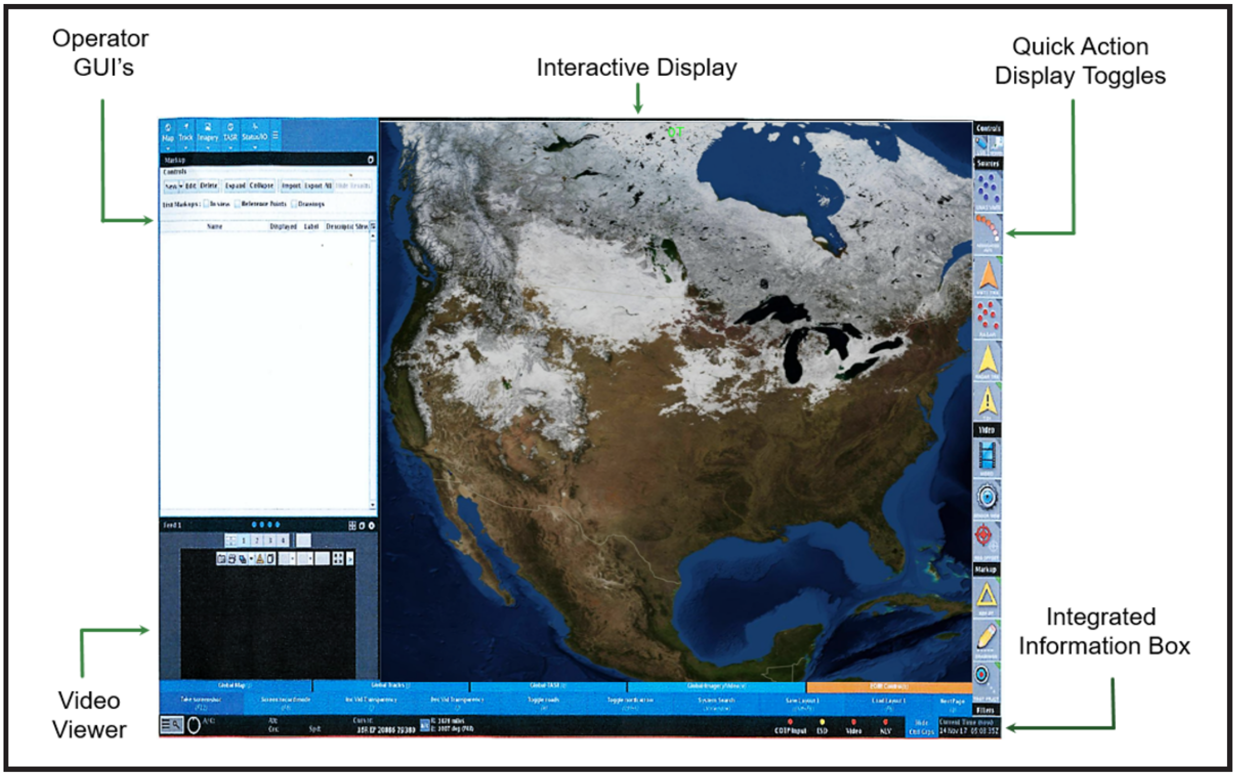
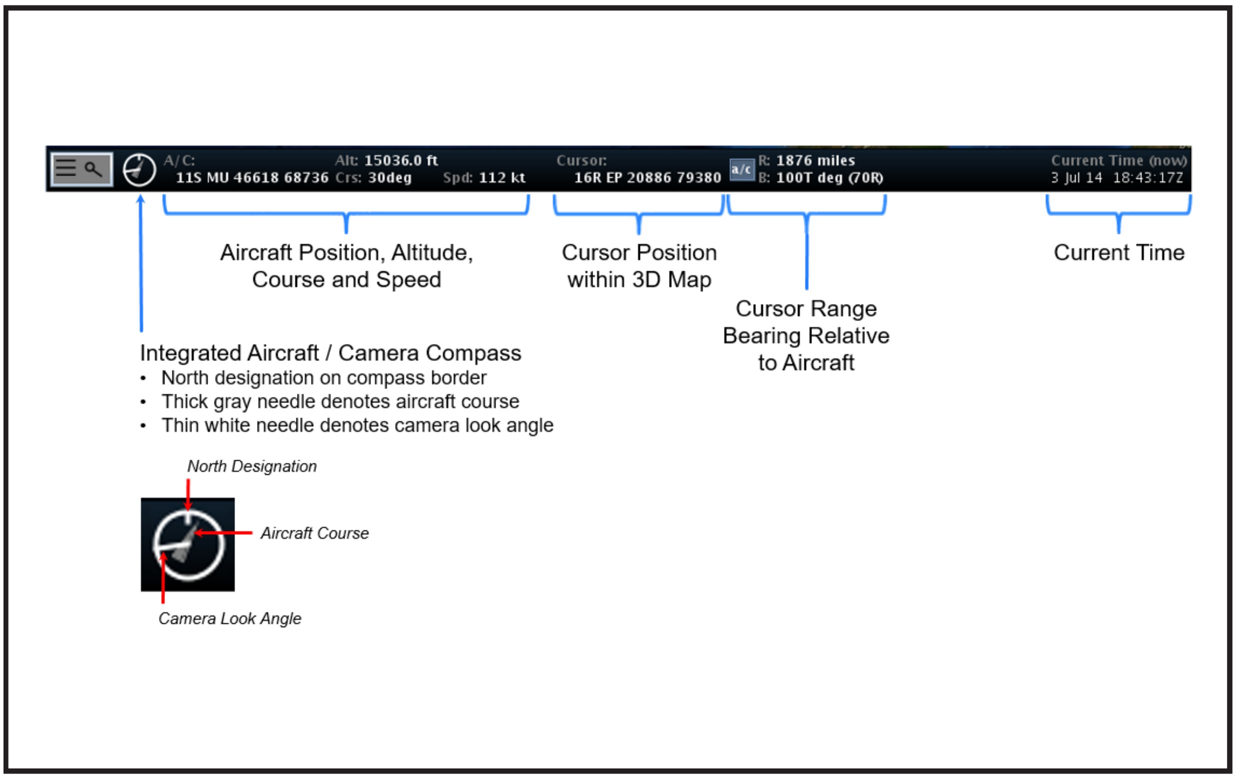


Figure 10.42 Integrated Information Box.



10.10.2.3 Quick Action Display Toggles. Consists of five different sections of different information to choose from. “Controls,” “Sources,” “Video,” “Markup,” and “Filters.”

10.10.2.3.1 Controls. Under the “Controls” section, the user can choose “USB” (unmounts a USB device), and “Top Down” (Re-centers Display in Top-Down North-Orientation over Current Display Center).

10.10.2.3.2 Sources. Under the “Sources” section the user can choose “UNAS VMTI” (unassociated VMTI detections), “ASSOCIATED VMTI” (associated VMTI detections), “VMTI TRK” (VMTI tracks), “RADAR” (VADER detections), “RADAR TRK” (Vader tracks), and “TOI” (VADER contacts-of-interest). See **Figure 10.43**, Quick Action Display Toggles Display Icons.

10.10.2.3.3 Video. In the “Video” section, the user can choose “VIDEO” (Full-Motion video display), “SENSOR VIEW” (Full-Motion video in Sensor View), and “REG OFFSET” (Full-Motion video Geo-Registration correction offset display).

10.10.2.3.4 Markup. The “Markup” section, the user can choose “REF PT” (User-Defined reference points), “DRAWINGS” (User-Defined drawings), and “TRGT PRJCT” (User-Defined target projections). While VMTI is on the operator can toggle “CLASS” Under the “Filters” section to get returns on vehicles, walkers, or unknown (if the system does not recognize the moving object). See **Figure 10.44**, Filters.

Figure 10.43 Quick Action Display Toggles Display Icons.

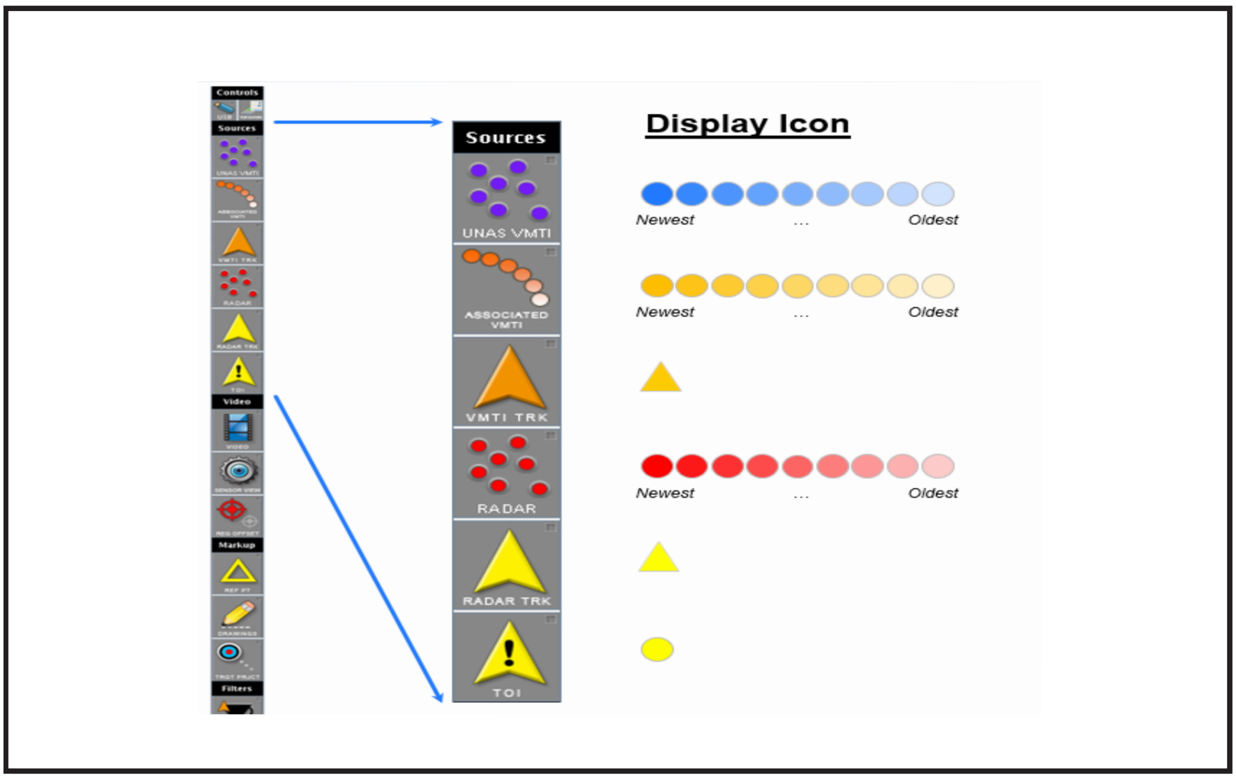
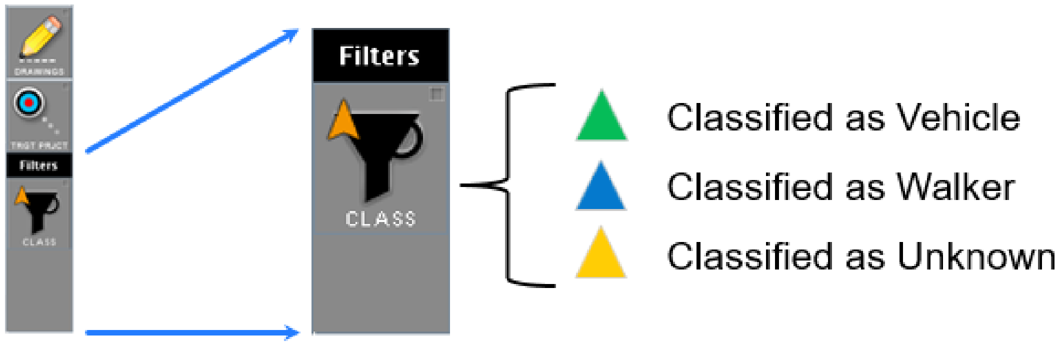


Figure 10.44 Filters.



10.10.2.4 Video Viewer provides the capability to display up to four simultaneous full-motion video feeds (one local feed under direct control by SO, up to three remote feeds from other sources). See **Figure 10.45**, Video Viewer. The user can also take snapshots and recordings of the individual feeds with the "Take Snapshot" and "Record Video" buttons. The videos will be saved in the imagery table under the "Imagery" tab of the operator GUI.

10.10.2.5 Operator GUI's. Consists of six tabs the operator can choose from. See **Figure 10.46**, Operator GUI. The six sections are Map, Track, Imagery, TASR, Status/IO, and Layouts. An additional option for mission appears in mission playback mode.

10.10.2.5.1 Map. Selection of geographic display content/definition and selection of user-defined markup. From this tab, the operator can see what reference points have been put into Minotaur. The operator can also check and uncheck the different targets that are on the list to display or hide the object from the map. Also, from this menu, the user can create, edit, and delete reference points and shapes such as polygons, lines, and circles. The user can also change the type of map that is displayed on the "Interactive Display."

10.10.2.5.2 Track. Selection of track and detection displays content/track search functionality. From this tab, the operator can change the frequency of VMTI tracks to display on the "Interactive Display."

Figure 10.45 Video Viewer.

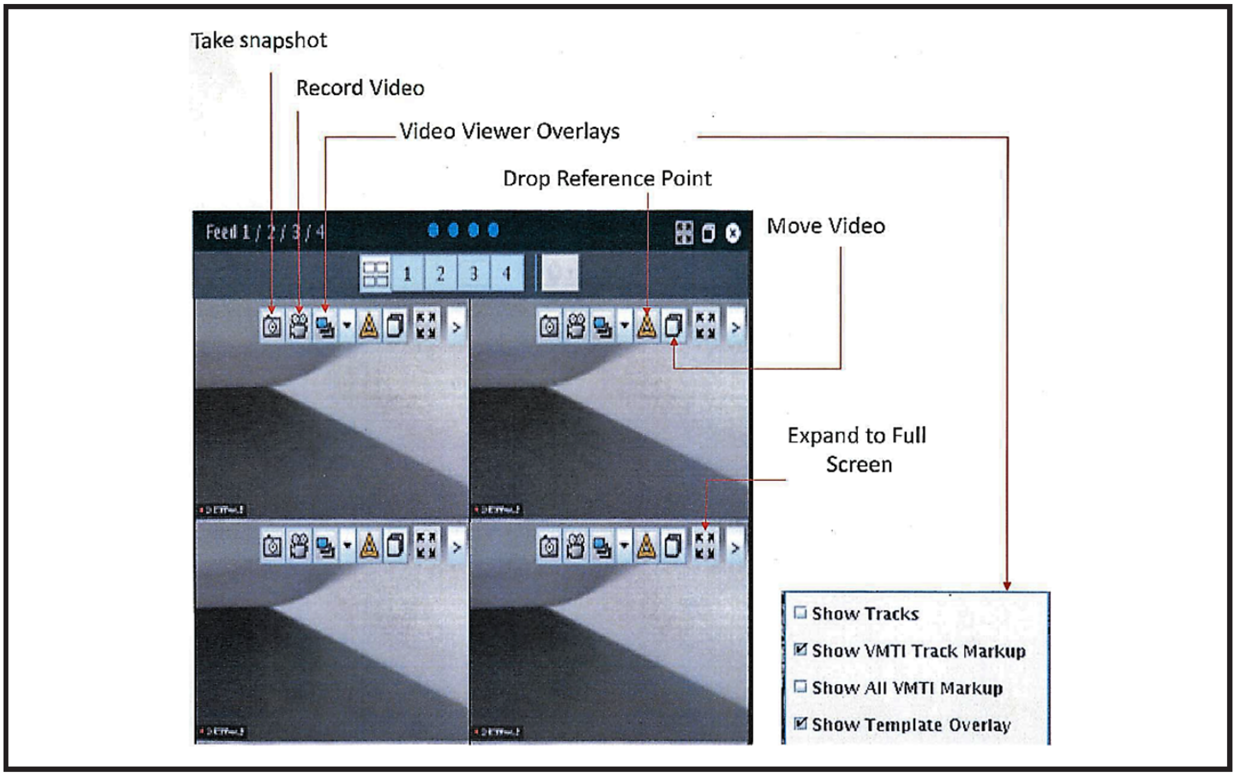
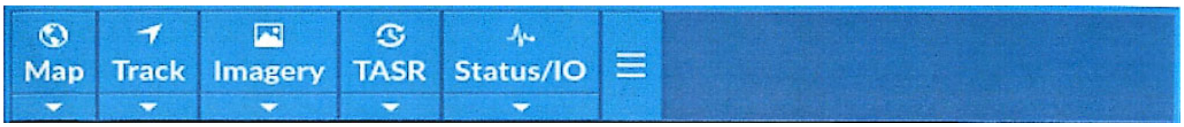


Figure 10.46 Operator GUI.



10.10.2.5.3 Imagery. Imagery is a listing of collected imagery snapshots and video clips/configuration of Minotaur server for video feed ingest/display of video exploitation performance statistics. From this tab, the operator can access all screenshots or recordings they have made. Screenshots of the whole system can be taken by either clicking "F8" on the keyboard or, as discussed in **paragraph 10.10.2.4**, from the snapshot button in the video viewer. Recordings can be taken in the video viewer of specific feeds or the entire system by clicking "F12" on the keyboard and selecting record on the toolbar that appears at the bottom of the screen.

10.10.2.5.4 TASR (listing of operator bookmarks for the current mission). From this tab, the operator can edit or return to bookmarks they make in TASR.

10.10.2.5.5 Status/IO. The status/IO panels are related to Minotaur status, mission export, etc. This tab serves as a more detailed screen to display the status of the Minotaur system.

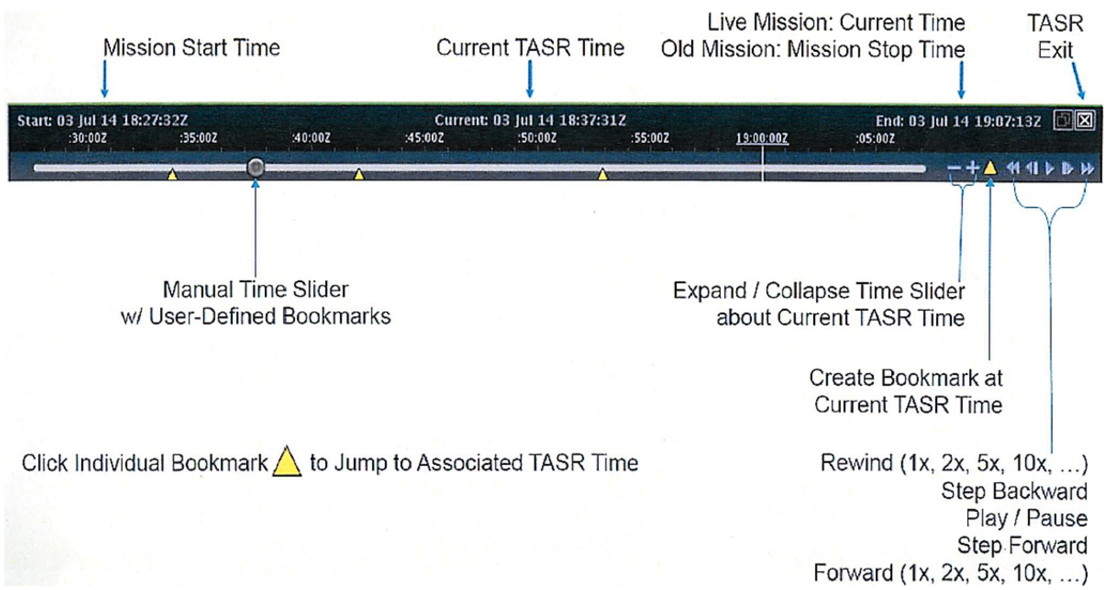
10.10.2.5.6 Layouts. The "Layouts" tab is used to configure hotkeys and trigger preset layouts. From this tab, the operator can create screen layout preferences that will be save to hotkey "F5" or "F6." These layouts will save how the user have the "Minotaur Display Layout" and can be beneficial for differing mission needs.

10.10.2.5.7 Mission. When in Mission playback mode, an additional tab will appear called the "Mission" tab which allows for the selection of the mission for playback.

10.10.3 Tactical All-Source Replay. TASR provides instantaneous access to all sensor data and derived products for the current mission in support of the real-time operation. TASR is a program DVR that allows for the replay of the mission's video. The user can pull up TASR by either clicking "P" on the keyboard or right-clicking the map and selecting "Enter TASR mode." A toolbar will then appear at the bottom of the screen. See **Figure 10.47**, Tactical All-Source Replay. When in TASR, it will be represented by a green border on the interactive display. With TASR, the user can rewind, drop bookmarks, and take snapshots from earlier in the mission.

10.10.4 Range Rings. Range rings can be used for a variety of tasks such as AOR definition, collateral clearing, plotting predicted point of impact (PPOI), and other functions. For a stationary target press "R" on the keyboard, while the user's cursor is on the interactive display, and the range rings will auto-populate on the map. For a moving target make sure the cursor is on the interactive display, Minotaur is in "Sensor View," and the SO has a track tight on the vehicle, this is to ensure accurate speed is passed to Minotaur. Hold down "R" on the keyboard, for 2 to 3 seconds (Minotaur takes average speed during the keypress), when "R" is released the range rings will be dropped based on the average speed of the MTS's slew. Manual range rings may need to be dropped if the speed of a vehicle is variable or a vehicle is not moving yet. To drop manual range rings, make sure Minotaur is not in "Sensor View," range rings will plot on the cursors postion when "R" is pressed. The user will need to input the predicted speed into Minotaur.

Figure 10.47 Tactical All-Source Replay.



10.10.4.1 Engagement Zones. Along with range rings, there is the additional option to create engagement zones. After dropping an initial set of rings with the "R" key, within the menu that appears in the bottom of the interactive display there will be a drop down that will allow the operator to select the "Zone-tool." To use this tool the user will need to create a path with the line drawing tool and an engagement zone with the polygon tool from the markups. Afterwards, the operator can input vehicle speed and weapon parameters such as time of flight in order to display a Rifle no earlier then, Rifle no later than, and predicted point of impact on the path.

10.10.5 Cross-Cue. Automatic, real-time camera slewing to operator-selected aimpoints or cues, leveraging video geo-registration results to correct camera pointing errors. To enable cross-cue, the user must first select "XCTRL" on the TGP Toolbar, any input into the stick or pressing the "break track" button on the stick will disable cross-cue. The user can slew the TGP five different ways using Minotaur cross-cue. Operator-selected location on map (mouse over the aimpoint, right-click, select "Imaging," select "Slew MTS-B to this location," the TGP will slew to the location on the map), reference point (left click on the reference point, right-click "Slew MTS-B to reference point," the TGP will slew to the reference point), detection (hook VADER or VMTI detection, right-click "Image this contact," select "Slew MTS-B to this contact," the TGP will slew to detection), track (hook VADER or VMTI track, right-click "Image this track," select "Slew MTS-B to this track, the TGP will slew to track), or contact-of-interest (hook VADER contact-of-interest, right-click "Image this track," select "Slew MTS-B to this track," the MTS will slew to contact-of-interest). The average slew-to-cue time is 4 seconds.

ATTACHMENT 1

GLOSSARY OF REFERENCES AND SUPPORTING INFORMATION

A1.1 References. The following is a list of Department of Defense, Chairman of the Joint Chiefs of Staff, Air Force, Army, and joint directives, and publications used in the preparation and classification of this document. Most are available through Air Force channels and the others can be acquired through HQ ACC or the office of primary responsibility.

Department of Defense Publications

1. *DOD Flight Information Publication (En Route)-Flight Information Handbook*.

Joint Publications

1. Joint Publications 3.09.3, *Close Air Support*, 25 November 2014.

2. *ALSA Multi-Service Tactics, Techniques, and Procedures for the Joint Application of Firepower (JFIRE)*.

3. *ALSA Multi-Service Tactics, Techniques, and Procedures for Multi-Service Brevity Codes*.

Air Force Publications

1. AFI 11-2MQ-9V1, *Flying Operations*, MQ-9 Crew Training.

2. AFI 11-2MQ-1 and 9 V3, *Flying Operations*, MQ-1 AND MQ-9 Operations Procedures.

3. AFMAN 11-202-V3, *Flying Operations*, General Flight Rules.

4. AFI 11-214, *Air Operations Rules and Procedures*.

5. AFTTP 3-1.General Planning, *General Planning and Employment Considerations*.

6. AFTTP 3-1.Threat Guide, *Threat Reference Guide and Countertactic*s.

7. AFTTP 3-1.MQ-9, *Tactical Employment-MQ-9*.

8. AFTTP(I) 3-2.5, *Multi-Service Brevity Codes*.

Air Force Forms

1. AF Form 70, *Pilot's Flight Plan and Flight Log*.

2. AF Form 847, *Control Log*.

Technical Orders

1. TO 1Q-9(M)A-1, *Flight Manual*, USAF Series MQ-9A Aircraft.

2. TO 1Q-9(M)A-1CL-1, *Flight Crew Checklist*, USAF Series MQ-9A Aircraft.

3. TO 1Q-9(M)A-34-1-1, *Nonnuclear Munitions Delivery Manual*, USAF Series MQ-9A Reaper Remotely Piloted Aircraft.

4. TO 1Q-9(M)A-34-1-1CL-1, *Flight Crew Checklist*, All Nonnuclear Munitions Delivery Manual, USAF Series MQ-9A Reaper Remotely Piloted Aircraft.

5. AFSOC ASI-11114, *Flight Manual*, AFSOC Series MQ-9A Aircraft, 5 March 2018.

6. AFSOC ASI-07047, *Nonnuclear Munitions Delivery Manual, AFSOC Series MQ-9A Reaper Remotely Piloted Aircraft*, 1 February 2018.

26th Weapons Squadron Handbooks

1. *MQ-9 Lynx Synthetic Aperture Radar Handbook*, V3.1.

2. *Hellfire Handbook*, Version 2, Change 2, 1 February 2016.

3. *26 WPS Debrief Guide v 7.1*.

A1.2 Acronyms and Abbreviations. The following acronym list is UNCLASSIFIED unless otherwise marked.

3D....................................three dimensional
A/A...................................air-to-air
AB ....airburst
A/C ....aircraft
ACC ....Air Combat Command
ACM ....airspace coordinating measure
ACO ....airspace control order
AFB...................................Air Force base
AFI ....Air Force instruction
AFMAN.............................Air Force manual
AFTTP ....Air Force tactics, techniques, and procedures
A/G...................................air-to-ground
AGL ....above ground level
AID ....auxiliary information display
AO....................................area of operations
AOA..................................angle of attack
AOB ....angle of bank
AOR ....area of responsibility
APS ....air proximity sensor
A/S ....airspeed
ASI ....Aeronautical Systems, Inc.
ASR...................................approach surveillance radar
ASULT ....airspeed, SMS, update, laser/LAR, track
ATC ....air traffic control
ATEAM.............................altimeter, tracker, emergency mission, antenna, MSA
ATO ....air tasking order
AV ....air vehicle
AVT..................................automatic video track
AW ....acoustic warning
AZ ....azimuth
B ....basic
BADDC ....barrel asymmetric digital computer
BDA ....battle damage assessment
BFD...................................battery-firing device
BHA ....bomb hit assessment
BIT ....built-in test

BLOS ....beyond line of sight
BLU ....bomb live unit
BOC ....bomb on coordinate
BPSK ....binary phase shift key
BRP ....ballistic release point
BSL ....bomb steering line
C2 ....command and control
C3 ....clear, concise, and correct
C3I ....command, control, communications, intelligence
CAS ....close air support
CBEAR ....communicate, build, execute, assess, report
CCG ....computer control group
CCRP ....continuously calculated release point
CCTGP ....cross-cued targeting pod
CD ....compact disk
CDE ....collateral damage estimate
CEP ....circular error probability
CHUM ....chart updating manual
CL ....command link
cm ....centimeter
COA ....course of action
COAC-N ....Combined Air Operations Center-Nellis
COCOM ....combined command
COIN ....counter insurgency
CONOP ....concept of operations
CONUS ....continental US
CP ....control point
CR ....crossrange
CRC ....control and reporting center
CRM ....crew resource management
CT ....continuation training
CTP ....circuit to packet
CTTN ....correlator tracker track number
CWL ....common weapons library
DA ....depression angle
dbW ....decibel watts
DFP ....debrief focus point
DLER ....description, location, elevation, remarks
DLO ....desired learning objective
DLOS ....digital line of sight
DO ....director of operations
DOD ....Department of Defense
DOW ....squadron weapons shop
DPI ....desired point of impact
DR ....deficiency report/downrange
DRP ....detection reduction profile

DSN ....defense switch network
DTED..............................digital terrain elevation data
DTV ....daytime television
DWE ....desired weapons effect
EEI ....essential elements of information
EIRP...............................effective isotropically radiated power
ELINT.............................electronic intelligence
EO ....electro optical
EOM...............................end of message
EOR ....explosive ordnance ramp
EPoD..............................emergency procedure of the day
ER ....extended range
ESD ....exploitation support data
ETA ....estimated time of arrival
F2T2EA...........................find, fix, track, target, engage, and assess
FAA ....Federal Aviation Administration
FAC(A) ....fast attack craft (airborne)
FAWG ....fuel, alibis, winds, and GMT
FB...................................flash bulletin
FCIF ....flight crew information file
FENCE............................fuel, emitters, navigation, communication, and engage
FFM ....fixed format message
FLUG ....flight lead upgrade
FMS ....foreign military sales
....flame out
FOD ....foreign object damage
FOV................................field of view
fpm ....feet per minute
FPM ....flightpath marker
FROTIES ....formation, roles, ordnance, timing, ingress, egress, sort
FSST ....fixed site satellite terminal
ft ....feet
FVH ....field of view height
FVW...............................fields of view width
GBIT ....GBU bomb impact tool
GCS................................ground control station
GDT ....ground data link terminal
GEOREF.........................georeference
GFC................................ground force commander
GHO...............................gaining handover
GK..................................general knowledge
GLS ....GPS landing system
GMT...............................Greenwich Mean Time
GMTI ....ground moving-target indicator
GPS ....global positioning system
GRR ....graphical range restriction

GTL................................gun to target line
GUI ....graphical user interface
GWTS ....guided weapon trajectory software
HAE ....height above ellipsoid
HAT................................height above target/height above terrain
HD..................................high definition
HDD...............................head-down display
HIFI................................high fidelity
HK..................................high key
HOB ....height of burst
HPA................................high power amplifier
HQ..................................headquarters
HUD...............................heads-up display
HUR ....high update rate
HVI ....highly valued individual
HVT ....high value target
IA ....impact angle
IAM................................inertially aided munition
IAS ....indicated airspeed
IAW................................in accordance with
ID ....identification
IFF..................................identification friend or foe
IFG ....in-flight guide
ILLA...............................initial lost link altitude
ILLH ....initial lost link heading
IMC ....instrument meteorological conditions
IMEA ....integrated munitions effects assessment
IMINT............................imagery intelligence
IMOM ....improved many on many
in ....inch
INS ....inertial navigation system
IP....................................Internet protocol
IR ....infrared
IRC.................................Internet relay chat
ISR ....intelligence, surveillance, and reconnaissance
JDAM.............................joint direct attack munition
JICC ....joint interface control cell
JOG ....joint operations graphic
JP....................................joint publication
JPF ....joint programmable fuze
JRE.................................joint range extension
JREAP............................joint range extension application protocol
JTAC ....joint terminal attack controller
JTIDS ....joint tactical information distribution system
JTN.................................joint track number
JU ....JTIDS unit

JWICS ....Joint Worldwide Intelligence Communication System
kbps ....kilobytes per second
KGS ....knots ground speed
KIAS ....knots indicated airspeed
KIO ....knock it off
km ....kilometer
KTAS ....knots true airspeed
KVM ....keyboard video mouse
LAGS ....links, autopilot, gear, start point
LAP ....local area processing
LAR ....launch acceptable release
LGB ....laser-guided bomb
LGM ....laser-guided munition
LHO ....losing handover
LIMFAC..........................limiting factor
LJDAM ....laser joint direct attack munition
LLPL ....long last pulse logic
LLTV...............................low-light television
LNA ....low noise amplifier
LOAC..............................law of armed conflict
LOAL ....lock-on after launch
LOC ....line of communication
LOWAT ....low altitude
LP ....learning point
LRD ....laser range designator
LRE ....launch and recovery element
LSAB ....laser-to-sensor auto boresight
LTL.................................laser-to-target line
LTM ....laser target marker
LUC ....line up card
LWIR..............................long wave infrared
MA ....master arm
MACA............................military assumes collision avoidance
MAJCOM ....major command
MARSA ....military assumes responsibility for separation of aircraft
MATL.............................maintain aircraft control, analyze the situation, take the proper action, land as soon as conditions permit
MATS ....mag, add, true, subtract
MAU ....munitions armament unit
mbps ....megabytes per second
MCC...............................mission commander
MCE ....mission control element
MEA ....munitions effectiveness assessment
MESL ....mission equipment serviceability list
MFW ....multifunction workstation
MGRS ....military grid reference system

MHz ....megahertz
MIDS ....multifunctional distribution information system
MIGS ....map, initial lost link heading, GLS, start point
mIRC...............................multi-user Internet relay chat
MOA ....military operating area
MPC ....mission planning cell
MPEC..............................mission planning and execution cell
mph ....miles per hour
MPP................................mission planning program
ms ....millisecond
MSA ....minimum safe altitude
MSCT..............................multi-source correlator-tracker
MTD...............................moving target detection
MTE ....moving target engagement
MTI ....moving target indicator
MTT ....moving target track
MWAS ....maritime wide area surveillance
MWIR ....medium wave infrared
NAI ....named area of interest
NAR ....narrow
NATO ....National Atlantic Treaty Organization
N/C ....not calculated
NIPR ....nonsecure Internet protocol router
NIPRNET........................nonsecure Internet protocol router network
NLT ....no later than
NM ....nautical mile
NOAD ....network operations and assurance division
NOB ....network operations branch
NOC ....network operations center
NORDO ....no radio
NOTAM ....notice to Airmen
NPG ....network participation group
NRT ....near real time
NTTR ....Nevada Test and Training Range
OFP ....operation flight program
OPR................................office of primary responsibility
OPTASKLINK................operational tasking link
ORM ....operational risk management
OWT ....on wing tracking
PACE..............................primary, alternate, contingency, and emergency
PAR ....precision approach radar
PAROC............................persistent attack and reconnaissance operations center
PAX ....passenger
P_H ....probability of hit
PIC ....pilot in command
PID ....positive identification

PIO ....pilot induced oscillation
P_K ....probability of kill
PRF ....pulse repetition frequency
PMA....................................predator modem assemblies
PMOC ....payload management operations center
POC....................................point of contact
POI ....point of interest
PPDM..................................payload power distribution module
PPLI ....precise participant location and identification
PPOI...................................predicted point of impact
psi.......................................pounds per square inch
PSO ....pilot/sensor operator
PTT ....part-task training
RCM...................................redundant control module
RCS ....radar cross section
R_{DL}....................................range at desired launch
RF.......................................radio frequency
RL.......................................return link
RMIT..................................Romeo-missile impact tool
ROE ....rules of engagement
ROT....................................rule of thumb
ROZ ....restricted operating zone
RPA ....remotely piloted aircraft/record, plot, assess
rpm ....revolutions per minute
RSO....................................remote split operation
RTB ....return to base
RTT ....round-trip-timing
RVT....................................remote video terminal
RX ....receive
S/A ....surface-to-air
SA.......................................situational awareness
SADL ....situational awareness data link
SAFIRE..............................surface-to-air fires
SAM...................................surface-to-air missile
SAR....................................search and rescue
SAT ....surface attack
SATCOM ....satellite communication
SCAR ....strike coordination and reconnaissance
SD ....standard definition
SEGT..................................single redline exhaust gas temperature
SETSS ....SATCOM Earth terminal subsystem
SFO ....simulated flameout
SHF ....superhigh frequency
SII.......................................special interest item
SIGINT ....signals intelligence
SIPR ....secure Internet protocol router

SIPRNET ....secure Internet protocol router network
SLAPUM ....SMS, laser/LAR, airspeed/autopilot, payload, update, master arm
SLMA.............................secure link manager assembly
SLPL ....short last pulse logic
SMART ....specific, measurable, attainable, realistic, timely
SMM ....shared mental model
SMS ....stores management system
SO ....sensor operator
SPI.................................sensor point of interest
SPINS.............................special instructions
SRT ....standard rate turn
SSAA ....sensor-to-sensor auto alignment
STAT ....steering, timing, airspeed, track
STORM...........................safety, tactical, operation, reliability, and maintenance
SUV................................small utility vehicle
SWIR ....shortwave infrared
TAC................................tactical
TACP..............................time at control point
$TACP_{RO}$ ....time at control point after roll out
TacSit ....tactical situation display
TAL ....transfer alignment
TAMS.............................true, add, mag, subtract
TASR..............................tactical all-source replay
TCP ....transmission control protocol
TDF ....tactical display framework
TDL................................tactical data link
TDMA............................time-division, multiple access
TES ....test and evaluation squadron
TFOCA...........................tactical fiber optic cable assembly
TFT ....tactical field terminal
TGP ....targeting pod
THB ....target handover boundary
TIC ....troops in contact
TIP..................................tactic improvement proposal
TN ....track number
TO ....technical order
TOF ....time of flight
TOI ....time of impact
TOT ....time on target
TR ....training rule
TSL.................................target steering line
TSM ....target sorting message
TTCP..............................time to control point
TTI ....time to impact
TTP.................................tactics, techniques, and procedures
TTR ....time to release

TTT ....time to turn
TTZ ....time to zone
TVB ....target velocity boundary
TWD ....target width distance
TX ....transmit
TXA ....transfer alignment
UHF ....ultrahigh frequency
ULTN ....ultra-narrow
US ....United States
USAF ....United States Air Force
USAFWS ....US Air Force Weapons School
UVDS................................unified video dissemination system
VBIED ....vehicle born improvised explosive device
VDL ....video downlink
VFR...................................visual flight rules
VHF ....very high frequency
VI-A ....vertical impact angle
VISRECCE ....visual recognition
VIT ....vital information table
VLC ....videoLAN client
VMTI ....video moving target indicator
VOIP ....voice over Internet protocol
VOSIP ....voice over secure Internet protocol
VVI ....vertical velocity indicator
WARNSELF ....warnings, start point, emergency mission, links, flaps
WAS ....wide area search
WET..................................weather, emergencies, type of procedure
WEZ..................................weapons engagement zone
WPS ....weapons squadron
WRM ....weapons resource management
WTARSEC........................weapon, target/track, aimpoint, restriction/run-in, shift, egress, clearance
ZSU ....Zenitnaya Samokhodnaya Ustanovka (Russian self-propelled anti-aircraft weapon

ATTACHMENT 2

MQ-9 LINK 16 MPC DATA SHEET

A2.1 MQ-9 General Link 16 Information.

A2.1.1 Architecture.

- MQ-9s access Link 16 via a ground based JREAP C connection, there is not an MIDS terminal on the aircraft.
- MQ-9s are assigned to Network Participation Group (NPG) 9 command and control.

A2.1.2 J Series Message MQ-9s Can Transmit.

- J3.0 Reference Point.
- J3.1 Emergency Point.
- J3.2 Air Track.
- J3.3 Manual Surface Track.
- J3.5 Land Point/Track.
- J7.3 Pointer.
- J12.6 (must be publishing J2.0 and be "donorized" by the other player).
- J28.2 Free Text Message.

A2.2 Squadron Link 16 Information. Bring the following information to the MPC (it can be found in the OPTASKLINK).

- Squadron/Call Sign JU Number(s).
- Number of track blocks assigned.

Table A2.1 J-Series Messages by Network Participation Group.

NPG Number	NPG Name	Associated J-Series Messages
1	Initial Entry	J0.0, J0.2, J0.5, J0.7, J28.2(0), J31.7
2	Round-trip-timing (RTT)-A (Addressed)	RTT-A
3	RTT-B (Broadcast)	RTT-B
4	Network management	J0.3, J0.4, J0.5, J0.6, J0.7, J1.0, J1.1, J1.2, J1.3, J1.4, J1.5, J1.6, J2.2, J2.3, J2.4, J2.5, J2.6, J28.2(0), J31.0, J31.1, J31.7
5	PPLI and Status Group A (aka "high update rate [HUR] PPLI")	J0.5, J0.7, J2.2, J2.3, J2.4, J2.5, J2.6, J13.0, J13.2, J13.3, J13.5, J28.2(0), J31.7, RTT-A
6	PPLI and Status Group B	J0.5, J0.7, J1.1, J2.2, J2.3, J2.4, J2.5, J2.6, J13.0, J13.2, J13.3, J13.5, J28.2(0), J31.7, RTT-A
7	Surveillance	J0.5, J0.7, J2.0, J2.2, J2.3, J2.4, J2.5, J2.6, J3.0, J3.1, J3.2, J3.3, J3.4, J3.5, J3.6, J3.7, J5.4, J6.0, J7.0, J7.1, J7.2, J7.3, J7.4, J7.5, J7.7, J15.0, J28.2(0), J31.7
8	Mission management/ weapons coordination and management	J0.5, J0.7, J9.0, J10.2, J10.3, J10.5, J10.6, J13.0, J13.2, J13.3, J13.5, J15.0, J28.2(0), J31.7
9	Control	J0.5, J0.7, J12.0, J12.1, J12.2, J12.3, J12.4, J12.5, J12.6, J12.7, J13.0, J13.2, J13.3, J13.5, J17.0, J28.2(0), J31.7
10	Electromagnetic warfare	J0.5, J.07, J13.0, J13.2, J13.3, J13.5, J14.0, J14.2, J28.2(0), J31.7
11	Imagery	J0.5, J0.7, J28.2(0), J31.7
12	Voice Group A	Free Text (Voice)
13	Voice Group B	Free Text (Voice)
19	Non-C2 JU to Non-C2 JU A (formerly "Fighter-to-Fighter A")	J0.5, J0.7, J12.0, J12.6, J12.7, J17.0, J28.2(0), J31.7
20	Non-C2 JU to Non-C2 JU B (formerly "Fighter-to-Fighter B")	J0.5, J0.7, J12.0, J12.6, J12.7, J17.0, J28.2(0), J31.7
21	Engagement coordination	J0.5, J0.7, J9.1, J10.2, J28.2(0), J31.7
22	Composite A	J0.3, J0.4, J0.5, J0.6, J0.7, J1.1, J7.1, J9.0, J10.2, J10.3, J10.5, J10.6, J12.0, J12.1., J12.2, J12.3, J12.4, J12.5, J12.6, J12.7, J13.0, J13.2, J13.3, J13.5, J17.0, J28.2(0), J31.0, J31.1, J31.7
23	Composite B	J0.5, J0.7, J2.0, J3.0, J3.1, J3.2, J3.3, J3.4, J3.5, J3.6, J3.7, J5.4, J6.0, J7.0, J7.2, J7.3, J7.4, J7.5, J7.7, J14.0, J14.2, J15.0, J28.2(0), J31.7
27	Joint Net PPLI	J0.5, J0.7, J2.2, J2.3, J2.4, J2.5, J2.6, J28.2(0), J31.7, RTT-A
28	Distributed network management	J0.5, J0.7, J1.0, J1.1, J1.2, J1.3, J1.3, J1.4, J1.5, J1.6, J28.2(0), J31.7
29	Residual messages	J0.5, J0.7, J5.4, J28.2(0), J31.7
30	IJMS position and status	RTT-A, P1, P2, P3, NI-7
31	Other IJMS messages	Other IJMS messages

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AFTTP 3-3.MQ-9