DCS - INTRODUCTION TO FIGHTER FUNDAMENTALS

TACTICAL FLIGHT TRAINING

CURRENT AS OF Jun 22, 2023

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INTRODUCTION

Some words of wisdom from an old pilot. The world of Aviation in general and Combat Aviation in specific is not an exact science, or a precise cause & effect flow. *The world of aviation is more art than it is science*. Yes, throwing specific switches in a specific order will cause the aircraft to do a specific action. BUT, that is where it stops, in aviation we fight, bend or in some cases break the rules of physics as we know it. As pilots we learn 'tools' and tricks and gain experience with flight time, and many times we employ those tools in weird & new ways, because no 2 flights are the same. Every flight can, and usually does, present a new situation or scenario. You constantly have to be adjusting, managing, and improvising to achieve the desired goals. *IT IS NOT A QUICK PROCESS*. Give yourself permission to take the time and enjoy the process of learning. Enjoy the journey for it is not short, nor boring.

Creating these manuals and guides are a labor of love and passion, but it doesn't happen in a vacuum. It takes a lot of time, patience and research and support from many people around me. If you enjoy these manuals and they help you, they've accomplished exactly what they are designed to do. If you are feeling like paying it forward and want to help me keep making these manuals and guides, feel free to buy me a beer or a coffee (https://bmc.link/NapaPilot81) or support me on Patreon (http://patreon.com/NapaPilot).

Thank you for your support, see ya in the skies

NAPA "SPEEDY"

Chapter 1 - General

1.1 Overview.

War in the aerospace environment is currently in a period of fast-paced evolution. Since the beginning of aerial combat, technological development has driven, and been driven by, progress in building more efficient and effective aircraft and weapons. Nevertheless, the very basic principles of aerial combat remain virtually unchanged. As technology advances, mutual support and situational awareness (SA) are still critical to effective employment of airborne weapons. *Current data-link systems and situation displays can not replace core competence in basic skills.* These fundamentals, or standards, are only part of training for combat, and provide the building blocks for effective tactical employment. Discussions on formation flying, air-to-air (A/A) and air-to-surface (A/G) use the T-45C as a common training aid to make building a strong foundation of tactical skills easier to understand and grasp. The maneuvers addressed are a means to an end, a starting point for pilots to study and explore first hand describing the methods used to achieve desired results in air combat.

1.2 Purpose.

This manual contains fundamental procedures and techniques to learn the basic fundamental concepts and skills to be able to succeed in DCS World. It is designed to supplement training programs; and when used in conjunction with instruction from an experienced and knowledgeable Instructor Pilot, provides a solid foundation on which tactical training can be accomplished. This volume is not directive in nature and is not the final authority for all things in combat aviation. It is merely a single collection of the fundamental and basic tactical concepts that are universal to US Navy, USAF, RAF, and other fundamental training programs. The training set ups mentioned in this document are designed to teach a particular objective. *This document will not cover every single eventuality or situation you will encounter in the air-combat arena. These are **fundamental guidelines**. That should give you the ability to adapt in whatever situation you find yourself.*

1.3 Using This Manual.

In general, this manual is part of an organized training flow or pipeline, starting with basic pilot training. It broken into 3 general sections. General Review, Air-to-Air Combat, Basic Surface Attack. Chapters 2-5 are designed around review of important info from previous training as well as adding some more details that apply with this higher level of flying you are participating in now. Chapters 6-8 (Air-to-Air) and 9-10 (Basic Surface Attack) are designated for those specific arenas of combat. This manual is written with the assumption that the student has already achieved a certain practical skill level with fundamental aviation skills and tasks, and only covers the building blocks for tactical aviation. You will also find specific passages *highlighted and annotated*. These specific passages are marked because they are the "nuggets" of info that I would highlight or mark if I were reading and studying this document while in a flight training program.

Chapter 2 - MISSION PREPARATION

2.1 Overview.

Mission preparation, individually and as a flight, is the foundation of successful fighter operations. It encompasses cockpit resource management (CRM), objective application, the prioritization based on Situational Awareness (SA), and flight leadership. Each factor is part of a professional attitude, which increases tactical potential, and allows you to fully experience and enjoy the world of DCS.

All of these and more are addressed throughout this chapter. The success of all that follows (briefing, execution, and debriefing) is directly related to the amount of and quality of preparation.

- First, individually prepare yourself for the mission.
- Second, determine mission objectives in terms of measurable combat capability and related basic pilot skills.
- Finally, decide how to brief and execute the mission.

2.2 Effective Communication (Comm).

Preparation must always start with Effective Communication. From the beginning of mission planning through the lessons learned in the debrief, effective communication is the basic determinant of both mission accomplishment and success. This includes knowledge of common errors, cultural influences, and barriers (language, age, experience). Skills will encompass listening, feedback, precision, and efficiency of comms with all members. Effective communication ties the mission together. The flight leads must communicate thoroughly during planning to produce the correct flight products for their mission. In the briefing, they must address the flight's execution plan and major contingencies that can be expected during flight and the planned reactions. Standards must be established to cover those contingencies that are not briefed. Briefings must be complete and understood so that contingencies can be executed in the air using concise radio communications. Preparation to ensure effective in-flight communication includes the following:

- Know and adhere to accepted and standard terminology
- Brief anticipated comm flow.
- Have zero tolerance for complacent, sloppy, or ambiguous radio calls (in flight and during debrief).
- Establish an appropriate assertion level; ensure two-way communication. · Assume nothing.
- State concerns and intentions and get an acknowledgment/decision.

2.3 Task Management.

Task management involves establishing priorities for maximum efficiency and avoiding task saturation.

2.3.1 Establish Priorities.

There are occasions during nearly every mission when you cannot do everything in the time available. This requires assigning priorities (task prioritization). At the top of the list are Critical Tasks – things you have to do. Lower on the list are things you would like to do – Noncritical Tasks. The list of have-to-do tasks should be established long before getting near an aircraft.

Critical Tasks. These are tasks that cannot be ignored without catastrophic consequences. If noncritical tasks begin to cause inattention to critical tasks, immediately disregard the non-critical tasks until all critical tasks are accomplished. Critical tasks include:

- Maintaining aircraft control.
- Deconflicting flightpath.
- Avoiding terrain.
- Being aware of fuel.

Prioritizing Non Critical Tasks. Lower priority tasks fall into two general categories: formation tasks and mission tasks. Formation tasks range from ops checks to proper execution of tactical turns. Critical tasks, such as element deconfliction, can never be disregarded, but other tasks will require monitoring and management. For example, Fencing in, or formation tasks (deconfliction, staying in formation, and radio awareness) should be prioritized above mission tasks (heads-up displays (HUD), weapons checks, and avionics). Although mission success is usually measured by how well mission tasks are accomplished, keep overall mission success in perspective. Remember, if the aircraft does not get back home, the mission has failed. If formation tasks become secondary to mission tasks, as a general rule, mission success will suffer. Letting nice-to-do things take priority over have-to-do things will jeopardize yourself and those around you.

Misprioritization. Misprioritization can have disastrous results. Remember the basics of *Aviate, Navigate, and Communicate*. Be alert for situations that regularly require prioritization of critical and noncritical tasks: Switch changes during formation; Fencing out during a rejoin; digging out an approach plate while in instrument meteorological conditions (IMC); etc.

2.3.2 Task Saturation.

Task saturation is a temporary failure to properly assess available information and initiate required pilot actions.

Hazards. Some of the possible hazards of task saturation include the following:

- Loss of mission effectiveness due to inability to perform mission tasks.
- Interference with the tasks of others.
- Fuel waste.
- Loss of control of the aircraft.
- Ground collision.
- Midair collision.

Causes. The main cause of task saturation is the sheer number of duties which must be handled by the pilot or crew. Among the tasks to be performed are aircraft control, navigation, formation, tactics, and weapons employment. Loss of visual references, which occurs most often while flying in weather or at night, increases the possibility of task saturation. Other contributing factors include complex training or combat scenarios as well as habits formed while flying other types of aircraft (such as switch and display locations), which is very common within DCS. Managing cockpit tasks requires good judgment and strong interpretive and discriminatory skills.

Symptoms of Task Saturation. Symptoms of task saturation include:

- Missing radio calls.
- Difficulty controlling the aircraft.
- Getting behind the aircraft.
- Loss of SA.
- Spatial disorientation.
- Channelized attention.

2.3.3 Task Management Techniques.

The following techniques will assist in preventing or overcoming task saturation:

Preflight:

- Know what is expected on the mission. Ask questions if any aspects of the mission are unclear.
- Ensure checklist items and habit patterns are followed. If events interrupt habit patterns (ground abort, night, etc.), slow down to ensure everything is accomplished.

In Flight:

- Anticipate and be prepared for the next briefed event. Always try to stay ahead of the aircraft.
- Do not dwell on mistakes.
- Control false sensations and quickly transition to instruments when visual cues become unreliable.
- Be prepared for changes in task priorities.
- Reduce head-down time by maintaining a good cross-check among instruments, sensors, and visual references.
- Watch for symptoms of task saturation and act to minimize them:
    - If low altitude, climb to cope.
    - Reprioritize current tasks, placing aircraft control first.
    - Inform crew mate or flight member about the situation.
    - Call a KIO if in a training situation.

2.4 Flight Discipline.

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

2.5 Mission Planning:

2.5.1 Planning Considerations.

The flight lead establishes priorities for mission planning and delegates them to flight members to ensure all planning considerations are addressed and to preclude any duplication of effort. All flight members should be involved in the mission preparation. The depth of planning detail is dictated by the syllabus, mission and flight experience level, but the bottom line is "All necessary mission planning is completed in time to conduct a concise, comprehensive briefing."

Flight Lead Responsibilities. *Flight leads have the general responsibility for planning and organizing the mission, leading the flight, delegating tasks within the flight, and ensuring mission accomplishment*. They are in charge of the resources entrusted to them; they must know the capabilities and limitations of each member of the flight. Once airborne, they have the final responsibility and controlling authority for establishing the formations, maximizing the flight's effectiveness, and leading the flight successfully during the mission.

Wingman Responsibilities. Wingmen have critical responsibilities of helping the leader plan and organize the mission. Review the standard departure and recovery for the mission and study a map of the working area; ensure familiarization with boundaries, altitudes, and restrictions.

2.5.2 Mission Objectives.

Preparation for any given mission should be based on mission objectives. The mission objectives should give the "big picture" of what is happening for each mission and are used to measure individual and team mission success. Well defined objectives should be based on the mission requirements and tasking, environment, threat, and other factors such as wingman experience. Clear objectives limit the impact of distractions and focus attention on mission accomplishment. A valid objective has three parts: performance, conditions, and standards.

Performance. Describes what each pilot or the flight does during the mission. It is action and is not vague. Use action verbs such as employ, practice, negate.

Conditions. Describes starting parameters such as "from an offensive perch" or "given two Bandits with noise jamming and a BVRsetup."

Standards. States how well the performance must be done and is categorized by time limits, accuracy, and quality (such as, "meeting valid kill criteria," or "ranging within +500 feet").

2.6 Briefing.

The purpose of the briefing is to clearly convey the "what" and "how to" of the mission.

2.6.1 Preparation

Preparation is the Key to a Quality Briefing. If the briefing time is limited, and/or a large amount of information needs to be covered (instructional or highly complex missions), management of the allotted briefing time will be improved by practicing the briefing. This will allow the briefer to formulate verbiage and rework areas that may not have been well thought out.

Briefing Guides. *Briefing guides are one of the most useful tools for preparing and delivering flight briefings*. They help the briefer organize thoughts and identify areas where knowledge may be lacking. Using another aviator's briefing guide, or a generic, can be useful as a reference; however, developing an individual briefing forces the briefer to think through the briefing material. The detail contained in the briefing guide will depend on the familiarity with the subject. The less familiar a briefer is with the topic, the more detailed the briefing guide should be. If a briefer is familiar with a topic, an outline may be sufficient.

Computer Slide Usage. Preparing white boards and/or slides is essential to enhancing the overall quality of the briefing. Information on boards should be limited to essential information. As a general rule, the less cluttered the briefing boards, the less distracted the flight will be during the briefing. Avoid filling the boards with laundry lists for the mission or "memory joggers" for the briefing.

Speaking Ability. A briefer may be very knowledgeable in a subject, but if the individual is unable to communicate ideas in a clear and logical way, the briefing will not be effective. *Practice, including "dry runs," will help improve speaking skills as well as prevent some of the most common pitfalls during briefings*: improper focus/time allotment, excessive rambling/going off on tangents, and not presenting in a logical order/disjointed flow. Practice also aids in eliminating distracting verbal pauses (for example, "with that," "basically," "big picture," or "um").

2.6.2 Flight Lead/Direct Support Coordination Briefing.

The "coord" briefing describes what is to be accomplished and sets the tone for the entire mission. Establish objectives that include a standard that measures successful performance. Admin, or "motherhood," items should be covered in an efficient manner. Locally developed standards can be used to brief common or repetitive elements of the mission. Most of the time should be spent on the "meat," or primary focus, of the mission. Alternate missions should be less complex than the original mission but also have specific objectives. The flight lead controls the brief and should be dynamic, credible, and enthusiastic. He should motivate and challenge the flight to perform to planned expectations, asking questions to involve flight members and determine briefing effectiveness.

Techniques for a Good Briefing:

- Ensure all writing and drawings are neat and legible
- After any necessary introductions, lead the briefing with the overall mission objective(s) and "big picture" overview.

Wingman Briefing Role. Wingmen should be prepared to brief all topics required by the flight lead, or syllabus. Be organized and efficient while briefing. Stay focused and pay attention during the brief. Write down any questions you may have and ask them at the appropriate time. Never leave a briefing with doubts or unanswered questions.

2.6.3 Instructional Briefing.

The instructional briefing describes how to accomplish specific mission tasks. Like the coord briefing, the focus should be on the primary mission objectives—the "meat" of the mission. The instructor must take into account the experience level of the wingmen and adjust the brief accordingly. Be sure to end your brief with adequate time for everyone to mentally review the mission and accomplish any other prestep requirements—normally not less than 10 minutes.

Briefing Flow. The briefing should start with the mission objectives and narrow to the specific mechanics, incorporating how to recognize the pictures and describing techniques to execute the correct maneuvers – Picture, Plan, and Execution. ***Philosophical discussions and blanket statements should be avoided.***

2.7 Debrief.

It is a well-accepted axiom that *the majority of the learning takes place in the debrief*. Because of this, it is important each flight member devotes as much intensity to this part of the mission as to the briefing and in-flight execution. The objective of the debrief is to determine if the desired mission objectives were achieved, identify lessons learned, and define aspects of training needing improvement. *An honest assessment of performance is more important than "winning the debrief." Do not allow pride to stand in the way of admitting mistakes*. Receive instruction openly using the debrief as a tool for improvement. Furthermore, the debrief should also cover those areas that were executed well, and the overall performance should be compared with the mission objectives. The end result should be all participants gaining solid direction on how to do it better next time. All debriefs include the following main areas: preparation, reconstruction, analysis, instruction, and summary.

2.7.1 Preparation.

Flight leads should have a specific mission debriefing guide aligned with the mission briefing guide – this will ensure a logical structure and flow. All participants should know (from the briefing) what will be required from them during the debrief, and sufficient time between arriving in the debrief area and starting the debrief should be allowed to gather that information (normally 20 to 30 minutes). Use everything available (notes, tacview, etc.) to best gather the needed data.

2.7.2 Reconstruction.

Flight leads set the rules of engagement (ROE) for the debrief to ensure accurate mission reconstruction. Additionally, they should be aware of all participants' time constraints – tight turn times, follow-on training events, other commitments, etc. The debrief is conducted in a professional atmosphere and *critiques of execution should not be taken personally*. Follow debrief etiquette – give only the information asked for when asked and save questions for the appropriate time. *Avoid defensive attitudes and do not make excuses for poor performance*. Take notes for later review.

2.7.3 Analysis.

Once execution has been reconstructed, the next step is to highlight the areas that require further analysis. In any given mission or engagement, there are dozens of execution areas that could be discussed in detail. The problem with doing so is that *it is impossible for the average flight member to absorb more than three or four major points per engagement*. For this reason, it is critical to determine which errors were key to the overall outcome of the engagement and focus on these during the instructional phase of the debrief.

2.7.4 Instruction.

There are two basic components to providing an instructional fix to a particular error.

1. *Flight Members must determine if the error was due to perception, decision, or execution so the flight can understand why the error was made.* This is important to consider because there may be cases where the end result was acceptable, but it was more due to luck or a gross error on the part of the adversary than on correct execution on the flight members part.

2. *The Flight Lead must provide quantifiable techniques or procedures to correct the flaw on future missions.* If there are numerous methods for correcting the execution flaw, The flight members must determine which one(s) will be most effective for each particular case. Too much information can create confusion; too little can leave the flight member with insufficient understanding. Like the mission briefing, if used correctly, visual aids can reinforce instruction and significantly enhance a student's understanding.

2.7.5 Summary.

Use the mission objectives to provide a quantifiable measure of performance. In addition, look to each event to find learning points and determine trend items. At the conclusion of the debrief, summarize the key performance areas that are working well and those that need to be improved upon for the next mission.

2.7.6 Debrief Technique.

Begin the debriefing with an overview of the debriefing flow. While exact formats will vary depending on mission types, a normal debrief flow for an IFF mission is: plan/brief, flight admin to and from the working area, area/fight admin, and primary mission execution. In most cases, debrief of the plan/brief and admin should be expeditious – the focus should be on the execution of the primary mission. To ensure this, review tape/notes and be prepared at the beginning of the debrief with desired points. If a major execution error will be caused by the plan/brief, emphasize that point when debriefing the execution. There are numerous techniques to run an effective debrief. The most commonly used and easiest to structure is the:

Performance Measure Technique. - When accomplishing multiple repetitive events, such as BFM sets or container pattern bombing, a good technique is to evaluate the performance at each event. When doing this, look to answer the following questions:

- ***What Happened?*** This involves reconstructing the event and determining "what" occurred. This portion helps focus the use of ACMI, drawings, and tapes to find a cause for the error.
- ***Why Did It Happen***? This involves determining the cause or causes of why things went wrong. In this phase, the answer to "why" the event occurred should be drawn back to perception/"picture," plan, or execution.
- ***How to Prevent This Error from Happening Again?*** This is the most important portion of the debrief. The "how" gives all of the flight members a concrete lesson to pull from the training that just took place. Without this step in the debrief process, the opportunity for flight members to grow as combat aviators is lost. When answering the "how," the instructor is offering recommendations to the student as the best method to:
    - Recognize the error.
    - Prevent the error.
    - Fix the error if it occurs again.

Chapter 3 - GROUND OPERATIONS

3.1. Introduction.

In earlier training you learned the fundamental ground ops of flying your aircraft. Now you must learn the fundamental process of how to get your aircraft ready to fight, not just fly.

3.2. Engine Start.

As a Wingman: Ensure your aircraft is ready as quickly and efficiently as possible. Ensuring the following are ready to be referenced or pre-programmed into the aircraft.

- Comm's Plan
- Flight Plan
- Weaponeering Plan
- Aircraft Weapons Load

In the wise words of Wyatt Earp, "you must take your time in a hurry". *You and you alone are responsible for the proper configuration of your aircraft*. With the increase of items that need to be addressed during start-up it is very easy to forget one or several required tasks. *Use and trust your Checklists*. Verify everything. Double & Triple check everything.

As a Flight Lead: Not only do you need to ensure that your aircraft is configured. You need to keep in mind the skill level of your wingman, which in DCS can range. Be knowledgeable and confident in the current and next phases of flight.

As a wingman, stay ahead of your jet. ***As a flight lead***, stay ahead of your flight.

3.3. Radio Procedures.

No change from 2-ship formation procedures and techniques learned in Basic Flight Training. Lead is responsible for all radio communications outside of the flight, unless delegated to another flight member.

Example of additional group flight ground communications

Hammer 1: UHF Radio	"Hammer Flight, Radio Check, Uniform"
Hammer 2-4: UHF Radio	"2","3","4"
Hammer 1: VHF Radio	"Hammer Flight, Radio Check, Victor"
Hammer 2-4: UHF Radio	"2","3","4"
Hammer 1: VHF Radio	"Nellis Ground, Hammer Flight, Ready for taxi, with Alpha"

3.4 Taxi Operations

Multi-ship taxi operations do not differ much from 2-ship operations. Only in that now, you must coordinate more aircraft movements with your flight lead, and it's a longer train now.

3.4.1 Trail

Flight lead will be in the number 1 slot, with his nose wheel on the centerline and establishing the pace of the taxi. All following aircraft will be approximately 2 'plane' lengths away and also centered on the taxiway. This is the most commonly used, as it is the easiest and simplest way to follow the lead aircraft. But it does take up the most space, and can take longer for aircraft to get into position upon reaching the runway.

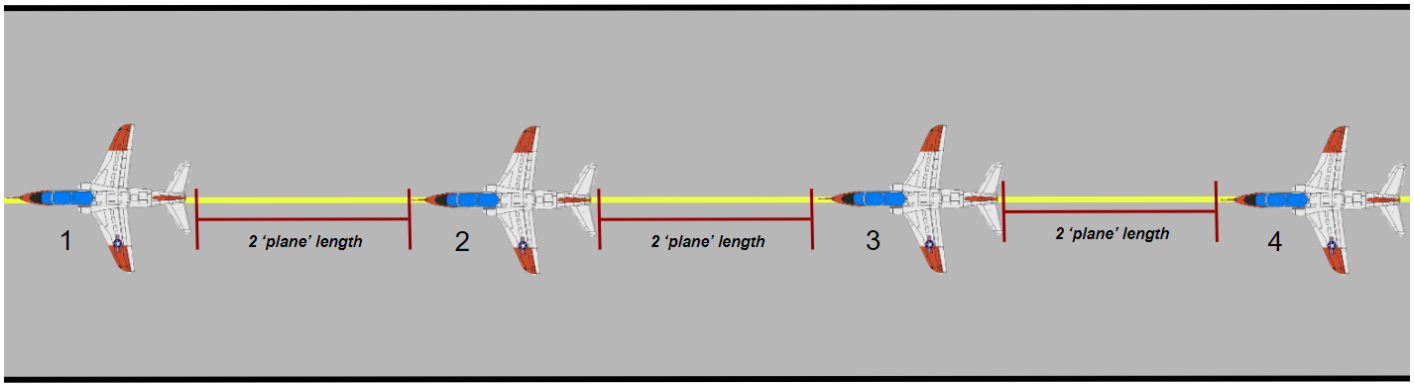


Figure 3.1 Trail Taxi

3.4.2 Staggered

Lead aircraft will be on the appropriate side (standard is right side), centered in that 'lane'. While the wingman will be centered in the opposite lane, with approximately one 'plane' length between the preceding tail and his nose.

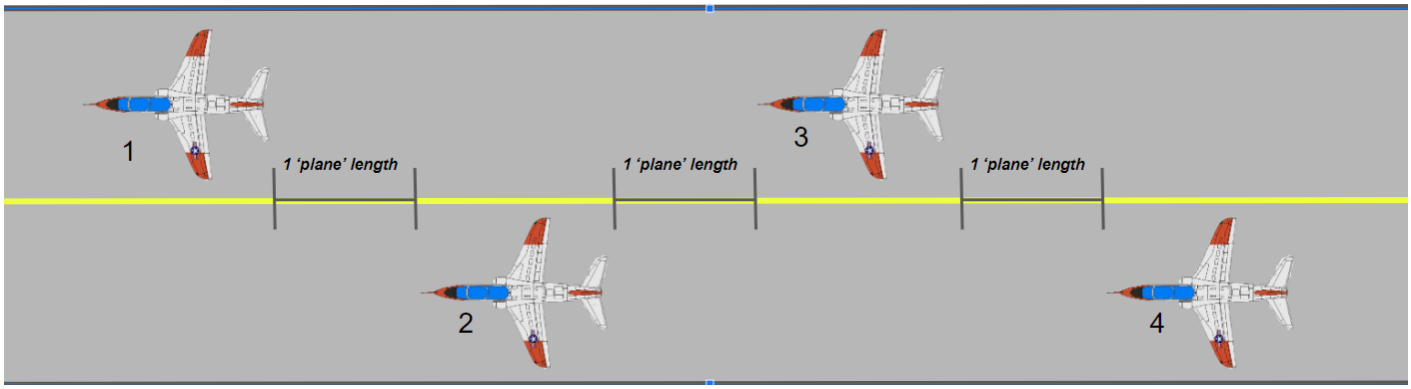


Figure 3.2 Staggered Taxi

3.5 Takeoff & Lineup

BFT covered how to taxi and line-up on the runway as a 2-ship. In IFF we will cover 3 and 4-Ship Ground Operations. The fundamental procedures for Taxi Operations does not change from a 2-ship to multi-ship. But the runway line up does change slightly.

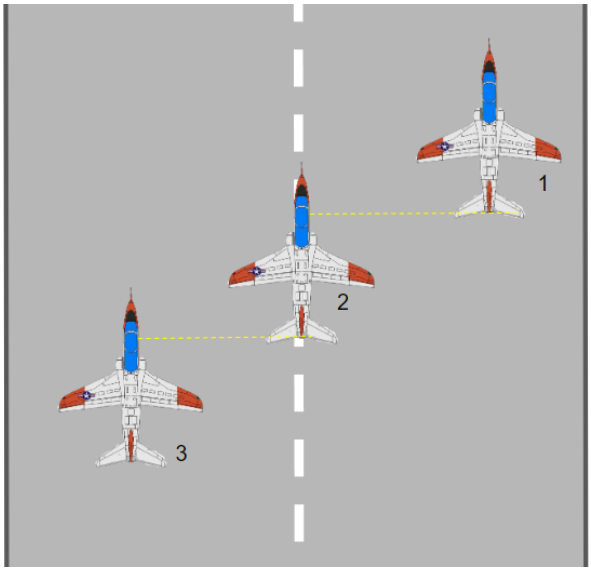


Figure 3.3 3-Ship Runway Lineup

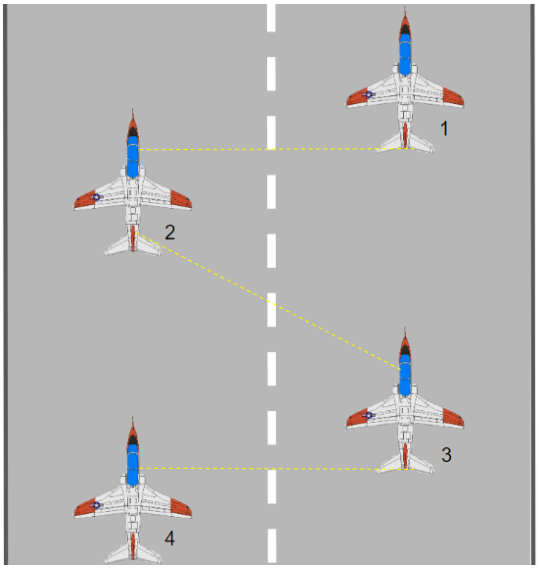


Figure 3.4 4-Ship Runway Lineup

3-Ship Lineup

Lead - Should align the outermost wingtip as close as possible to the runway line marker on the appropriate side

#2 - Should align the nose wheel on the runway centerline and be visually inline with the exhaust can of lead

#3 - Should align the outermost wingtip as close as possible to the runway line marker on the appropriate side and be visually inline with the exhaust can of lead

4-Ship Lineup

Lead - Should align the outermost wingtip as close as possible to the runway line marker on the appropriate side

#2 - Should be centered on the appropriate side of the runway and in line with the exhaust can of lead.

#3 - Should be in a position where he can see down the leading edge of the closest stabilator of #2.

#4 - Should be centered on the appropriate side of the runway and in line with the exhaust can of #3.

3.6 After Landing.

No change from 2-ship formation procedures and techniques learned in Basic Flight Training

Chapter 4 - BASIC AERODYNAMIC REVIEW

4.1 Introduction

The measure of success in air combat is simple, it is to kill or be killed. In order to be successful, we must maneuver our aircraft into a position in which we can employ our weapon systems while denying our enemy the ability to employ his. We will begin with the first part of the equation: maneuvering the aircraft.

4.2 Lift Limit

The forces acting on an aircraft in flight are thrust, weight, lift, and drag (Figure 4.1). The interactions and changes between these forces define the motion of an aircraft through the air.

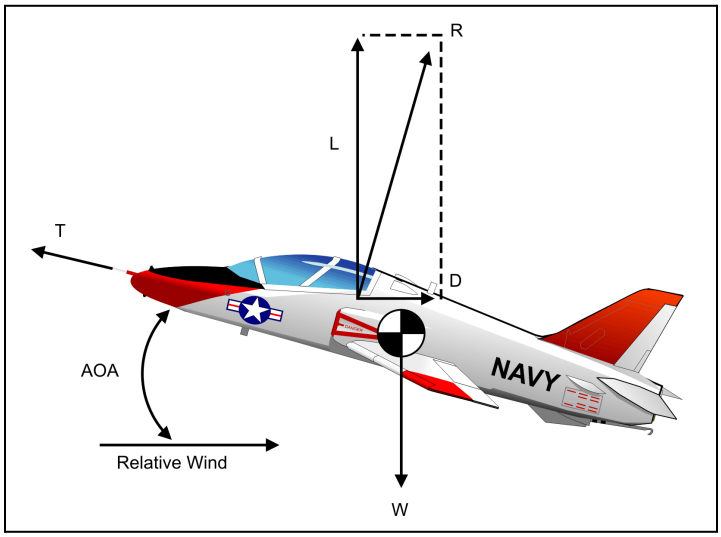


Figure 4.1 Aerodynamic Forces Acting Upon an Aircraft in Flight

During BFM, because thrust is usually at the maximum (MAX Power or full afterburner) and weight change is negligible at any given moment, thrust and weight will be considered constant during the aerodynamics review. This leaves the aerodynamic forces of lift and drag as the primary variables to consider when analyzing an aircraft's maneuvering performance.

We will introduce some definitions for our discussion:

Lift - Created by the resulting pressure differential as air flows over a wing.

Coefficient of Lift (C_L) - A non-dimensional constant that is based on the shape of the wing. It is a function of angle of attack (AOA). Figure 4.2 depicts the relationship between C_L and AOA.

As AOA is increased, lift is also increased up to C_L Max. The steep drop in C_L at high AOAs indicates the point at which a portion of the wing stalls. At the lift limit, the aircraft will be in a heavy buffet. Lift and performance quickly diminish when pulling beyond C_L Max.

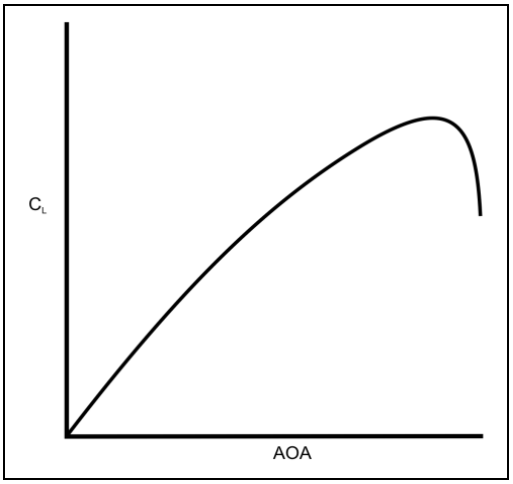


Figure 4.2 Angle Of Attack

4.3 Energy Maneuverability Performance Numbers

Before discussing the maneuvers to use in order to achieve a positional advantage, you must first be familiar with the performance of your own machine throughout the flight envelope. Two of the most important source documents when familiarizing yourself with the full performance capabilities of any fighter aircraft is the E-M diagram, also known as Turn Performance diagram, or simply The Dog Fighting chart. The E-M diagram outlines aircraft turn performance during a level turn in the horizontal plane. It also allows us to define our tactical maneuvering options and reference airspeeds, as well as the structural and lift limit of our platform. Although engagements rarely remain level, understanding the principles behind the E-M diagram allows you to make smart tactical decisions based on energy states.

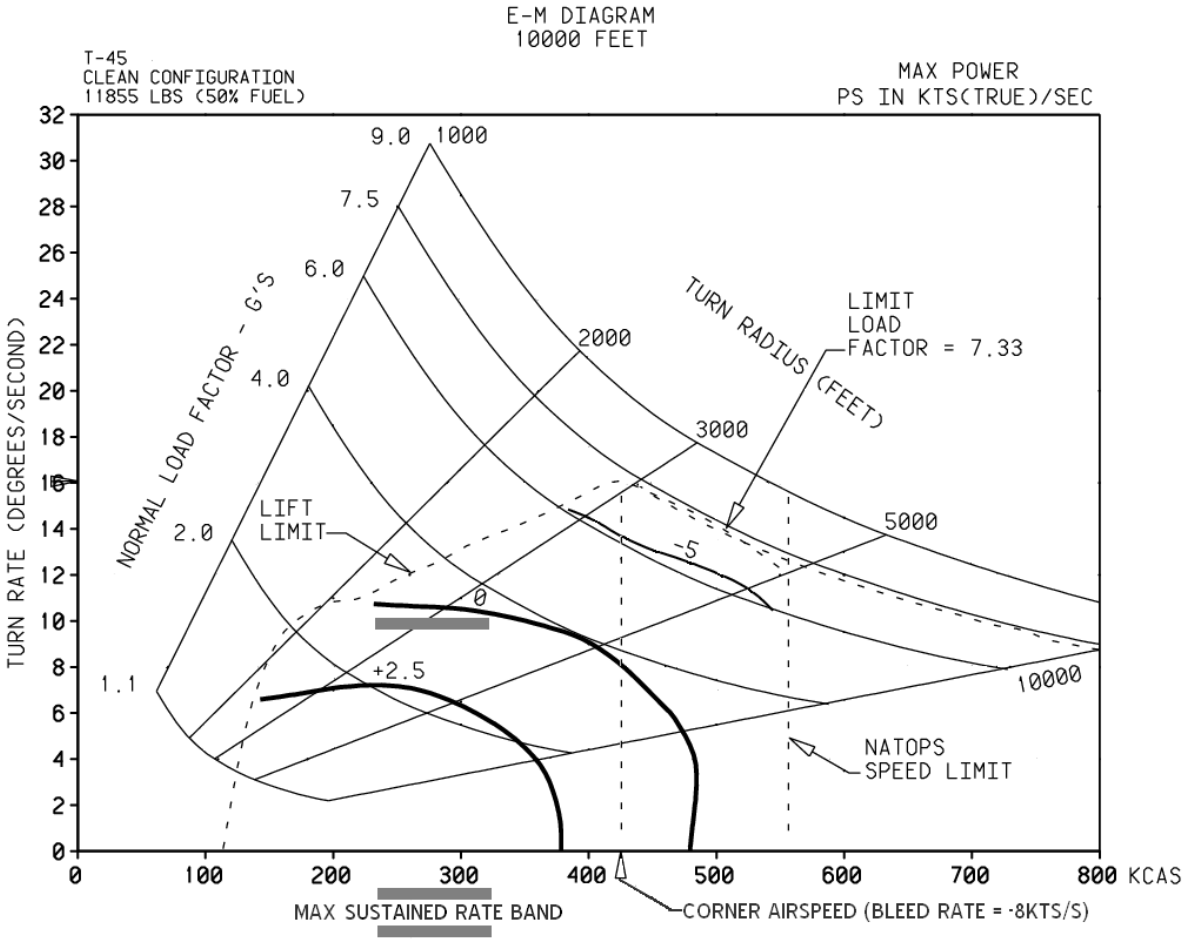


Figure 4.3 10K E-M Diagram

We are not going to build an E-M diagram in this chapter, but we are going to identify the main ideas and extract the most important information so as to arm you with the basic fundamental knowledge to be able to understand the diagrams. Each diagram is specific to aircraft, configuration, and altitude, all of which can be found in the periphery of the diagram. Make sure to always read this information first to ensure you are deriving the correct performance characteristics for a specific aircraft in a specific scenario.

Although we do not fly with an E-M diagram in the cockpit, it is imperative that you commit certain performance numbers to memory. *These numbers are required pieces of information. Do not show up at a merge without them!*

4.4 Vertical Maneuvering

E-M diagrams only depict an aircraft's turn performance in a level turn. Once the fight shifts into the vertical realm, we can no longer reference E-M diagrams alone to accurately represent the aircraft's turn performance, as the effects of gravity will affect turn rate, turn radius, and the bleed rates associated with a given maneuver.

4.4.1 Nose-High Maneuver:

Figure 4.4 illustrates the effects of gravity on vertical turn performance. The load factor (LF) is illustrated with a constant G force of 4, and is controlled by the pilot. Gravity (G) equals the effect of gravity on the aircraft. Finally the radial g (RG) is the combination of G and LF and denotes total performance.

Gravity can positively affect the turn rate and turn radius of an aircraft during a nose-high maneuver. The diagram shows a T-45 executing a pure nose-high loop. The pilot executing the maneuver maintains a constant 4G pull, but the aircraft overall performance (RG) must account for 1 unit of constant gravity. Remember the RG is the sum of the load factor the pilot applies and the one unit of gravity. Although the pilot pulls 4Gs at the beginning of the maneuver, the aircraft is fighting uphill against 1 unit of gravity and achieves only 3RG of turn performance. Conversely at the top of the maneuver, the aircraft achieves 5RG of aircraft performance, which produces a smaller turn radius and allows the aircraft to turn through more degrees per unit of time (greater turn rate). When the aircraft is bullseye nose-high, or nose-low, the effects of gravity are effectively zeroed, and a 4G pull results in 4RG of aircraft performance.

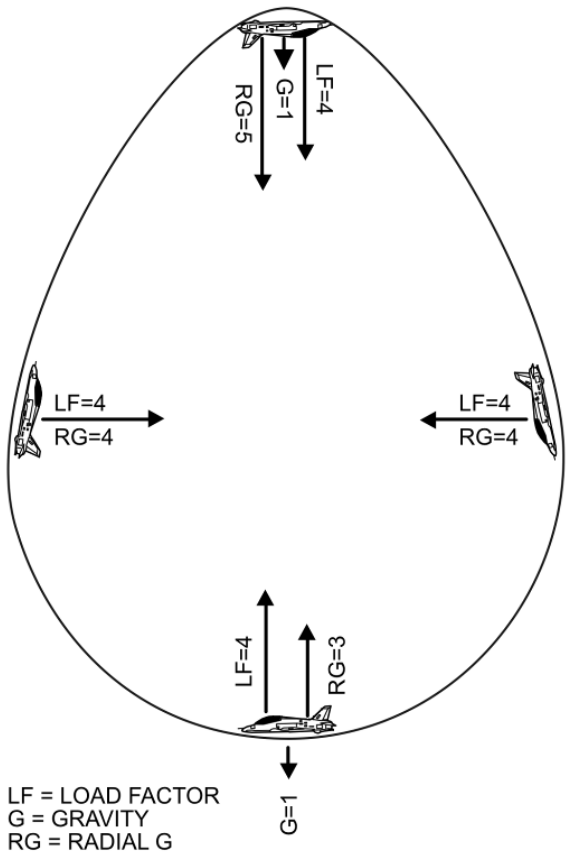


Figure 4.4 Vertical Maneuvering – The Egg

4.4.2 Nose-Low Maneuver:

While gravity can assist the aircraft's turn performance as it maneuvers nose-high, a combination of power, AOA control, and gravity can adversely affect turn performance as the aircraft begins to maneuver nose-low. The T-45 does not bleed energy in an extreme nose-low maneuver. The aircraft will accelerate when extreme nose-low despite max performing at Max Power. Finally, an aggressive nose-low maneuver at airspeeds in excess of 350 KIAS will create a greater probability of the pilot succumbing to GLOC.

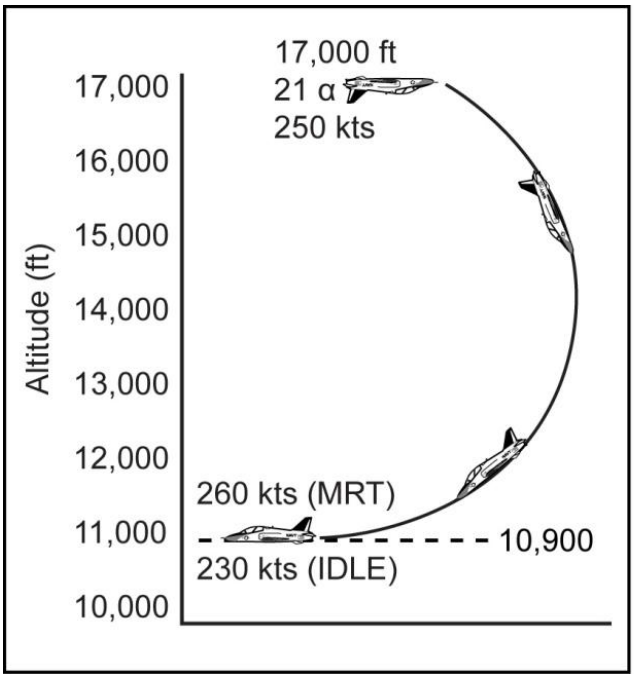


Figure 4.5 Nose-Low Maneuver (250 kts)

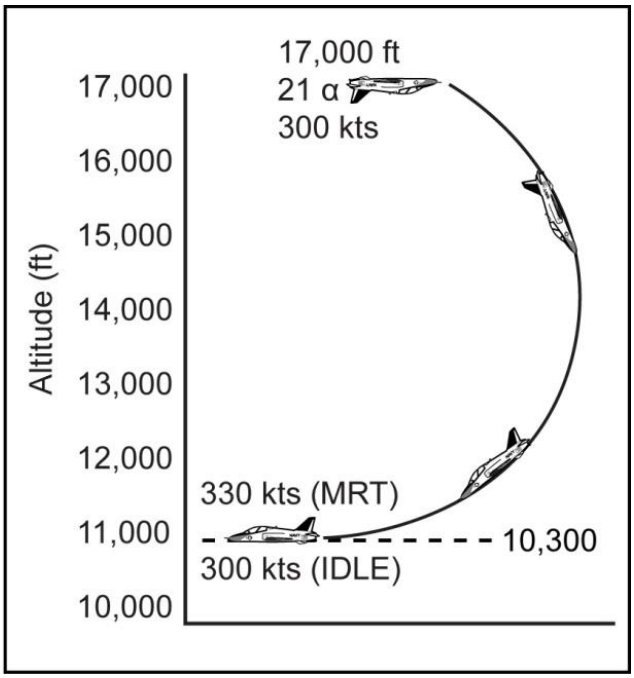


Figure 4.6 Nose-Low Maneuver (300 kts)

While performing a nose-low maneuver the effects of gravity on turn rate and radius are reversed from the nose-high maneuver. If the aircraft maintains constant G, the turn rate will decrease and the turn radius will increase throughout the maneuver. Figure 4.5 illustrates a T-45 executing a nose-low maneuver, max performing on the lift limit at MAX Power. Due to the change in radius, the aircraft's post will shift from its original position. This lateral separation between the posts needs to be accounted for when timing the nose-low maneuver, as is the case during the slow-speed merge discussion in High-Aspect Basic Fighter Maneuvers (HABFM). If the pilot executes a pull that is above or below the lift limit, the turn radius will grow even larger.

A T-45 requires approximately 6,000-6,500 ft of altitude to execute a pure nose-low maneuver (split-s) when max performing at 19-21 units AOA. Slower airspeeds will generate a smaller turn radius and require less altitude to go pure nose-low. While a T-45 at 350-400 KIAS will require 7,000-7,500 feet for a split-s, the same jet at 200-250 KIAS will require only 5,500-6,000 ft. It is important to know that throttle position (idle vs. MAX Power) does not affect turn radius (i.e. altitude loss) in a max performance pure nose-low maneuver—airspeed dictates turn radius and altitude required. Keeping the throttle at MAX Power will generate approximately 30-40 knots more at the bottom of the turn than keeping the throttle at idle. Throttle position on the way down will depend on what BFM problem you are trying to solve (discussed later in set specifics).

4.4.3 Slow-Speed Vertical Reversal:

Typically, slow-speed (less than 150 KIAS) vertical reversals are used during BFM when reversing from a nose-high to a nose-low pitch attitude in minimal time and turn radius. Maintain the throttle at MAX Power and ensure to keep the nose tracking past vertical outside +/- 20 degrees of pure vertical. It is paramount that you keep a light nibble of buffet pull. If you pull too hard or don't keep the nose tracking back to the horizon, a departure may occur. Although the jet is quite controllable during this parabolic maneuver at slow airspeeds, the aircraft may still depart. If the aircraft ever starts to move in a direction that was not commanded, immediately neutralize the controls, reduce the throttle to idle.

4.5 Deck Transition Rule of Thumb (10% rule):

The deck transition rule of thumb provides a conservative flight path profile to transition from a nose-low attitude to level flight without flying through the hard deck. We will discuss when to use the rule of thumb later on. With practice and experience you will be able to perform a more aggressive transition, but these recommended numbers provide a good starting point. Note that the max degrees nose-low translates to 10% of the altitude above the deck.

Nose-Low Altitude Above the Deck

50° 5,000 ft

40° 4,000 ft

30° 3,000 ft

20° 2,000 ft

10° 1,000 ft

Chapter 5 - TACTICAL FORMATIONS

5.1 Introduction.

This chapter builds on the formation fundamentals learned in basic flying training. We begin introducing the concepts of Tactical spacing, and TACFORM (turns).

5.2 Purpose.

The two-ship is the basic employment standard for tactical aviation. Even when part of a four-ship, you will have element leads and wingmen. The primary reason for two-ship execution is mutual support. This concept follows the basic rules of war: mass of firepower and coordinated maneuvering. Additionally, aerial warfare moves at a rapid pace and in multiple dimensions. As a result, visually supporting one another in the air increases our likelihood of survival and mission success. In many fourth- and fifth-generation fighters, this visual mutual support is enhanced with "sensor" mutual support as well.

5.3 Communications.

All communications must be received and understood by every member of the flight in order to be effective. As a guide to clear, concise, and correct communication, utilize the brevity words found in Appendix A of this manual. While in IFF, you and your flight lead will likely be the only players using your tactical frequency. No fundamental difference between BTF Communications and IFF.

5.4. Inflight Checks.

Each flight member must accomplish required checks. Visual signals or radio calls from lead may be used to initiate required checks for the appropriate phase of flight. Wingmen should be given an appropriate amount of time to complete inflight checks. Lead should adjust the formation position if necessary based on wingmen's skill level. Lead should also avoid any abrupt maneuvering to afford wingmen time to accomplish cockpit tasks without compromising deconfliction abilities. While performing inflight checks, wingmen will continue to prioritize their attention on lead, using only short glances to perform cockpit duties.

5.5 FENCE Check.

"FENCE-in" is normally directed by lead upon entering the combat/training area. "FENCE-out" will normally be accomplished exiting the combat/training area or route at lead's direction. Items to accomplish will vary with the mission type and will change during follow-on training. You may accomplish items in any meaningful sequence or cockpit flow. Use the following format ("Bully 01 Fence In/out", "2, 3, and 4"). The FENCE acronym is one good technique for accomplishing required items in UFT and is explained as follows:

FENCE Check.

- ***F*** - Fuel - Check balance, total, NORM feed, Set Bingo
- ***E*** - Emitters - Use the acronym TRAIL
    - ***T*** - TACAN. Check operation. Set as briefed.
    - ***R*** - Radar. *Not applicable with the T45 in DCS*
    - ***A*** - ALQ & ALR. Set RWR as required.
    - ***I*** - IFF. Set modes, codes, and Auto/Man as required.
    - ***L*** - Lights. As desired
- ***N*** - Navigation - INS check/verify steerpoints.
- ***C*** - Chaff and flares - ARM and check operation airborne.
- ***E*** - Employment - Recheck SMS programming. Check arming options to include weapon, fuze arming option, release pulses, spacing, and delivery modes. Ensure Master Arm is set as required, HUD has correct symbology, proper arm indication, and SOI in proper place. Confirm TGP laser code is set IAW mission requirements and Arm as required.

FENCE IN/OUT is a directive call made by the flight lead to set cockpit switches as appropriate prior to entering/exiting the combat or working airspace. Unit standards and/or the flight briefing will dictate what items are to be accomplished during FENCE checks. Normally it will require multiple intracockpit switch actuations.

5.6 Visual Lookout.

One of the most compelling reasons to fly tactical formation is to increase the effectiveness of our visual lookout in the tactical scenario. *Despite our advanced radars, radar warning receivers (RWR) and off board SA enhancers such as Airborne Warning and Control System (AWACS), it is possible for an enemy to achieve an undetected entry into our combat formation.* Therefore, you need to exercise a disciplined visual lookout to detect threat aircraft before they can achieve a weapons engagement zone (WEZ) on any member of the formation. Figure 5.3 shows the priority of visual lookout for both members of the formation. It is important to remember that we operate in three dimensions. Therefore, every sector of the visual lookout must be scanned not only level with your own jet, but higher than you, and lower than you.

As a result, each sector depicted in Figure 5.3 can be divided up into three vertical sectors as well. It is also important to pause in each sector allowing your eyes to focus at range and detect movement. The environment, threats, weather, and other factors may alter the visual search responsibilities of each member of the flight. For instance, at low altitude, checking 12 o'clock and own ship altitude are very high priorities.

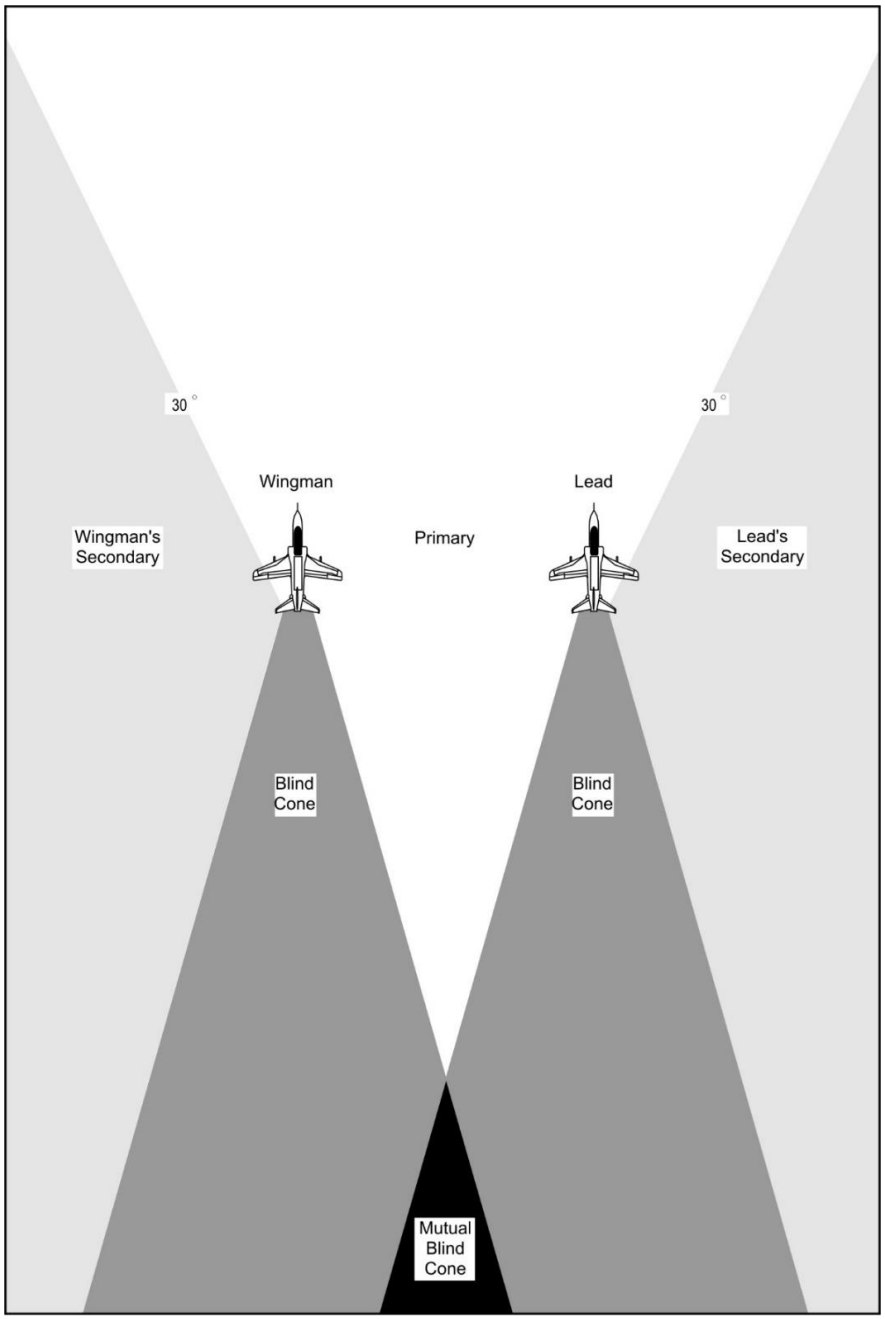


Figure 5.3. Wingman Visual Lookout Priorities in Tactical Formation.

5.7 Two-Ship Tactical Formation.

Two-ship tactical formations are the baseline formations for employment. These formations include line abreast (LAB), Wedge. Although the parameters vary from airframe to airframe, the tactical formations flown in this course are the common tactical formations taught by the major Air Forces. Factors that affect how we fly our formations include the threat, weather, visibility, background, and terrain. Unlike in Basic Flight Training, we use tactical formations not as an end to themselves, but as a means to facilitate proper visual lookout, task prioritization and offensive and defensive tactics.

Wingmen should aggressively pursue being in position. This is an "aggressive" mental state, not necessarily aggressive flight control actuation. The degree of aggressiveness depends on how far out of position you are. Maneuvers to correct excessively poor formation may be aggressive but never erratic. Continuously assess your position and make corrections. The earlier you perceive a formation error the smaller the fix required and easier it will be to correct.

5.7.1 *Visual Cues for Formation Ranges.*

Due to the difference of monitors, resolution, VR goggles, etc. establishing a universal visual cues for lateral spacing in DCS is impossible. Some aircraft have different systems (HMD's (Helmet Mounted Device's), Yardstick) that can display distance to your wingman. By using these systems, AND with experience, you can develop a feel and sight picture specific to your equipment to be able to visually gauge range.

Yardstick

Yardstick is the term for air-to-air (A/A) TACAN ranging. If modeled in that specific aircraft, Yardstick gives DME ranging to the nearest aircraft transmitting 63 channels apart from the TACAN channel you have in your system. For example, 29X A/A gives ranging for an aircraft with 92X A/A. This is usually assigned in the brief, but may be modified as required in flight.

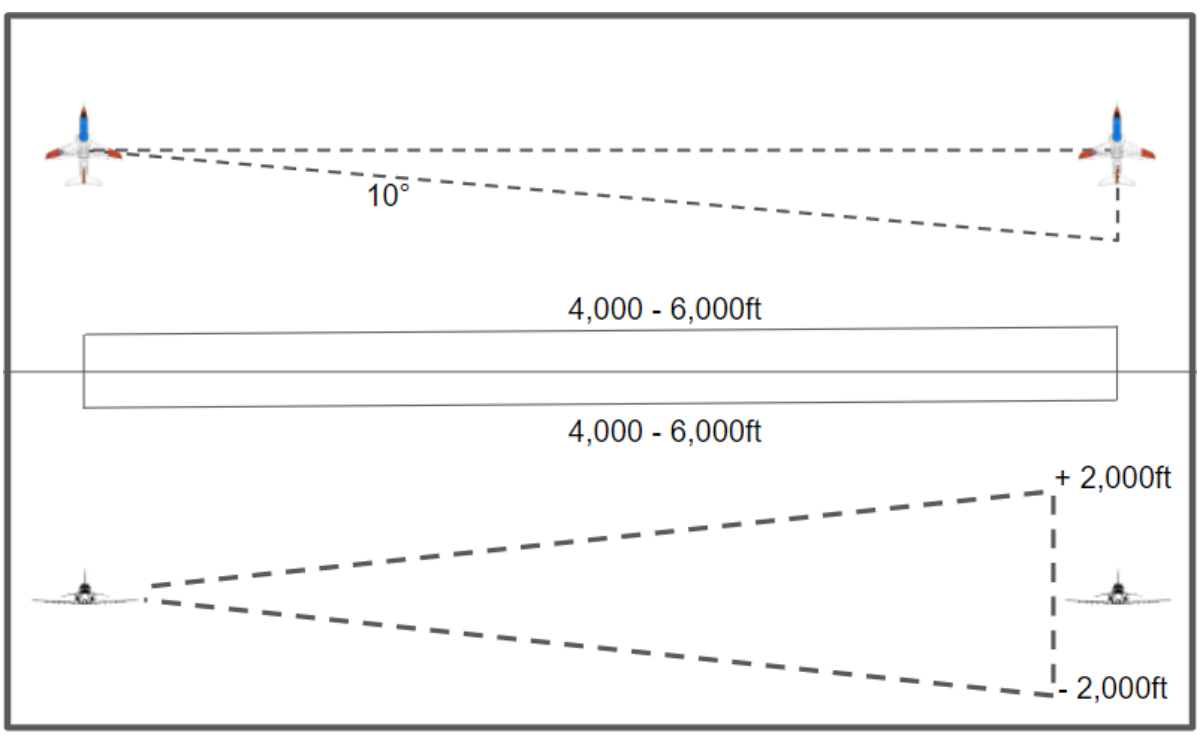


Figure 5.4 2-Ship LAB

5.7.2 Line Abreast (LAB).

The LAB is most commonly used in Air-to-Air engagement situations because it allows for the greatest ability to maintain mutual support and visual scanning. While being able to have both aircrafts weapon systems with a clear sector of fire. But, LAB is also the most rigid and least flexible formation. It requires more attention from the Wingman to maintain position.

Position:

- Range 4,000 to 6,000 feet with
- 2,000 feet of altitude stack.
- 0° to 10° aft

Always strive for 0° aft. Your priorities in flying LAB formation are: LAB first (0° aft), range second, and lastly taking a stack. Maintaining a cross-check instead of constantly staring at the flight lead will allow you to see subtle changes in your position.

Correcting LAB Position. The easiest way to correct formation position is to establish a cross-check that allows you to perform all assigned tasks and maintain your assigned formation position. In order to determine whether or not you are LAB with your flight lead, assess aspect angle; you should see 90°. Assuming you are coheading, this position is approximately when the other aircraft is over your shoulder to about an inch in front of your shoulder in the 4,000- to 6,000-foot range.

5.7.3 Trail

Position:

- Range 6,000 to 12,000 feet
- Within 20° cone from 6 o'clock

5.7.4 Wedge

Wedge formation allows for the maximum flexibility but does so at the expense of mutual support. Because #2 is behind #1, it doesn't allow for #1 to visually scan and support #2. This formation is more often used in strike type situations when one of the aircraft is the active attacker (shooter) and the other is cover for them. It allows for #2 to advice #1 of any threats on them.

Position:

- Range 3,000 to 9,000 feet with
- 2,000 feet of altitude stack.
- 30° to 60° aft

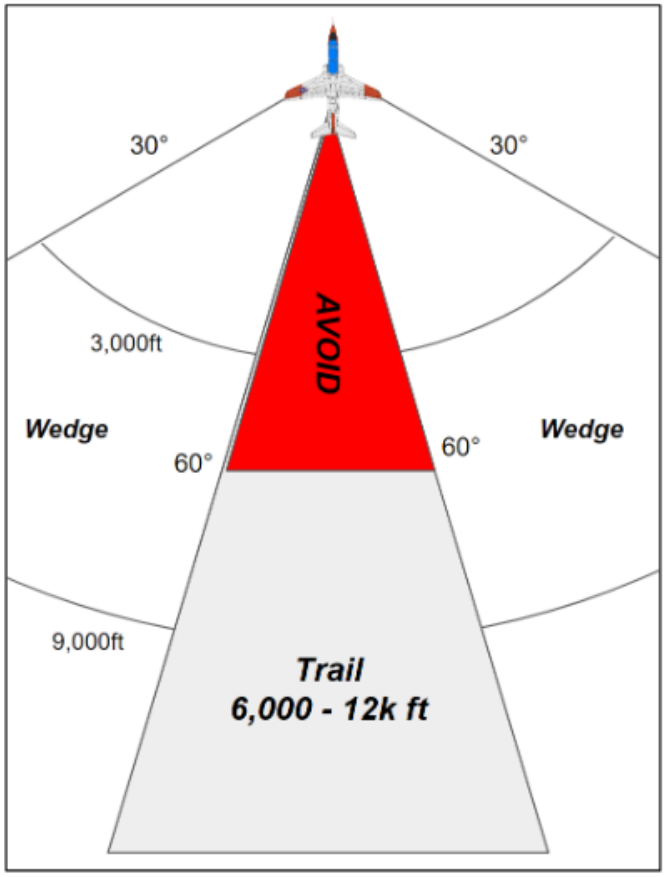


Figure 5.4 2-Ship Tactical Formations

5.8 Position Corrections

The laws of physics that affect your position-keeping when flying in Combat Spread are the same laws that affect your position-keeping while flying in Parade. The only major difference is your ability to discern deviations due to the relatively large separation between you and your Flight Lead. A disciplined inside/outside scan is crucial to seeing deviations, but the real key to staying in position is basic air work; how long do you think you could stay in Parade position with five more knots than Lead, or two degrees difference in heading? While Spread is much farther from Lead than is Parade, the same principles of position-keeping apply.

There are three variables you must solve to correct and maintain position in Spread. TACFORM positioning order of priorities is:

1. Bearing line.
2. Abeam distance.
3. Altitude.

A rapid inside-outside scan will be required to maintain the proper bearing, abeam distance, and altitude. The right combination of airspeed, heading, and power will control the proper Combat Spread position, so remember what each of these controls; airspeed controls bearing, heading controls distance, and power controls altitude. Any deviation in just one of these parameters will cause a deviation to the accepted Combat Spread position. It is possible, and preferred, to apply multiple corrections simultaneously to control your Combat Spread position.

We are going to apply a few rules to our corrections while trying to fix the above variables:

1. ***Always lead acute or altitude corrections;*** be accelerating back to 300 KIAS before you hit bearing line while fixing an acute, and/or starting level-offs before you blow through altitudes.
2. ***Never lead sucked or abeam distance corrections;*** wait until you drive all the way up to the bearing line from a sucked position before you climb to decelerate, and don't turn to parallel Lead before you've driven in or out to the abeam distance that you need.

Now is a good time to introduce the concept of energy conversion. Getting proficient at trading altitude for airspeed, and vice versa, will pay dividends in making smooth, expeditious, and efficient corrections while attempting to maintain Combat Spread. Maneuvers and corrections need to be timely and smooth. It is important to note that erratic and/or abrupt control inputs will just aggravate all involved. Learn to make smooth and controlled, yet aggressive corrections; sometimes a 7 unit AOA pushover will be required. Other times, rolling upside down and pulling will achieve the same result. Going up on a wing might also be used if applicable; whichever technique is used, be aware of what you are trying to achieve with the jet, and do it smoothly.

5.8.1 Correcting For a Sucked Position

Correcting for a sucked position is simply a matter of trading altitude (potential energy) for airspeed (kinetic energy) to start the correction, and reversing the trade to stop the correction. If you find yourself sucked, simply push the nose over (up to 7 units AOA) to gather airspeed as you come downhill. Take your extra airspeed 'along the bottom' and drive forward to the bearing line. Only when you hit the bearing line (*never lead a sucked*), smoothly and aggressively pull 2 to 3 Gs until the nose is up, and climb back to your desired altitude. This significant pull up and nose-high attitude will rapidly start you climbing, while concurrently decelerating. As a useful rule of thumb, every 1,000 ft of altitude that you climb or descend will lose or gain about 30 knots respectively. This correction can be accomplished with little to no throttle modulation, but for a large deviation you may need to add power to further expedite the correction. Adjust the climb attitude to arrive back on bearing, at altitude, and 300 KIAS. This is simplified, but the premise works for all variations of sucked corrections as long as you tailor your application of the above method for the magnitude of correction to be made.

5.8.2 Correcting for an Acute (Forward) Position

There are many ways to decrease downrange travel with respect to Lead, and work off an acute. Listen to your instructors to develop techniques to get the desired result. *Remember, you must spend a majority of your time looking outside, referencing Lead, to build the sight pictures necessary to become skilled at fixing geometry problems*. Use the following procedures to help build your own techniques. For slightly acute positions, you can simply make level turns, or climb and slow down. Making level turns can correct the bearing line, but may bleed energy, so power may be needed to maintain airspeed (which uses more fuel).

Climbing and slowing down is more fuel efficient. Simply climb to trade airspeed for altitude and start a drift aft towards the bearing line. Before arriving on the bearing (always lead an acute) push the nose over and descend back to altitude. You will continue to drift aft to the bearing line as you accelerate in the descent. Adjust power as necessary to arrive on bearing as you reach 300 KIAS. As in the sucked correction, this method can be utilized with little to no throttle modulation.

For full acute positions, the above methods will work but you can get back to the bearing line more expeditiously by coupling turns with an altitude excursion and power adjustment. It is very important to make your corrections smooth and precise. Abrupt and erratic turns will only result in a loss of SA. Use nose position and power as required to arrest downrange travel. This might involve greater pure level deviations or by combining turns with power and altitude adjustments. There are many techniques your instructors will talk through that you can use. Regardless of the techniques used, accelerate and correct back to capture bearing line, abeam distance, altitude, and airspeed prior to going sucked.

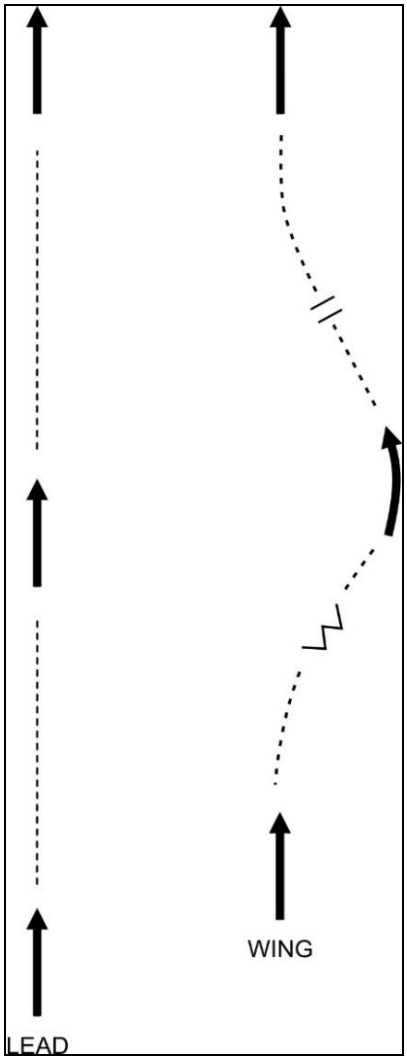


Figure 5.5 Acute Correction

5.9 Two-Ship Tactical Turns.

Expect flight leads to have solid wingman consideration; however, they will fly wherever required to accomplish the mission. This means that turns may not be exactly 180°, 90° or 45°. As tactical turns are initiated, you should assume standard turn amounts, however, continue to monitor and fly off of lead during the remainder of the turn. This will allow you to make corrections early and still roll out in position.

The contract for tactical turns is MIL power and G to hold airspeed (normally 300 KIAS). When in level flight between 10,000 and 18,000 feet, this will be approximately 80° of bank and 3 Gs. However, not all turns are level (for example, climbing between BFM sets), and sometimes turns are initiated from nonstandard positions and/or energy states (for example, just after a BFM set). A constant cross-check of the flight lead is necessary so that you can match their turn rate, radius, and line-of-site rate (LOSR) and end up in the proper formation.

5.9.1 Check Turns

A Check Turn is used to turn the section 30 degrees or less. Lead will roll into a 30-degree AOB turn for 30 degrees or less of heading change at 300 KIAS. Think of these turns as putting you instantly acute or sucked, requiring smooth and aggressive bearing line corrections. As will be the case for all the turns in your TACFORM flights, Lead will not start maneuvering until Wing acknowledges the Lead's comm:

Lead: "*Hammer, Check left, 250*"

Wing: "*Hammer 12, 250*"

You will see Check Turns used to get Wing back into position in order to expedite setting up for the next maneuver later in your training. This will happen when applying cooperative maneuvering. While in the Tactical Formation stage of training we will use them to create an acute so you gain an understanding of geometry and fixes required. Tactical Formation is an art that you will continue to perfect throughout your career.

5.9.1.2 Turn Into Wing

Check Turns into the wingman requires corrections that basically mirror what you would use for an acute position that was covered in BFT Formation training. There are many ways to achieve the same goal, even more than are listed here. We will reference three options that you can pull from to build your own technique for fixing an acute. Some of these steps are deliberately vague so the focus is on looking outside and assessing, vice concentrating inside on rigidly achieving specific parameters.

1. ***Turn with a climb:*** turn to the new heading, referencing Lead in the turn. Manage your nose position and power to decrease downrange travel (increase nose attitude, reduce power). Watch the bearing line as it approaches from behind and be in a correction to capture the bearing line, abeam distance and altitude. Continue to assess and manage power to capture and maintain airspeed (300 KIAS) out of the maneuver. Your IP's will have many techniques to include gouge power settings, nose attitudes and timing for success. Bottom line, look outside and continue to assess for corrections and re-corrections to be in position expeditiously.

2. ***Pure level maneuvering:*** use a series of hard level turns away from and into Lead to slow your downrange travel using pure geometry. Be aware of excessive abeam distance errors, as this makes your judging of position more challenging; allow your jet to displace for a while to decrease down range travel, then reassess. A good rule of thumb is to take a mental snapshot of how much correction is required, and reverse your turn back towards Lead when 50% of that correction has been made.

3. ***Oblique maneuvering with S turns:*** a climbing turn past the flow heading, then turning down and into Lead, is another way to quickly slow downrange travel. The power should remain constant during this maneuver to eliminate variables, unless needed due to resultant geometry. Large vertical and lateral errors should be avoided as this makes it harder to judge where you are in relation to Lead. As a technique, avoid maneuvering further away than 2.0 nm, climbing more than 2,000 feet, and decelerating more than 50 knots.

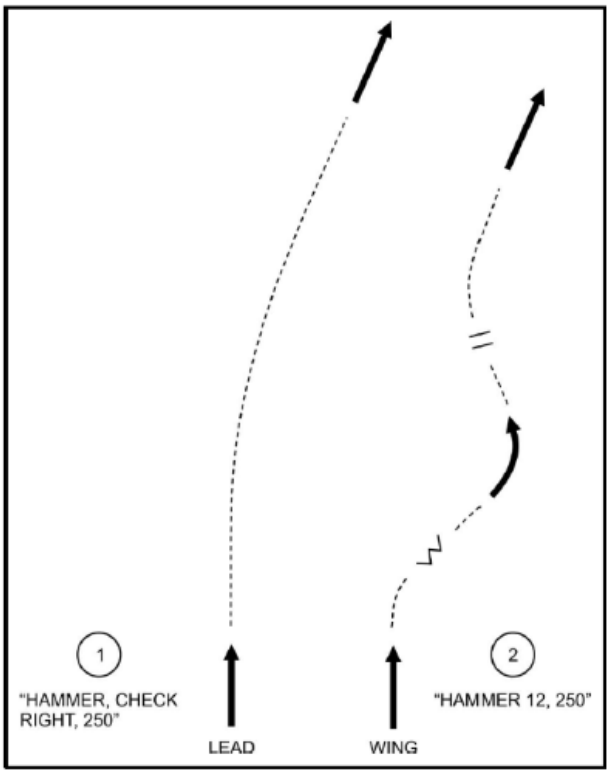


Figure 5.6 Check Turn Into Wing

It will not be obvious reading this text, but you will soon realize that check turns into Wing can be one of the most difficult corrections to master.

Common Errors:

- Floating (less than 2 Gs) the cuts away and into Lead.
- Not looking back at Lead, and not continuing to quickly adjust for desired results.

5.9.1.2 Turn away from Wing

A Check Turn away from Wing will induce a sucked position. The goal is to accelerate quickly so that you reduce your positional error as expeditiously as possible. For a Check Turn away from you, make a turn to the new heading while aggressively lowering the nose to gain airspeed (descending below Lead is acceptable and encouraged). This is one situation where you can justify bringing the throttle up to expedite acceleration. Once you have a healthy excess of airspeed, reset your fuel flow, and keep the extra airspeed gained to drive forward to the bearing line. Abeam distance errors can be fixed as you approach the bearing line. Once you hit the bearing line, aggressively climb back to altitude and recapture 300 KIAS.

5.9.2 Shackles

Shackle Turns allow the Lead to re-dress the section (get Wing back into position), or to have the jets maneuver to opposite sides of the formation. If Lead desires to keep the section on the current heading, both aircraft begin a level 14-unit turn toward each other for approximately 45 degrees of heading change, adjusting power as necessary to maintain 300 KIAS. Both aircraft will roll out with the new heading on the appropriate 45-degree benchmark and wait for the pass. The wingman is responsible for altitude deconfliction, and should keep Lead in sight throughout the Shackle. If both aircraft cross over each other and reverse back to the flow heading at the same time (roughly 2 sec after the pass), you should come out of the turn on bearing line at the appropriate abeam distance.

A Shackle can be used to help the wingman regain bearing line from either a sucked or an acute position. If the wingman starts out slightly sucked, he/she may elect to turn 45 degrees, and reverse earlier after the pass, back to the flow heading. If the wingman is excessively sucked, he/she may turn less than 45 degrees, or not at all in the worst instances. If the Wing starts out slightly acute, he/she may turn 45 degrees, and wait longer after the pass to reverse back to the flow heading. If the wingman is excessively acute, he/she can turn greater than 45 degrees initially before turning back to the flow heading. Any of these techniques may be used, and are situation-dependent, so adjust accordingly.

Since a Shackle is a somewhat cooperative maneuver, don't blindly initiate a correction without assessing what Lead may be trying to accomplish with the Shackle. Mentally note whether you were in position or out of position to begin with, and tailor your correction according to what Lead is trying to accomplish.

Common Errors:

1. When in position and Shackling straight ahead, Wing turns all the way to the pass (greater than 45 degrees), instead of rolling out on the 45-degree benchmark.
2. Not pulling 14 units in either turn.
3. Not scanning airspeed and getting either too fast or too slow.

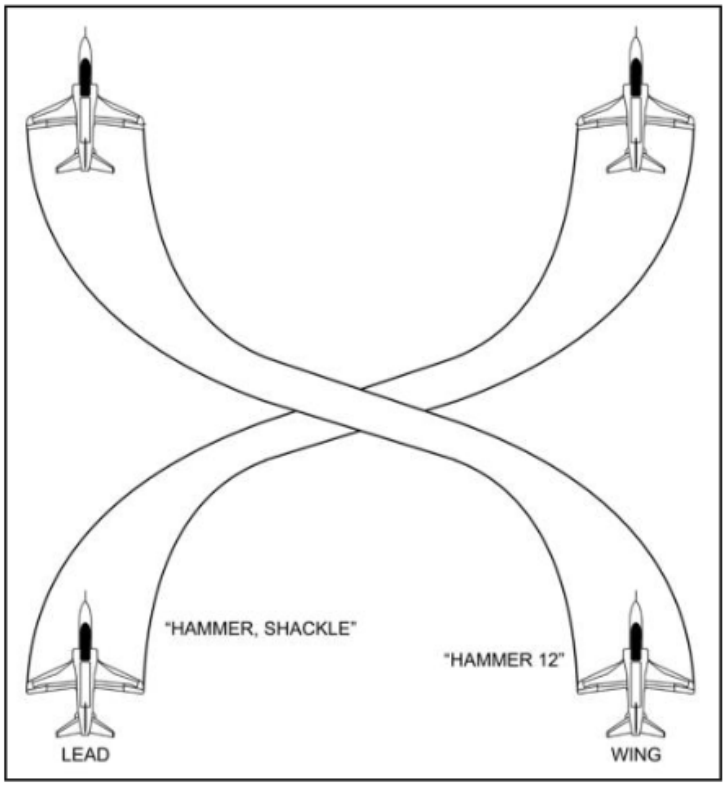


Figure 5.7 Shackle

5.9.3 90-Degree Turn

When the flight needs to make a 90-degree turn, this will allow for the formation to make the turn while being able to maintain proper combat spacing.

The geometry and procedure for the turn is the same no matter which side you turn to, it just becomes a mirror image. We will use Figure 5.5 as an example of a 90 degree TAC turn into the wingman.

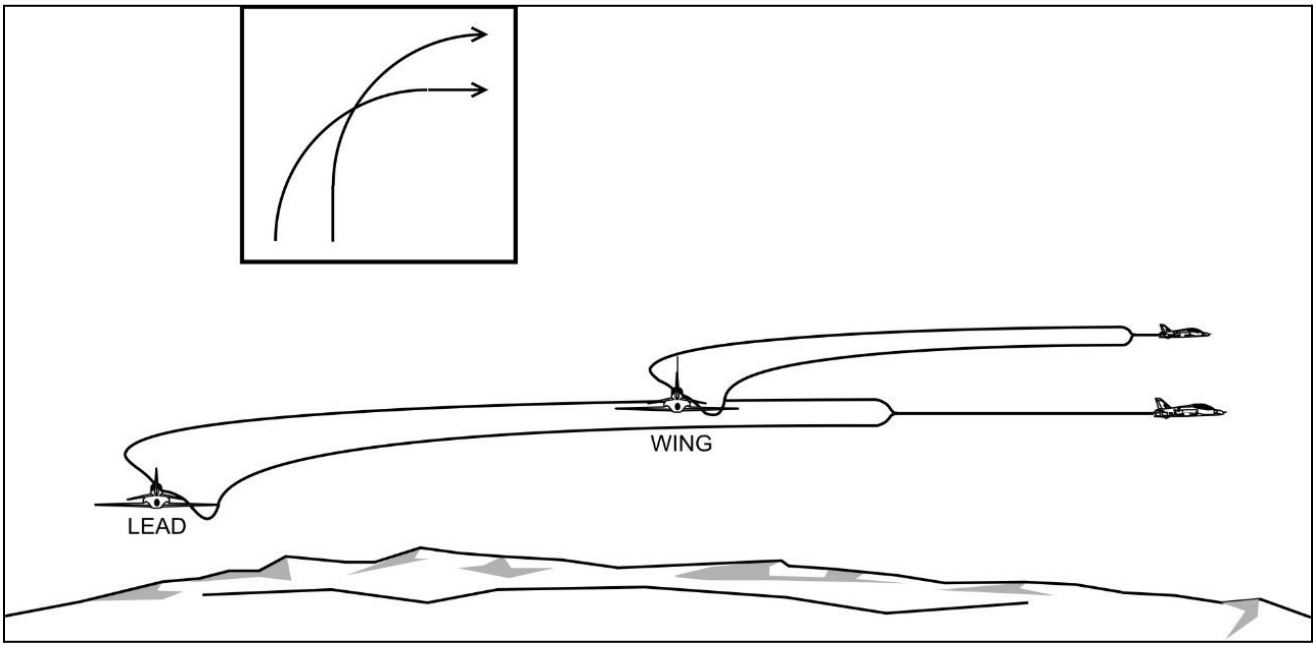


Figure 5.8 90 degree TAC-Turn

Procedure:

- Lead (Outside aircraft to turn) starts turning into the wingman (inside aircraft).
- Once lead is pointed at the wingman, the wingman starts his turn.
- Both aircraft continue their turn until the 90 degree turn is achieved.
- Once both aircraft have finished their turns, both should be in the same spacing having only flipped sides.

Common Errors:

1. Not maintaining 14 units AOA and 300 KIAS during the turn.
2. Not assessing corrections needed during the turn.
3. Not maintaining altitude while blind in the turn.

5.9.4 In-Place Turns

The In-Place Turn is an engaging turn that changes flow heading by 180 degrees, and causes the Fighters to swap sides of the formation. Both Fighters should begin and finish their turn at the same time. Realize that if you are out of position at the start it will require adjustments to your AOA and nose position in order to arrive in position out of the turn. An In-Place Turn is used to engage a bandit that is in the section's rear quarter, in the direction of the turn. The turn begins immediately following Wing's acknowledgement of Lead's comm:

Lead: "*Hammer, In-Place right*"

Wing: "*Hammer 12*"

Common Errors:

1. Not maintaining 14 units AOA and 300 KIAS during the turn.
2. Not assessing corrections needed during the turn.
3. Not maintaining altitude while blind in the turn.

IN-PLACE TURNS INTO WING, Upon responding to the initiating comm, immediately begin your turn away from Lead adding power as required to maintain 300 KIAS. After roughly 135 degrees of turn look for Lead to appear over your shoulder, and assess the bearing line. Since In-Place Turns take twice as long to accomplish as Tac Turns, bad airwork from Wing will result in amplified deviations after the turn is complete, so think ahead as the maneuver is progressing, and assess your airwork; adjust AOA as soon as you recognize deviations. Thinking ahead, and making early or mid-maneuver corrections, may save you from having to make bigger corrections at the end of the maneuver.

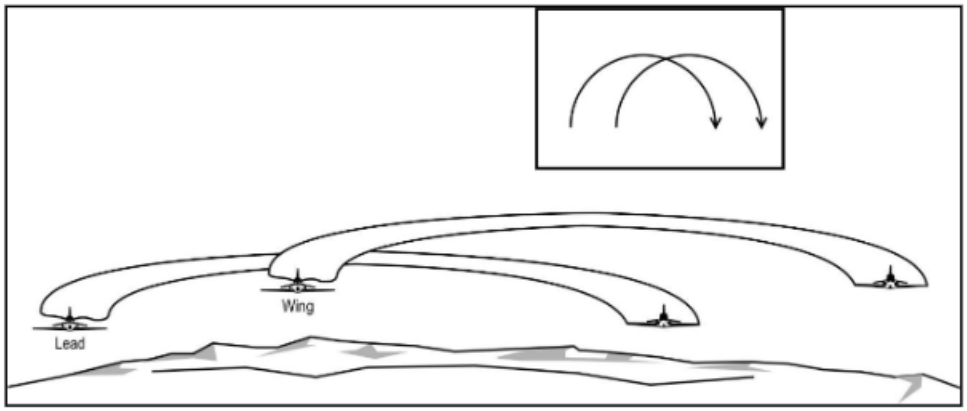


Figure 5.9 In-Place Turn into Wing

IN-PLACE TURNS AWAY FROM WING, Upon responding to the initiating comm, immediately begin your turn into Lead adding power as required to maintain 300 KIAS. Your first check point in the turn will be after 90 degrees of heading change. You need to assess if you are leading or lagging Lead's turn rate, and whether or not you are offset to what would appear to be outside or inside Lead's turn. If you are lagging Lead's turn rate, or appear to be outside of his/her turn, you need to wrap up the turn using an extra unit or two of AOA to catch up. If you are leading Lead's turn rate, or appear to be inside of his/her turn, then you need to float the turn a comparable amount. Be mindful that when you wrap up or float the turn, you are going to induce abeam distance errors; anticipate abeam distance errors, and start planning a correction out of turn to correct geometry deviations. As a safety note, descending out of altitude during an In-Place Turn away from Wing should only be done with situational awareness to Lead's position.

5.9.5 Cross Turns

The Cross Turn is a 3-4G, 300 KIAS hard turn into each other at MRT, where the Fighters cross each others' flight path and change flow heading by 180 degrees. Out of Cross Turns, the Fighters are on the same relative side of the formation (if you start on the left, you finish on the left); additional comm's is needed for deconfliction because Fighters are going to make a relatively close pass.

Lead will initiate the Cross Turn, "*Hammer, Cross Turn, Cross Turn, Hammer 11 low.*" In early TACFORM flights, Wing will be the high Fighter, so he/she will respond "*Hammer 12 high.*" As Wing begins to transmit "Hammer," he/she should select MRT and be rolling to execute a 3-4G, slightly nose-low, hard turn into Lead. Lead will execute an identical turn into the wingman. Both Fighters will end up turning for 180 degrees to the new flow heading. The pass will occur just prior to either jet achieving 90 degrees of turn. Wing should be right above Lead, to slightly inside of Lead's radius of turn. The degree to which Wing goes nose-low is predicated on being no closer than 500 ft above Lead at the pass.

Once the pass is safely assured, Wing should overbank briefly, maintaining 3-4Gs, allowing the jet to accelerate past 300 KIAS in the nose-low slicing turn. As the section started out at 0.8 to 1.0 nm separation prior to the Cross Turn, the wingman should end up on bearing, wider than usual (due to radius of turn at 3-4Gs, >=300 KIAS). Wing will tend to be wide out of the Cross Turn, and should continue 30 degrees or so past the new flow heading into Lead, using excess airspeed to collapse and achieve the correct abeam distance. Wing can then parallel the new flow heading while simultaneously correcting back to altitude and 300 KIAS.

Typically, Wing ends up slightly sucked, so he/she will also have to drive forward to the bearing line after correcting for abeam distance.

Common Errors:

1. Not talking while turning at the start, resulting in Wing being outside Lead's turn.
2. Not selecting MRT early enough or maintaining 3-4Gs throughout the turn.
3. Overbanking too much and/or too early, resulting in a close pass with Lead.
4. Overbanking late, resulting in a lack of excess airspeed to correct for bearing line and abeam distance deviations.

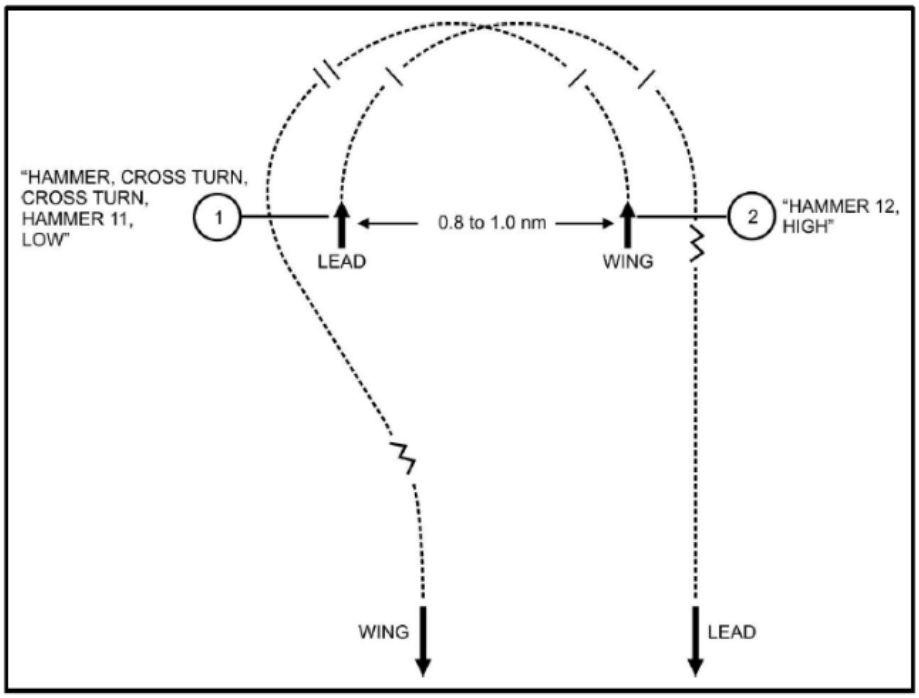


Figure 5.10 Cross Turn

5. Going belly-up to Lead to correct heading/abeam distance, while climbing through Lead's altitude.

5.10 Four-Ship Tactical Formation.

Four-ship tactical formations build on the basics of two-ship formations. These formations are typically used to efficiently maneuver two elements to mass firepower and maximize offensive and defensive capabilities. Four-ship tactical formations include: Wall, Fluid-4, Box, and Offset-Box. Each of these formations have advantages based on the tactical situation and must be flown proficiently. Typically, number 2 will set the stack. Number 3 will stack opposite of number 2, and number 4 will stack further in the opposite direction. To maximize the advantages of each of these formations, all flight members should strive to maintain visual with the other flight members. As a minimum, wingmen MUST maintain visual with their respective element leads.

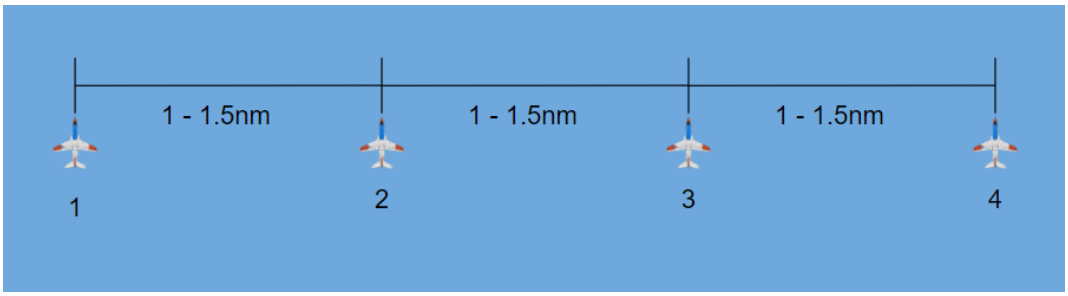


Figure 5.8 Wall Formation

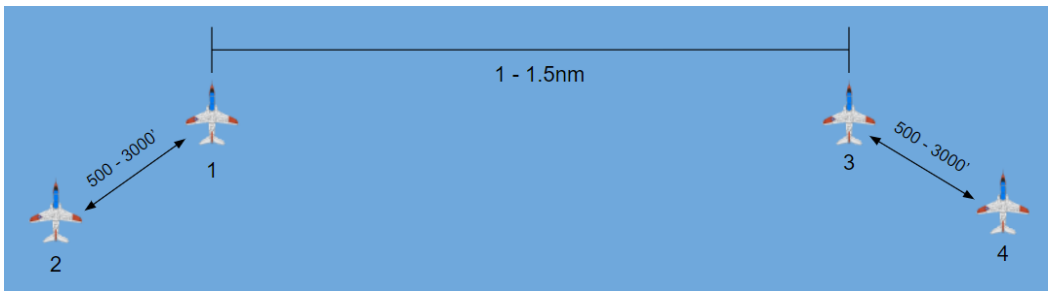


Figure 5.9 Fluid 4 Formation

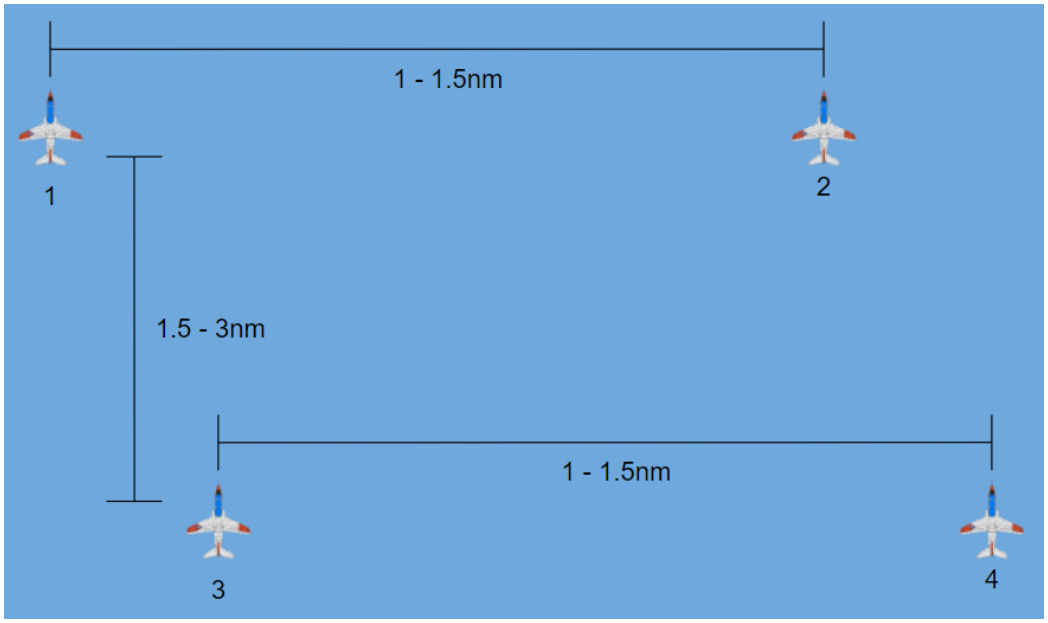


Figure 5.10 Offset Box Formation

AIR-TO-AIR COMBAT FUNDAMENTALS

CHAPTER 6 - OFFENSIVE BFM

6.1 Offensive BFM Objectives

The ultimate goal of offensive BFM is to kill the adversary as quickly as possible. If this primary goal is not achieved, ensure a positional advantage is maintained for follow-on weapons employment. Finally, if time to kill is up or you are losing the advantage, separate prior to becoming neutralized. Simply put, the goals of offensive BFM are, in order:

1. Maintain the offensive position.
2. Employ follow-on weapons.
3. Transition to High-Aspect BFM (HABFM) if neutralized.

NOTE

HABFM will not be executed until introduced on the first HABFM event.

6.2 Knock-It-Off (KIO) / Terminate Procedures.

Use KIO or terminate procedures to direct aircraft to cease maneuvering. A KIO or terminate applies to any phase of flight and all types of missions.

Any flight member can initiate a KIO or terminate. *Initiation of a KIO or terminate will start with flight callsign, followed by each flight members transmitting his or her position number—in order—with "knock-it-off" or "terminate".*

For example, if anyone transmits, *"Iron 11, knock-it-off"*, all flight members will respond as follows: *"Iron 1 knock-it-off"*, *"Iron 2 knock-it-off"*, *"Iron 3 knock-it-off"*, *"Iron 4 knock-it-off"*.

When hearing a KIO or terminate call, all participating aircrew will clear the flightpath, cease current maneuvering, climb or descend to a pre-briefed safe altitude (1,000 feet AGL minimum), and acknowledge with callsign.

If able, the aircraft that initiated the KIO or terminate will give the reason after the KIO drill is complete, if not obvious (for example, "Iron 2 engine flameout"). If any flight member fails to respond correctly, the sequence should be initiated again. Lead will be directive before resuming maneuvers.

6.3 T-45 Performance Numbers

Best Acceleration: Unload to .5-G with Full Power selected.

Corner Airspeed: ***410 KIAS.*** This airspeed yields the aircraft's best instantaneous turn performance, but also sustains the highest bleed rates.

Corner Bleed Rate: 8 knots/second. This is the rate at which the aircraft will decelerate in a max performance pull at corner airspeed.

Best Sustained Turn Rate: 240-330 KIAS. At the lower end of the rate band the aircraft yields a small advantage in turn rate (0.5° higher at 240 KIAS compared to 330 KIAS). However the aircraft's ability to trade airspeed for angles (energy excursion) is reduced below 300 KIAS. Furthermore at slower airspeeds the aircraft becomes more difficult to handle as it is more prone to stall/pitch buck. *Initially targeting the upper portion of the rate band (300-330 KIAS), until an airspeed excursion is necessary, is prudent in most cases*.

Max Performance:

- ***Pitch:***
  - Airspeed *above* corner airspeed: load limit pull, 7.33Gs.
  - Airspeed *below* corner airspeed: lift limit pull, 19-21 units AoA pull.
- ***Roll:*** Unload while utilizing coordinated stick and rudder. The slower the speed, the more rudder deflection you will be able to achieve due to lessened aerodynamic loads.

Due to this, the use of rudder at slower speeds becomes more beneficial in achieving maximum roll rates.

Minimum Radius Airspeed Band: 140-180 KIAS (all altitudes).

Minimum Vertical Airspeed: 300 KIAS. Minimum vertical airspeed will vary based on altitude and proficiency. As a technique, targeting a light nibble of buffet pull will optimize the execution of a minimum airspeed vertical loop.

Tactical Vertical Airspeed: 350 KIAS. Tactical vertical airspeed corresponds to the airspeed required to initiate a tactical nose-high maneuver. Once the aircraft is nose high, you still have tactical options available, including vertical extension, lift vector reorientation, and/or airspeed excursions.

High-Aspect Merge Recommended Airspeeds:

- *Nose High Gameplan:* 350-420 KIAS
- *Nose Low Gameplan:* 270-350 KIAS
- *Level Gameplan:* 370-410 KIAS

Understanding the performance characteristics of our aircraft will enable us to fly our aircraft more effectively. As we maneuver to gain positional advantage however, so is our enemy. It is important to understand the adversary's maneuvering capabilities, and reference those capabilities against our own. During training sorties, it is usually recommended that you fly the same aircraft, so that the proficiency and capabilities of the pilot at the controls are the only unknown variable. The aviator that best understands the aircraft's performance and weapon systems capabilities, and who applies the principles of BFM to coincide with known performance characteristics, will reign victorious.

6.4. BFM Concepts and Definitions

In order to achieve a victory, we must maneuver our aircraft into a position in which we can employ our weapons systems while denying our enemy the ability to employ his or her weapons. We have already covered some basic maneuvers. Combining offensive concepts with the cues in the cockpit will dictate when to maneuver the aircraft and employ a weapon.

6.4.1 - PADS

PADS is an acronym for the starting parameters of an engagement or maneuver: ***P**osition, **A**ltitude, **D**istance, **S**peed*.

6.4.2 - 3/9 Line:

The 3/9 line is an imaginary plane extending from wingtip to wingtip, perpendicular to the flight path. Positional advantage is generally defined by your aircraft's position relative to the bandit's 3/9 line, or vice versa.

6.4.3 - Vertical 3/9 Line:

Vertical 3/9 line is similar to the 3/9 line, but oriented in the vertical plane; it is not represented by the lift vector. The vertical 3/9 line is 180 degrees off orientation from the weight vector. In a rolling scissors the vertical 3/9 line defines the horizontal overshoot.

6.4.4 - Turning Room:

Turning room is any separation that exists between two aircraft. Exclusive-use turning room is any turning room that is available to only one aircraft in the engagement.

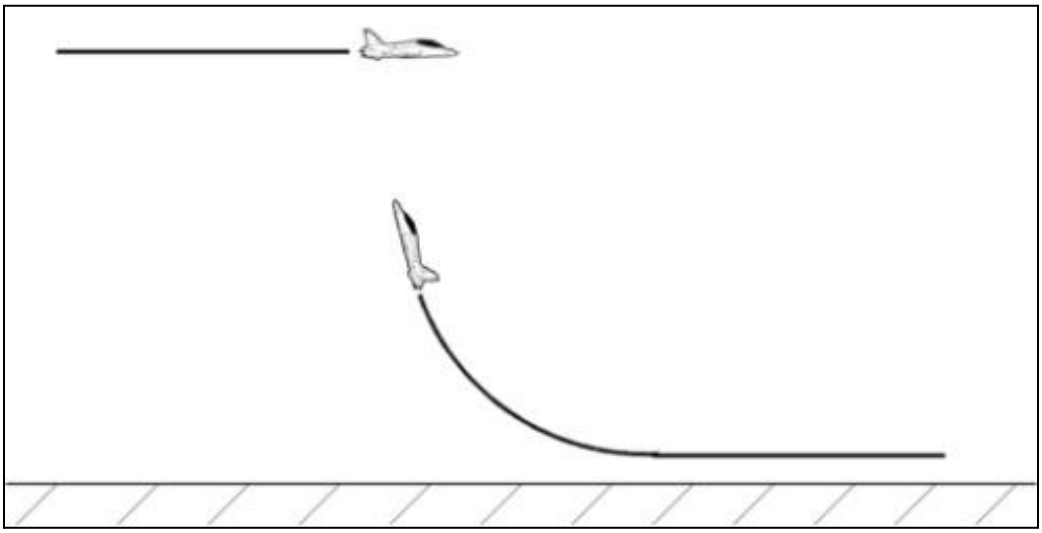


Figure 6.1 Exclusive-Use Turning Room

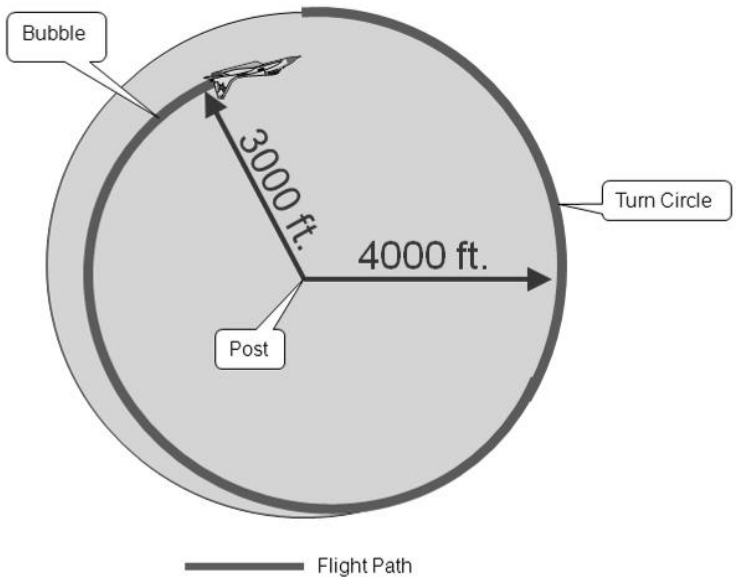


Figure 6.3 Turn Circle, Post, and Bubble

6.4.5 - Turn Circle, Post, Bubble

Turn Circle: Turn circle is the actual turn an aircraft is scribing, based on current turn performance.

Bubble: The actual turn an aircraft is scribing based on a current maximum performance turn. The visual cues in BFM are based on the aircraft's bubble. During your perch BFM briefs, the instructor will use a template that represents the average bubble of the T-45 in a BFM engagement; this should be a 3,000 ft turn radius. An aircraft cannot turn inside its own bubble; this means that if you are inside another aircraft's bubble you are, at least momentarily, immune from attack from that aircraft. This immunity, and its impact on the current engagement, is important to note, both offensively and defensively, and is by far the most important BFM concept to understand.

Post: The post is the center point of the turn circle. The post does not define pursuit curves.

6.4.6 Plane-of-Motion:

Plane-of-Motion (POM) is the two-dimensional plane in which the turn circle resides. When an aircraft is at a high energy state, or executing a symmetrical pull in the vertical, its POM is a close approximation of the plane of symmetry (POS), or the plane in which the LV lies. When at lower energy states (i.e., 130 KIAS level, 60-degree AOB turn), POM may be more difficult to determine.

6.4.7 Control Zone:

Control Zone (CZ) is a cone, approximately 2,000-4,000 ft, +/- 10° in the near side, and +/- 20° in the aft portion, of the pursued aircraft.

6.4.8 Attack Window:

The Attack Window (AW) is a location inside the bubble where, if we max perform an Offensive Break Turn (OBT), we will arrive in our opponent's CZ with range, angles, and closure (RAC) under control.

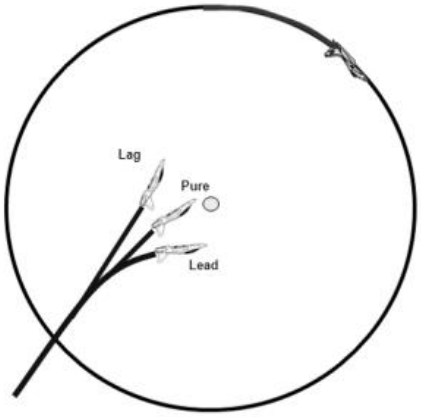


Figure 6.3 In-plane Pursuit Curves

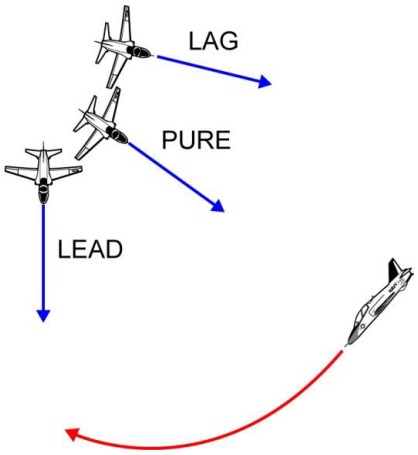
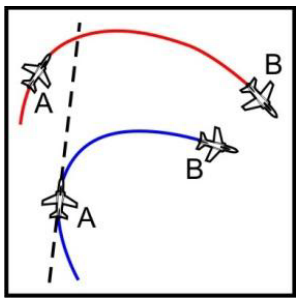


Figure 6.4 Out-of-plane Pursuit Curves

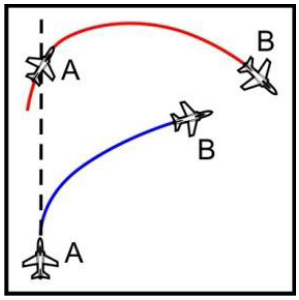
6.4.9 Pursuit Curves:

Pursuit curves are based on the fighter's nose position when in the bandit's POM, and the fighter's LV placement when not in the bandit's POM.



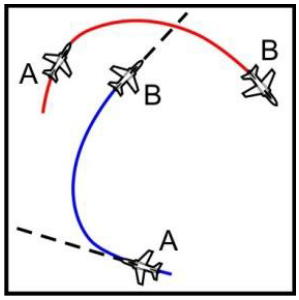
Lead Pursuit – Employ lead pursuit only for weapons employment, or when it is necessary to close nose-to-tail distance. Be ready to follow a lead pursuit maneuver with a lag pursuit maneuver to reduce V_c (rate of closure) and the AA developed while flying lead pursuit.

- Nose or LV in front of the adversary.
- Used to rapidly collapse the range & increase the closure without regard to angles.
- Maintaining lead pursuit for too long can potentially lead to an in-close overshoot.



Pure Pursuit – Utilize pure pursuit (i.e., have your opponent in the HUD field of view) when you are ready to employ a weapon, or when possibly attempting to enter the opponent's bubble (aspect/range dependent).

- Nose or LV on the adversary.
- Used to employ weapons.
- Leads to a slower collapse in range & increase in closure without regard to angles.
- Maintaining pure pursuit for too long can potentially lead to an in-close overshoot.



Lag Pursuit – Mainly utilize maneuvers consisting of lag pursuit/out-of plane techniques in order to correct back to the CZ, increase range or manage closure.

- Nose or LV aft of the adversary.
- Used to manage the range, angle, and closure problem.
- Maintaining lag pursuit longer than necessary can give away offensive advantage.

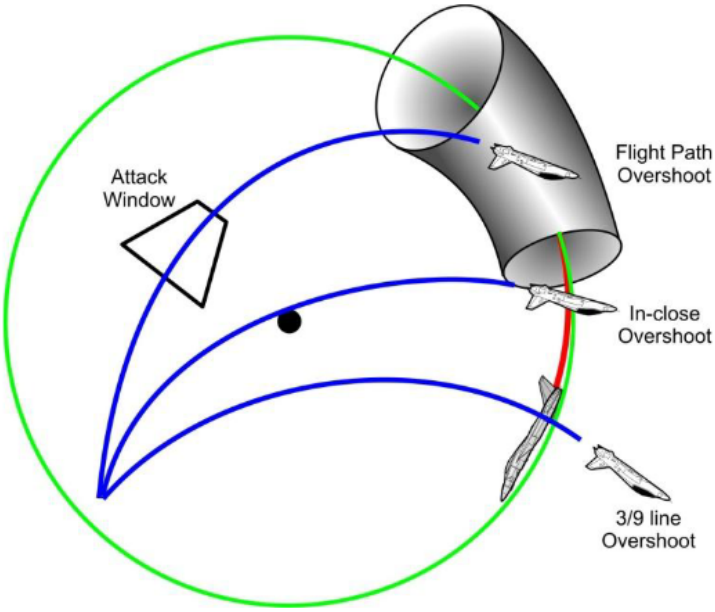
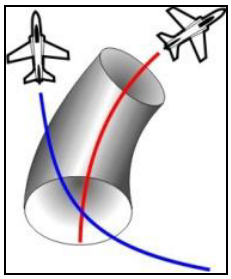
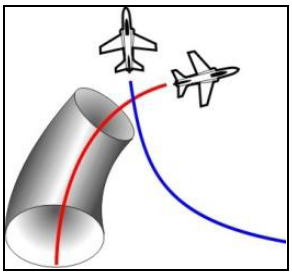


Figure 6.5 The Three Overshoots

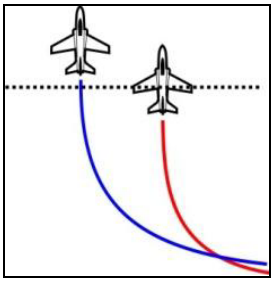
6.5 The Three Overshoots:



Flight Path Overshoot – Flying through the adversary's flight path. Ensure the flight path overshoot occurs within or aft of the confines of the CZ. This will deny a reversal opportunity.



In-close Overshoot – A flight path overshoot that occurs with high AOT inside the near portion of the defender's CZ, within 2,000 ft aft of the defender.



3/9 Line Overshoot – An overshoot of the defender's 3/9 line that results in a positional role reversal (i.e. passing from behind the adversary to in front of the adversary).

In-close flight path overshoots (ICFPOS) are extremely significant in that an instantaneous reversal by the defender may also cause a 3/9 line overshoot, possibly resulting in a role reversal. A flight path overshoot that occurs well aft of the defender is often insignificant because the defender cannot perform a role reversal.

If the overshoot occurs at the defender's CZ, the attacker will be able to maintain nose-to-tail separation by continuing his original turn to the defender's reversal point. By reversing at a CZ overshoot the defender actually helps the attacker solve some of his "degrees-to-go" problem.

6.6 Types of Fights/Flows

6.6.1 - 2 Circle Fight/Flow:

While circle flow is often applied to neutral merges, the concept applies anytime two aircraft maneuver in relation to each other and the horizon. 2C flow is a rate fight and the angular advantage usually goes to the aircraft with the higher turn rate at its corner speed. A good technique often used is to trade some altitude for energy in order to continue maximizing turn rate. Often this kind of flow is referred to as a nose-to-tail, rate, or energy fight.

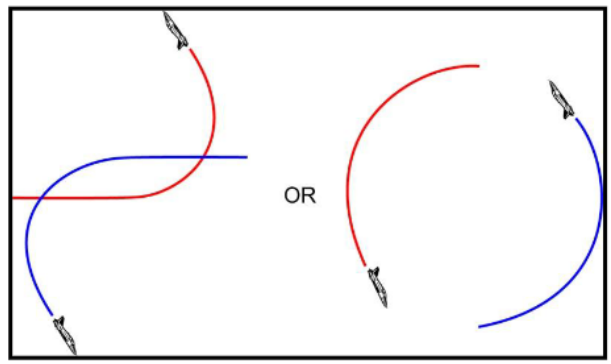


Figure 6.6 2C Flow

6.6.2 - 1 Circle Fight/ Flow:

During 1C flow, the fighter with the smaller turn radius will have the advantage. Pilots will often pitch up, out-of-plane, to help minimize turn radius. Since turn rate is of little importance during 1C flow, it is often called a radius fight. You can also hear it referred to as a nose-to-nose or positional fight.

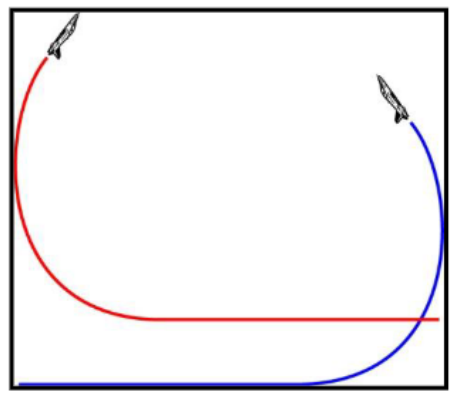


Figure 6.7 1C Flow

6.6.3 Misaligned Turn Circles (MATC):

MATC generally applies to 2C flow and are created due to the fact that each aircraft's bubble is displaced over a different geographic point in space. Given the same exact turn performance, the geometry of MATC will enable an attacker's nose to eventually come to bear on the defender through pure geometry without having to perform an energy excursion.

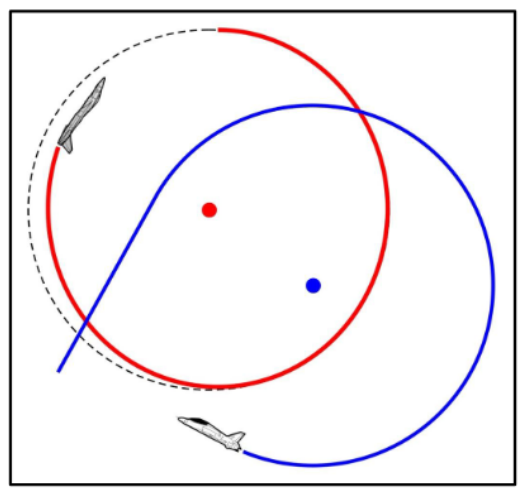


Figure 6.8 Misaligned Turn Circles

6.7. Energy Excursions:

An energy excursion is the conscious sacrifice of airspeed for angles. We are always willing to make energy excursions in order to take/deny a shot or to take/deny turning room.

6.8 BFM Cues:

Throughout an engagement, there are several visual cues that must be analyzed in order to make sound BFM decisions. The BFM problem can be measured by visual cues in the cockpit:

- ***Range:*** Being able to assess range is very important. This is accomplished by using the relative size of the aircraft or the information in the cockpit (A/A TACAN). Change in range will indicate closure or separation.
- ***Target Aspect (TA):*** The angular difference between the bandit's nose and your aircraft. A bandit that is pointing directly at your aircraft has zero target aspect. The ability to recognize the change in TA is very important.
- ***Angle off Nose (AON):*** AON is the angular measure that an aircraft is off your nose.
- ***Angle off Tail (AOT):*** AOT is the angular measure that an aircraft is off your tail. This is the best way to assess the angular problem of the engagement. AOT is used mostly in describing defensive BFM.

Being able to accurately assess the cues in a BFM engagement is very important. The most common cues are:

Eyeball Calibration (EBC) – Perhaps the most important aid you have in the cockpit is your own set of eyeballs. For example, you will need to visually assess range, AON, AOT, TA, and closure, as well as Attack Window Entry (AWE) and MATC, all while making an overall assessment as to whether or not you are winning or losing the fight. A proper eyeball cal is something that develops over time. With your training here and at the FRS, you will soon begin to accurately recognize and assess all of the cues that are presented in a BFM engagement.

Aircraft Cueing Systems – The T-45 has few onboard sensors to assess range, TA, closure, etc. Utilize a visual sight picture, A/A TACAN, and the gun reticle to aid in range assessment.

6.9 Utilizing the Gun Reticle:

In modern aircraft the gun reticle is controlled by the aircraft Fire Control Computer and takes into consideration (in-real time), your aircrafts speed, attitude, G-load, and ballistics of the rounds, and displays where the rounds will land if they were to fired at that moment, based on the manual range designated in the system. If the aircraft has a Fire-Control-Radar and has a target designated, the computer will take target range into consideration and adjust the sight accordingly.

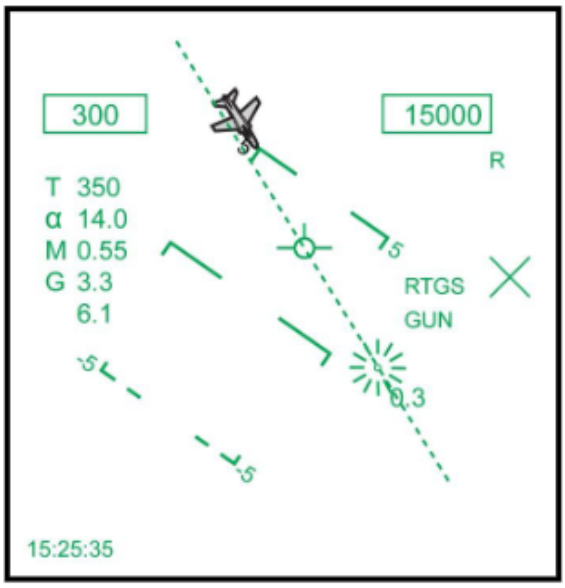


Figure 6.9 The Gun Reticle

6.10 Gun Snapshot

The aerial gun was the first weapon employed in dog fighting and still remains the most difficult weapon to use in the BFM arena. The snapshot is used when attacking at medium to high angles off an adversary in an attempt to achieve a quick kill. In order to achieve a valid snap there are three problems the shooter must solve:

1. Plane of Motion
2. Range
3. Lead

6.10.1 Plane of Motion (POM):

Plane of Motion is the most important parameter to solve. It is typically the hardest to solve and therefore the easiest parameter for the target to defeat. The key to becoming accurate with the gun is to reference the defender's POM relative to the horizon. Achieve a good inside/outside scan, referencing the bandit's position (distance) above the horizon, relative to that of your pipper. You should make large corrections for POM early by varying AOB to place the pipper the same distance above the horizon as the bandit's aircraft. As range decreases, make smaller corrections. A good scan pattern is: bandit – horizon, horizon – pipper. The faster you scan the more deviations you will notice and be able to correct.

6.9.2 Range:

To solve range, tighten or ease your pull to have the bandit filling ¾ to all of your pipper, as "snap" is called (this indicates a 1,000 to 1,500 ft shot). If the shot looks like it will be long, ease your pull to travel further downrange. Then reset your pull. If you assess it to be close, tighten your pull to achieve your gun solution earlier.

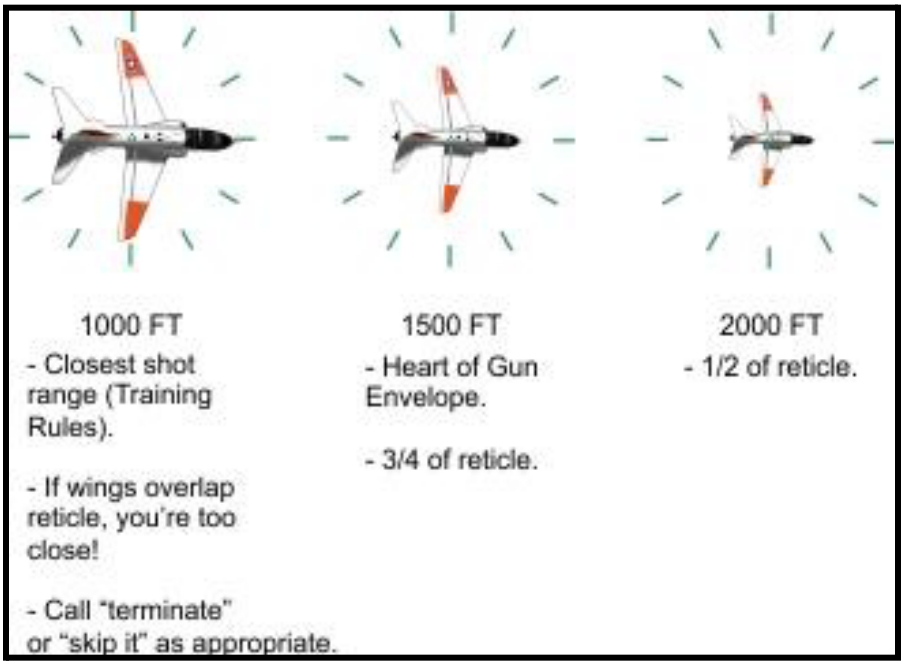


Figure 6.10 Estimating Range with the Gun Reticle

6.9.3 Lead:

Pulling the trigger when the bandit crosses the canopy bow and holding it down until he passes through your HUD is a good rule of thumb for establishing lead. This will account for ⅓ second pilot reaction time, ⅓ second gun spool-up time, ⅓ second bullet time of flight and allow the bullets to be at 1,000-1,500 ft downrange by the time the bandit crosses your pipper. If the trigger is pulled too early, bullets will be wasted. If the trigger is pulled too late, bullets will fall aft of the bandit. Therefore, in order to preserve ammunition, a disciplined and well-timed trigger squeeze is imperative. It is better to be a little early than late when pulling the trigger. Also, it is important to note that the ammunition drum combined with the rate of fire for most aircraft gun systems means that you typically have less than 10 seconds worth of ammunition.

6.10 Counter to a Guns Defense:

As the shooter you will need to react quickly to counter an effective guns-d. Decide early, then quickly roll to place the airspeed and altitude boxes two plane lengths out in front. The pipper will be unstable, and it may be difficult to determine a valid shot. With proper lead established, pull the trigger and evaluate the shot. Ideally the bandit would fly in between the airspeed and altitude boxes where the waterline symbol would be.

6.11 Snap Shot Drill

Execution as the Shooter: The snap shot drill is a cooperative maneuver designed to teach employment of the gun at high AOT for the shooting aircraft and a timely guns defense for the target aircraft.

P – Abeam
A – Deck + 5,000 ft
D – 1.0 nm
S – 300 KIAS

The student will be the shooter on offensive BFM hops. The typical flow for the SSD will be four passes with a non-maneuvering target followed by four passes with a maneuvering target. Initially both aircraft will make their set call's. Lead will then initiate the maneuver by calling "Hammer 11, in target." Wing will respond with "Hammer 12, in shooter."

The two aircraft will turn in towards each other utilizing a 2-3G pull. The shooter pulls to the inside of the turn while the target floats to the outside of the turn. The shooter controls the range while the target aircraft adjusts accordingly to maintain proper clock position for angles, targeting the 10/2 o'clock. Once the geometry has been set, both the shooter and the target will maintain a smooth pull so that as the shooter's nose starts to come to bear, the target will allow the shooter to track forward to aft for the snapshot. The shooter will then call "trigger down...snap, (looked good / missed high / missed low)." The "trigger down..." call should be made at the same time as the trigger squeeze. The "snap" call is made when the shooter assesses the bullets are at target range (e.g. as the target passes through the reticle) and is followed by the assessment of where the pipper actually was as it passed the target. It is important for a timely "snap" call so the target can make an appropriate evaluation of the shooter's nose position for future defensive maneuvers. Following the snapshot, both aircraft shall reverse their turns and adjust their pulls to complete what resembles a shackle turn. You should strive to be back on the original PADS at the apex of the reversal. The shooter will then set the next pass.

On the maneuvering snap shots, lead will call "Hammer 11, in target, maneuvering," followed by wing calling "Hammer 12, in shooter, maneuvering." During these passes, the target will attempt to maneuver out of plane in order to defeat the initial gunshot without subsequent maneuvers. The shooter will attempt to counter the defensive maneuver. After the gun defense and counter, both aircraft will maneuver cooperatively for the next pass. The flight shall attempt to work back to the original PADS. If the target cannot make it back to original altitude, then lead has the option to call for a terminate. Both aircraft will strive to achieve PADS prior to turning back in for the next pass.

SNAP SHOT DRILL EXAMPLE

Non-Maneuvering Target Set

1. Lead: "1 Set"
   Wing: "2 Set"
   Lead: "1 in target"
   Wing: "2 in shooter"

2. Wing: "Ripper 12 trigger down, snap, looked good"

3. Lead: "1 in, target"
   Wing: "2 in, shooter"

4. Wing: "Ripper 12 trigger down, snap looked good"

Maneuvering Target Set

Lead: "1 in, target, maneuvering"
Wing: "2 in, shooter, maneuvering"

Wing: "Ripper 12 trigger down, snap, missed low"

KIO Example

Lead: "Knock-it-off, Knock-it-off"
"Ripper 11 knock-it-off"

Wing: "Ripper 12 knock-it-off"
Lead: "Ripper flow XXX"
Wing: "Ripper 12 XXX"

Example terminate:
Lead: "Hammer terminate"
Wing: "Hammer 12 terminate"

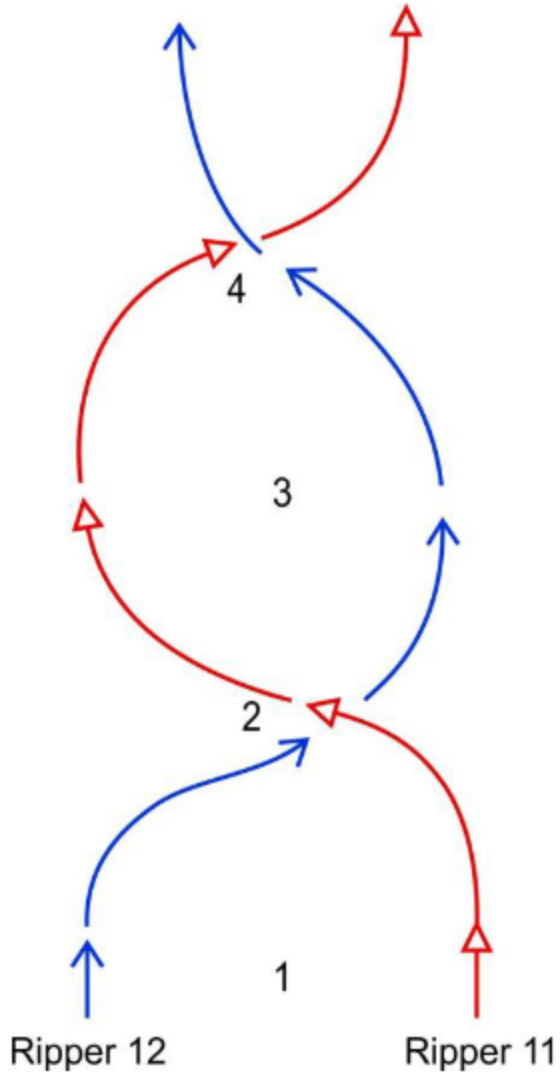


Figure 6.11 Snap Shot Drill

SSD Safety Considerations: If it appears the shooter will violate the 500 ft bubble, either aircraft may call "skip It." If a "skip it" call is made, the shooter will deconflict by executing a loaded pull inside the turn, nose-low (in and down), max performing his aircraft. The target will then execute a loaded pull away, and go nose-high (up and away). After a safe pass is affected, the maneuver may continue following the reversal unless a "knock-it-off" is called.

6.12 Offensive Flat Scissors

The horizontal, or flat, scissors is a slow-speed, high-AOA radius fight where both fighters are in each other's bubble and are attempting to minimize their downrange travel to achieve a positional advantage. Also colloquially known as "the phonebooth", because of how relatively close the range typically is between both fighters during this situation.

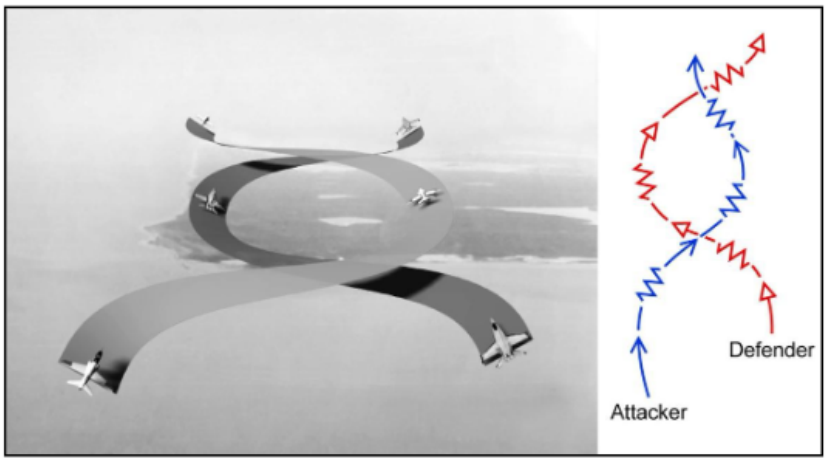


Figure 6.12 Flat Scissors Flow

A flat scissors typically results from an in-close overshoot. There are several scenarios which may result in a flat scissors, such as a delayed or poorly performed lag maneuver, the offender pulling lead for too long on a guns tracking solution, poor BFM following a snap guns attempt, or follow-on flow from a rolling scissors. The scissors may also be entered from a high-aspect merge where one fighter reverses to set 1C flow. The scissors is not a 1C fight. In the scissors you are inside each other's bubble (the bandit's target aspect and position on the canopy remain relatively constant). In a pure 1C fight, you are on the outside of each other's bubble which allows for the nose-to-nose type of fight. It is important to recognize the difference and fight your jet using the appropriate mechanics for the situation in which you find yourself.

Both aircraft will be attempting to decrease their downrange travel by performing a series of S-turns. This effect of weaving in and out, or "scissoring," gives this fight its name. If both aircraft are flying at the same speed with one flying in a straight line and the other turning, the turning aircraft will eventually end up behind the aircraft flying straight because it has increased the distance it must travel before arriving downrange.

6.12.1 Maneuvering:

While maneuvering in the scissors, you must remember that we are attempting to *minimize our downrange travel and turn radius*. Simply flying as slow as possible wings level and having no energy for maneuverability is not the answer, nor is flying at 200 knots with hard turns level across the horizon. With minimum lateral separation and high fuselage alignment, flying slower than the minimum radius band may provide better results. This is due to the fight being a true high-AOA slow-speed flat scissors, vice a 1C fight. With an increase in lateral separation however, we need to increase airspeed into the minimum radius band to achieve optimum turn performance (outside each other's bubble). When flying on the faster side of the minimum radius band, utilize more AOB while maintaining a lift-limit pull, to minimize your turn radius, to ultimately threaten the bandit with your nose. This is especially useful when you have altitude to spare, lateral separation exists, and you are turning away from the downrange direction of the fight. When maneuvering on the slower portion of the radius band you will not be able to utilize as much AOB but you will be minimizing your downrange travel due to your slower airspeed. This portion of the radius band is useful when your nose is pointed downrange (with respect to the fight) and little lateral separation exists between you and the bandit. Use a combination of both precise AOA control and smooth control inputs to fly your best jet.

6.12.2 Reversal Timing:

Time your reversals with the following criteria in mind:

- Turn aft of the bandit's 3/9 line prior to flight path crossing.
- If you notice a line-of-sight rate, and assess you are slower than the bandit, you should turn a little early to deny lateral room and take advantage of your slower speed.

During your reversals, utilize rudder inputs to turn towards the bandit and appropriate back stick to maintain optimum performance while monitoring your aircraft's attitude, airspeed, and AOA. Be cautious not to over control the jet. If you do, you may stall, causing the nose to drop as you accelerate, flushing out downrange. If this happens, relax back stick pressure, get the wings underneath you and re-establish your pull, working your nose up and getting your airspeed under control. Then reorient your lift vector as needed. As lateral separation decreases, precise airspeed control with an emphasis on generating the maximum amount of lift, to minimize downrange travel, becomes more of a priority.

After maneuvering in the scissors we will eventually find ourselves in an offensive position. We will summarize the offensive positions in the following two situations with respect to energy and position.

6.12.3 Up and Aft:

Up and aft maneuvering is the most desirable. We have an energy advantage in the form of altitude and a positional advantage behind the bandit's 3/9 line. Look to work just slightly out of phase (not letting the bandit hide under your nose) and assess weapons separation. With sufficient separation, work your jet down to a valid weapons envelope using one of the following three methods:

1. ***Pulling beyond lift limit*** – This will increase drag and decrease lift, thus you will lose altitude without gaining airspeed. This is not desirable due to the T-45 being very difficult to control in this AOA regime, the increased possibility of departing controlled flight, or potentially causing an engine compressor stall.
2. ***Idle push over*** – Once you assess weapons separation, select idle/SBs and push the stick aggressively forward, then reset back stick prior to the nose coming on the bandit to prevent excessive altitude loss and airspeed increase. Select MAX Power and retract SBs once you have the nose tracking up and work yourself back into the radius band. This technique is effective when desiring a quick shot; however, it is difficult to time and will need a good amount of weapons separation due to building airspeed and the risk of flushing downrange. *Care must be taken when resetting the nose-high attitude and advancing the throttle in order to avoid an engine compressor stall.*
3. ***Reduce throttle and slowly work down utilizing precise AOA and airspeed control.*** This is most desirable, however you need to be patient and keep flying your best jet.

6.12.4 Down and Aft:

Attempt to work in phase by performing early turns prior to flight path crossing. When the bandit reverses, ease your pull momentarily to gain 20-30 knots, then use this extra energy to work your nose up into a weapons envelope. In order to get your nose on the bandit you will need to use less AOB with the wings underneath you to work the nose up and achieve a valid weapons solution.

6.13 Offensive Flat Scissors Drill:

P – Abeam
A – Deck + 5,000 feet
D – 0.5 nm
S – 200 KIAS

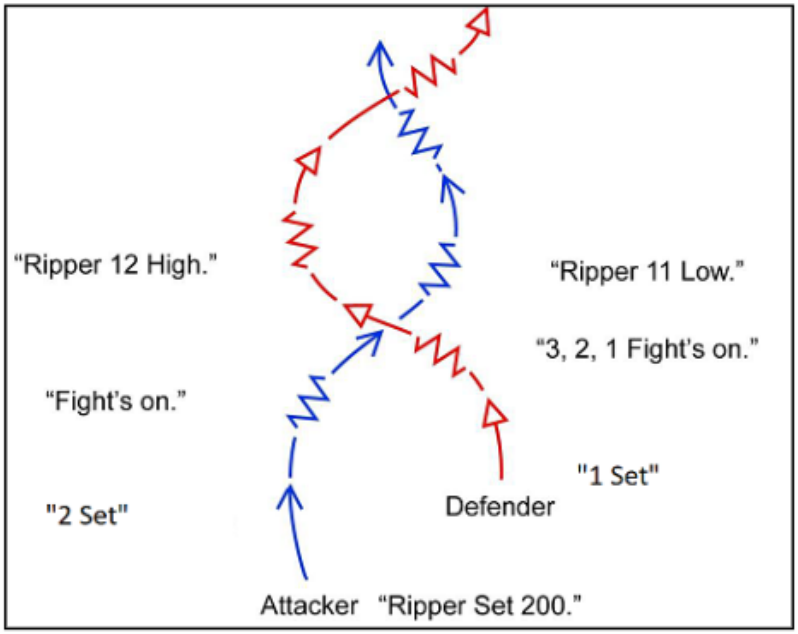


Figure 5.13 Offensive scissors

Lead will initiate the set by calling, "3, 2, 1 fight's on." Wing will respond, "fight's on." On the "3," select MAX Power. On the "F" in lead's "fight's on," smoothly start a vertical lift-limit pull. The bandit will delay his pull slightly (approximately two seconds after "fight's on") to establish a slightly offensive sight picture for the fighter. *When both your pull and flight path deconfliction (in the form of altitude separation) are established, turn in towards the bandit.* If no clear trend has been established, call ROE for the most appropriate trend at the time and the low aircraft will give way to make that pass happen. The bandit will delay turning in until the wingman turns. While in the pull, trade your airspeed for altitude while the nose tracks towards the vertical. Then, turn into the bandit, thus minimizing turn radius and collapsing lateral separation. At a certain point, you will no longer have the airspeed to continue the nose-high pull; when this occurs, you have two options to recover to a sustainable nose-high position:

1. Overbank (roll past 90° AOB) while maintaining the lift limit pull and get the nose tracking downward. Prior to 20 degrees nose-high, roll upright to achieve 15-20 degrees nose-high attitude at 130-150 KIAS.
2. Push forward on the stick to get the nose down, and then reset back stick pressure to achieve 15-20 degrees nose high at 130-150 KIAS.

A good rule of thumb is to initially pull 40-50 degrees nose-high, and at 150-160 KIAS, begin your recovery maneuver.

Lead: "Ripper set 200"
"1 set"

Wing: "2 set"

Lead: "3, 2, 1, fight's on"

Wing: "Fight's on"

(Once established in the pull and you have altitude separation, turn in towards the bandit)

Wing: "Ripper 12 high"

Lead: "Ripper 11 low"

(Continue fighting until a logical conclusion when your IP calls for a KIO)

Learning Objectives (emphasis) for the scissors:

1. AOA/airspeed control
2. Lift vector placement
3. Recognition of offensive/defensive position
4. Reversal timing execution
5. Shot opportunity recognition/mechanics
6. Guns-d recognition/mechanics
7. Fight redefinition

6.14 Offensive Rolling Scissors (Roller)

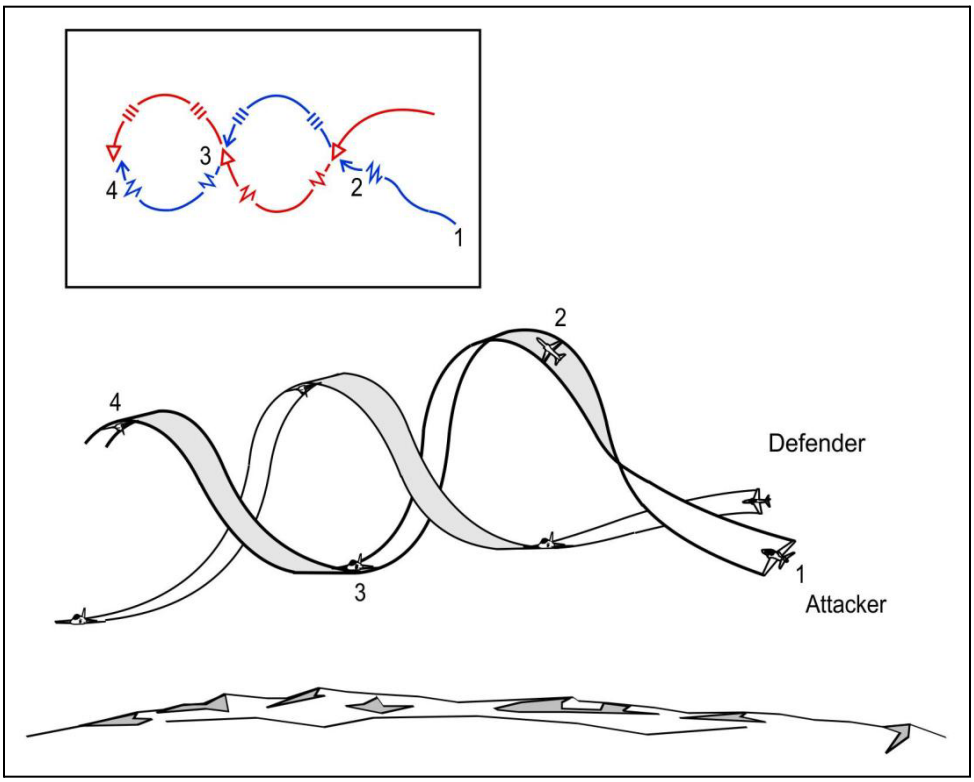


Figure 5-14 Roller Overview

The rolling scissors is a fight with both aircraft inside each other's bubble as long as the fight remains neutral. The rolling scissors may result from an in-close overshoot where the pilot attempts to stop his downrange travel by pitching up into the vertical without sufficient energy to execute a pure loop. The resulting fight is a series of vertical and horizontal overshoots where both pilots attempt to maximize their turn rate and minimize their turn radius in order to gain a positional advantage. Offensively, if you find yourself in a roller, you have made a mistake, which means you must strive to remain offensive or disengage at the earliest opportunity. A rolling scissors is not a desirable maneuver for an attacker because it limits opportunities for weapons employment.

6.14.1 Roller Maneuvering:

When lead calls "bandit going up," select MAX Power. At the "fight's on" call, perform a nibble of buffet wings-level pull to force a vertical overshoot. As you force the vertical overshoot, roll to place your lift vector over the top of the bandit, maneuvering your aircraft to force a 3/9 line overshoot. Be sure to keep your nose tracking above the horizon to preserve turning room (altitude above the bandit). Prior to 3/9 line passage (when you are directly above him), note the bandit's nose position to determine whether you are offensive, or neutral/defensive:

Offensive: If you predict the bandit will still be nose-low at 3/9 line passage, you have an offensive advantage. Perform an early turn by releasing back stick pressure, then rolling quickly to place your lift vector on to in front of the bandit, and recapture a nibble of buffet pull. This will help you get in phase with the bandit and reduce nose-to-tail separation. You should now feel like you are "chasing" him around. Keep the throttle at MAX Power to maintain energy for follow-on BFM. Continue to early-turn over the top as required until you have a shot opportunity, or until the fight is redefined.

Neutral/defensive: If you predict the bandit will be level or nose-high at 3/9 line passage, you are neutral or defensive. Increase your turning room by staying nose-high until 3/9 passage (slowing your downrange travel while gaining altitude). After you fly over the bandit, perform a pirouette maneuver by reducing the throttle to idle, unload, and then input full bottom rudder.

Once the nose starts slicing down, input lateral stick to quickly roll the aircraft. Neutralize the controls 10 degrees prior to the desired lift vector placement. Slowly advance the throttle back to MAX Power and reprogram a nibble of buffet pull. Place the lift vector slightly behind the bandit, when following across the bottom, maintaining a steady max lift back pressure. Your airspeed should be enough to force a vertical overshoot but not so much as to flush downrange (approximately 200-230 KIAS) at the bottom. As the bandit transitions above the horizon, assess lateral and vertical separation. If there is more vertical separation, look to get your nose up. If there is more lateral separation, look to collapse the fight by turning more level across the top.

If you are becoming offensive with a positional advantage, then at the pirouette, put your LV in front of the bandit pulling lead to align fuselages and possibly gain a shot opportunity.

However, if you do this you must avoid pulling too much lead and giving up your positional advantage. A good way to conceptualize lift vector placement is to place your lift vector on the bandit and vary it aft if you want to preserve/gain turning room. Vary your lift vector in front if you want to intimidate the bandit or take a shot. A key determinant in winning the roller is to strive to get your nose up when you are at the bottom before the bandit can get his nose down when he is at the top, and vice versa. If you can continually do this without sacrificing your position, you are then gaining the advantage you need to win in a rolling scissors.

At a certain point, one aircraft will gain enough advantage to pull for a shot, or the roller will be redefined.

In general, a four-step process can be used during the roller:

1. Starting from the bottom of the roller, execute a compromise pull straight up until the bandit crosses the horizon (vertical overshoot).

2. Roll to place your lift vector above the bandit (about 60º AOB), executing a lift-limit pull until you pass overtop the bandit (horizontal overshoot), or as prescribed based on offensive or defensive sight pictures.

3. Execute the pirouette by selecting idle, unloading the jet, and rolling to place the lift vector as appropriate while inputting bottom rudder. Typically, lift vector placement should be slightly aft of the bandit.

4. Use a lift-limit pull while maintaining your lift vector in the desired location. Reselect MAX Power as the nose approaches the horizon. If you anticipate being slower than 230 KIAS, then re-select MAX Power early.

6.14.2 Redefining the Roller:

When redefining the roller, the important thing to recall is our lowest split-s altitude. On average 6,000 feet above the hard deck is a good number to remember when at 150 KIAS. If we lack the altitude required to optimize our LV placement during the roller, it may be time to transition to a 1C fight, or separate.

To perform a full iteration of the roller, you normally need 4,000 ft of turning room above the deck. If you are below 4,000 ft above the hard deck, you have three options:

Option 1: Avoid committing your aircraft too nose-low, by placing your lift vector closer to the horizon. This option will allow you to perform a roller iteration whereas your opponent may not be able. To do this you most likely will be placing your lift vector in front of the bandit. In doing so, you are pulling lead and giving up turning room. So consider this option when you are offensive with sufficient nose-to-tail separation.

Option 2: Redefine into the flat scissors. If you do not have sufficient altitude and turning room to perform another roller iteration, redefine the fight into a flat scissors. Keep max performing your aircraft and work for a 3/9 line overshoot. Once the overshoot happens, perform an aggressive nose-high reversal.

Option 3: Utilize an energy rate-deck transition. Overbank in your current direction, trade altitude for airspeed, and transition to 2C flow.

Radial g affects your “sight picture” of being offensive, neutral, or defensive at various points in the maneuver. You will experience several optical illusions. At the top, your slower airspeed and radial g give you a smaller turn radius (reference Figure 4-4), while greater airspeed at the bottom causes a larger turn radius. As a result, relative position of the aircraft alone does not determine actual advantage. For example, if you are neutral in the fight, at the bottom of the roller you are slightly ahead of the bandit, while at the top you are slightly behind the bandit.

6.14.3 Bug Recognition/Counter:

For many reasons, it is critical to recognize the bandit's bug as soon as possible, because you want to kill the bandit, not let him run away. Early recognition allows you to keep more airspeed and reorient your LV to cut him off. Generally the bug will go opposite the direction of downrange travel. If your roller was progressing south, then the bandit will likely try to bug to the north. Keeping sight will be an issue because the bandit will try to bug towards your 6 o'clock. It is imperative that you do not lose sight since you may give away your offensive advantage, or worse, become defensive. You need to take whatever altitude you have and convert it to airspeed, typically with a nibble of buffet pull. Your lift vector placement should be leading the bandit's nose, especially if he is in a turn where we can cut across the circle to close the range effectively.

In the roller, the bandit will likely try to bug from the top. Therefore, when you see this you need to turn early to pull your nose towards his projected flight path. Try to keep your airspeed up as you initiate this pull by stopping your climb and using altitude for airspeed, without hitting the deck.

6.15 Offensive Rolling Scissors Drill:

Lead will initiate the maneuver by calling "Hammer check (right/left) 45" to establish wing 45º AOT. After the aircraft arrive on heading, lead will call, "bandit going up." At this time select MAX Power. Lead will maneuver to arrive over the top of the fighter in a defensive position and then call "fight's on" with the fighter echoing "fight's on."

P – Abeam

A – Deck + 5,000 feet

D – 0.5 nm

S – 200 KIAS

Bandit: "Hammer set 200"
"1 set"

Fighter: "2 set"

Bandit: "Hammer check left 45"
"Bandit going up"
"Fight's on"

Fighter: "Fight's on"

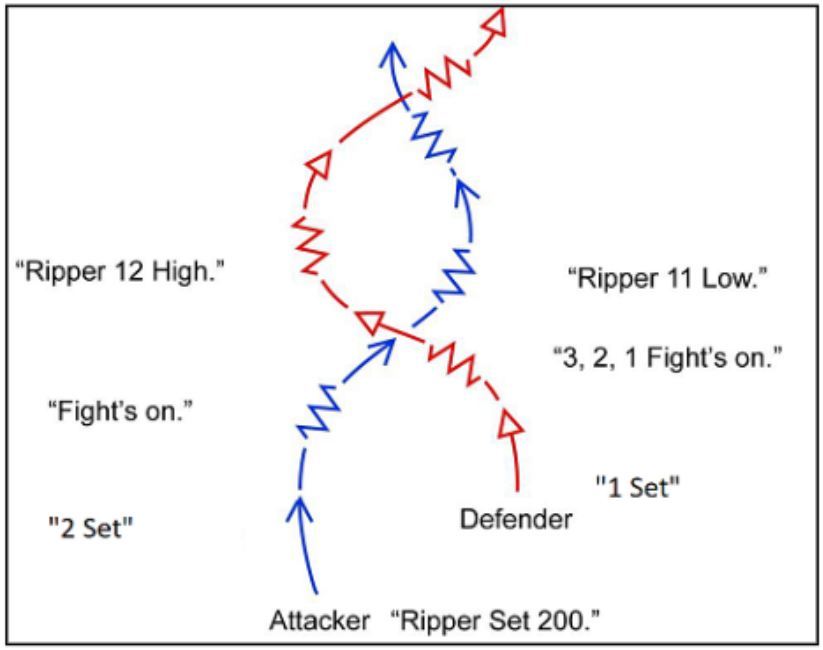


Figure 5.13 Offensive scissors

Learning Objectives (emphasis) for the roller drill:

1. Lift vector placement
2. AOA/airspeed control
3. Flight path projection
4. Fight redefinition

6.15 Offensive Perch BFM Overview

Perch BFM is partial task training to practice BFM with respect to an aircraft's relative location to the bubble. As described in earlier chapters, we know the average turn radius of the T-45 is 3,000 feet with a bubble of 6,000 feet in diameter. Thus, the 6k perch set starts you at the bandit's bubble and the 9k perch set starts you outside the bandit's bubble. Later you will be introduced to a 3k set that starts inside the bandit's bubble.

NOTE

Just because we are in a 2C fight does not mean we are in a pure rate fight. The less neutral the fight, the more it is a war of energy excursions, misaligned turn circles, and angles. As the fight becomes more neutral, it transitions to a true rate war.

All offensive perch sets will be executed as below with the exceptions/considerations noted for each set.

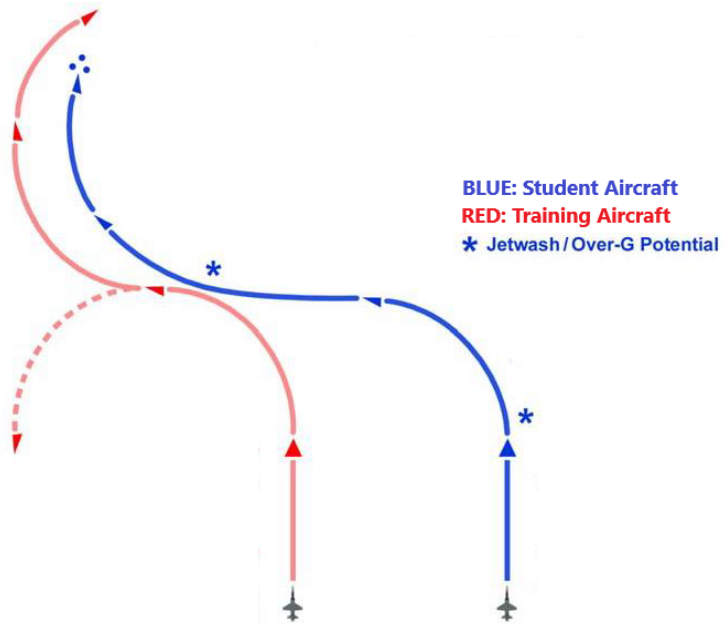


Figure 5-16 Generic Perch Setup

After a "Set" call from both aircraft, lead will check the flight 45 degrees away from the fighter. The fighter will turn using 2-3 G's toward the bandit and direct a "reverse" when the bandit is at the fighter's canopy bow. The fighter will reverse the turn and fly a pure pursuit curve, maintaining airspeed and altitude, and putting the bandit between the airspeed and altitude boxes in the HUD. The fighter will call "Ripper 12 in from X.X" and count down the ranges in tenths of miles while directing the bandit to "tighten/ease your turn" to maintain 40° AOT. At the desired range, the fighter will call "Fox-2." If the IP deems the A/A TACAN is lagging too much, he can initiate with a "fight's on."

At the "Fox-2" or "fight's on" call, select MAX Power, lag the bandit, and drive to his point of departure. A good technique is to use a geo-reference point to drive to the bandit's departure point (e.g. a cloud, ground ref, etc.).

When aspect stops changing and the Line of Sight (LOS) rate explodes, you are inside the bubble and have arrived at the Attack Window (AW). You need to execute an OBT. Roll to place your lift vector slightly below the bandit and pull to stabilize the bandit in your canopy (about 1 fist above the canopy bow). Analyze the AWE and subsequent defender maneuvering.

- ***If you are early to the AW***, it will be easy to pull the defender forward on your canopy, possibly to your HUD. Use a lag maneuver to prevent an in-close overshoot. You can ease your pull or roll 45° up and out of plane momentarily, then re-establish your pull or reorient your lift vector back on the bandit. An early correction normally results in a slight flight path overshoot similar to a slightly late entry.

- ***If late to the AW***, you will be unable to stabilize the bandit on your canopy while max performing. In this case, keep the pressure on the bandit with your lift vector on and maintain the pull to arrive in the rate band. Utilize an energy-sustaining pull once in the rate band. Now it is time to be patient and wait for misaligned turn circles. Keep in mind the later your AWE, the more neutral the fight, and the more of a rate war the engagement becomes.

- ***With a "nailed" AW entry and a properly executed OBT***, you will be able to stabilize the bandit on your canopy right above the canopy bow with only a small amount of movement aft (i.e. a slight flight path overshoot). Do not bleed your airspeed below 300-330 KIAS unless making an energy excursion to take a shot.

The bandit will slide aft on your canopy slightly during the flight path overshoot due to misaligned turn circles. Be patient, and do not bleed below 300-330 KIAS. After the flight path overshoot the bandit will stabilize on your canopy momentarily before starting to move forward. This is the time to perform an energy excursion, placing your lift vector on the bandit and execute a max-performance turn, trading airspeed for nose position. If the bandit is smart, he will recognize your nose coming on and perform a defensive energy excursion. If unable to counter your nose coming on due to a low energy state, the bandit will perform one of two nose-low maneuvers to make use of potential energy in the form of altitude: a radius defense or a ditch.

6.15.1 Radius Defense Follow:

When the bandit assesses your nose as becoming a threat, he will perform an oblique nose-low maneuver, a.k.a Slice (i.e. a radius defense). By maneuvering nose low, the bandit is forcing you to decide between weapons employment and follow-on 2C BFM. Smart fighters should always choose follow-on BFM to avoid a loss of angles upon arrival on the deck. This decision, however, will allow the bandit to create angles and hold your nose in lag. This can be compensated for by driving towards the bandit's point of departure where he first redefined to a radius defense. The cues for redefinition follow timing are the same in the vertical realm as they are in the horizontal. Do not attempt to gain vertical turning room while driving to his point of departure when countering a radius defense as this will keep you outside the bandit's bubble longer. The goal is to stop losing angles to the bandit by quickly entering his bubble. This concept differs from a ditch follow since those redefinitions are 1C in nature vice 2C.

1. ***If you nailed the entry*** (i.e. you see stable TA and canopy position from the bandit), you have maintained your advantage. The bandit will stabilize approximately 15 degrees below the horizon. Be sure to keep your lift vector slightly above him, and be patient. The deck will quickly become a factor and MATC will provide weapons employment opportunities if you manage your energy correctly.

2. ***If you are early***, you will be able to pull the bandit forward on your canopy – even just a small amount – and you will see the bandit nearer to the horizon. This will result in more angles to solve for on the deck with less of an altitude advantage to help solve for them. If left unresolved, you will arrive on the deck and likely have an ICFPOS, neutralizing the fight. To fix this, first you must ensure that any overshoot occurs inside the bandit's CZ. In order to avoid an in-close overshoot, either ease your pull to stabilize the bandit

on your canopy, or perform an aggressive lag maneuver (depending on how premature the follow). Once executed, place your lift vector slightly above the bandit and continue the lift limit pull at MAX Power all the way to the deck. If you quickly recognize and fix your early follow, you can maintain your advantage on the deck. However, time to kill will increase.

3. ***If you are late,*** you will see the bandit move aft on your canopy. Essentially, the bandit is out-rating you. Additionally, the bandit will appear farther below the horizon than he would on a well-executed entry. Unfortunately, you have already lost those angles. To compensate, simply keep your lift vector on to slightly above the bandit, and follow him down to the deck. Do not perform a low yo-yo type maneuver to make up angles as this will only result in a loss of altitude advantage. Maintain your lift limit pull at MAX Power, but realize that being late on your follow effectively increases time to kill.

6.15.2 Ditch Follow:

A ditch can be thought of as a pure nose-low vertical 1C redefinition. The timing and cues when following a ditch are the same for the radius defense follow with a couple minor exceptions. First, an altitude advantage will help you compensate for the steeper POM. Attempt to climb while driving to the bandit's point of departure in order to maximize your altitude advantage. Second, attempt to match the bandit's POM down to the deck.

6.15.3 On the Deck:

As you approach the deck, use the 10% rule to avoid busting it. You will typically find yourself about 30 degrees nose-low. If there is any excess altitude between the bandit and the deck, the bandit has essentially allowed turning room, and you should immediately take advantage of it. If you see a stable canopy position as you transition to the deck, maintain that current sight picture but do not bleed below 300 to 330 KIAS to avoid getting stuck in lag. As you capture the upper end of the rate band, MATC will develop, allowing you to arrive in a Launch Acceptability Region (LAR). MATC cues on the deck are the same as you used following your initial OBT. If you see the bandit tracking aft on the canopy, capture your airspeed. If you see the bandit tracking forward on the canopy, perform an energy excursion for a shot.

After each shot, *immediately* maneuver to lag to preserve your position in the bandit's CZ and, therefore, your advantage. As LOS rate once again takes off, perform another OBT assessing canopy motion, adjusting your pull appropriately. After a series of these shots/maneuvers, you will arrive in the near side of the bandit's CZ with RAC under control. The bandit will be out of airspeed, altitude, and options. Be cognizant of any closure problems the bandit may present in attempting to force an overshoot. Modulate the throttle to maintain your advantage. If the bandit reverses, realize you are now in a 1C fight. Use the vertical appropriately and control closure as required.

The overall objective is to arrive in the bandit's CZ with range, angles, and closure under control. Take shots of opportunity and apply follow-on BFM (e.g. a lag maneuver back to the CZ) to maintain your offensive advantage.

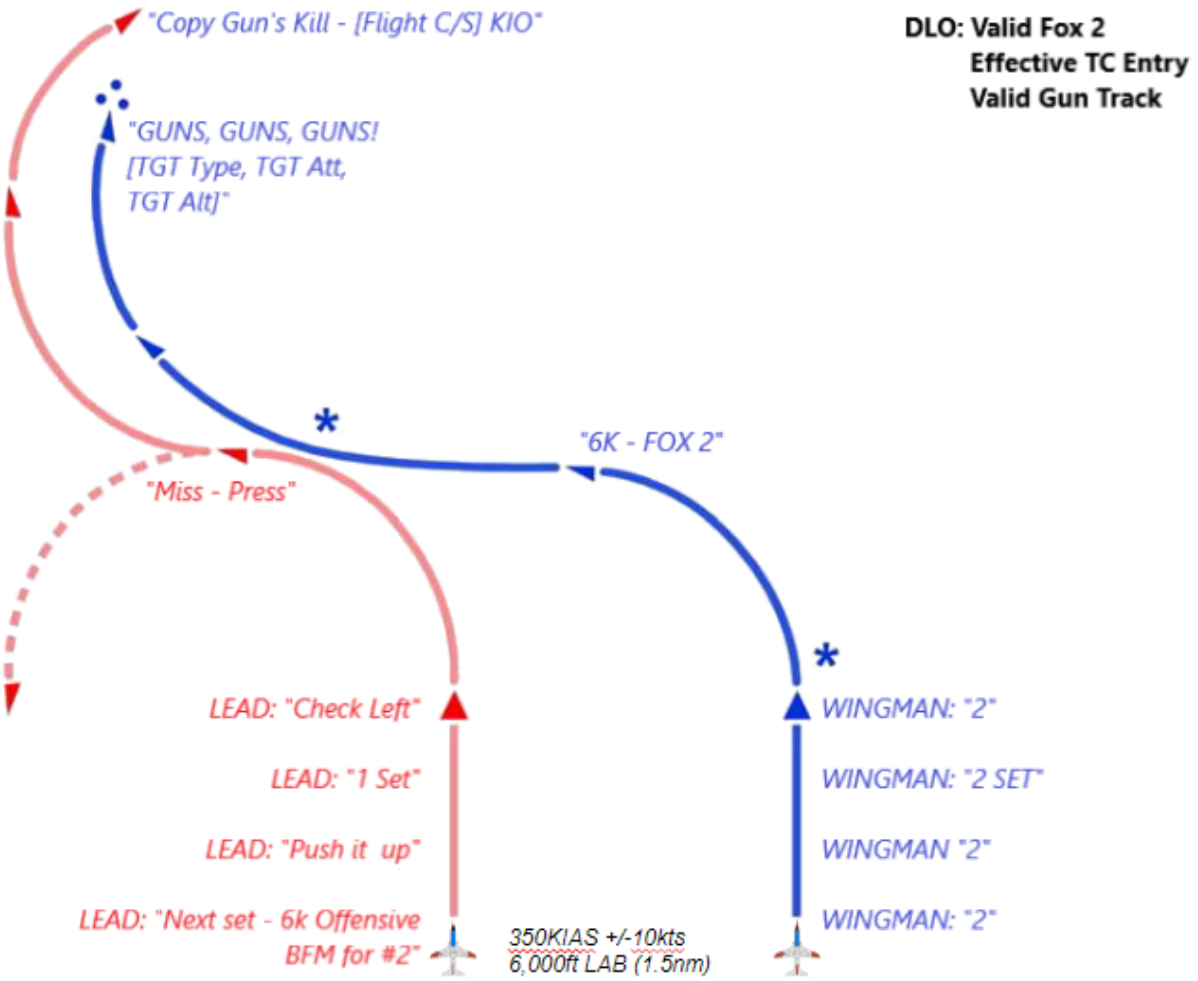


Figure 6.17 6,000 ft Perch Setup

6.16 6,000 FT Offensive Perch Set (6K)

Climb to PADS altitude at 300 KIAS abeam lead. To achieve 350 KIAS, we will perform a level acceleration for the extra 50 knots. Lead will call to "set 350." Select MAX Power. Keeping lead on the horizon, adjust the throttle to maintain abeam and arrive at PADS altitude and airspeed. Once established, the flight lead will initiate the "speed and angels" call.

The 6k set positions you just outside the bandit's bubble. Thus, after calling Fox-2 some angles will be gained by the bandit while you unload to the AW. Weapon selection should be primarily the AIM-9. During this set, if you nailed your AWE and performed an effective OBT, you should have a small flight path overshoot in the CZ. Following the overshoot, expect misaligned turn circles to work in your favor and either pull for a shot or follow the bandit through the deck transition. If a shot opportunity is not immediately available, utilize G to maintain airspeed and look for misaligned turn circles for an employment opportunity.

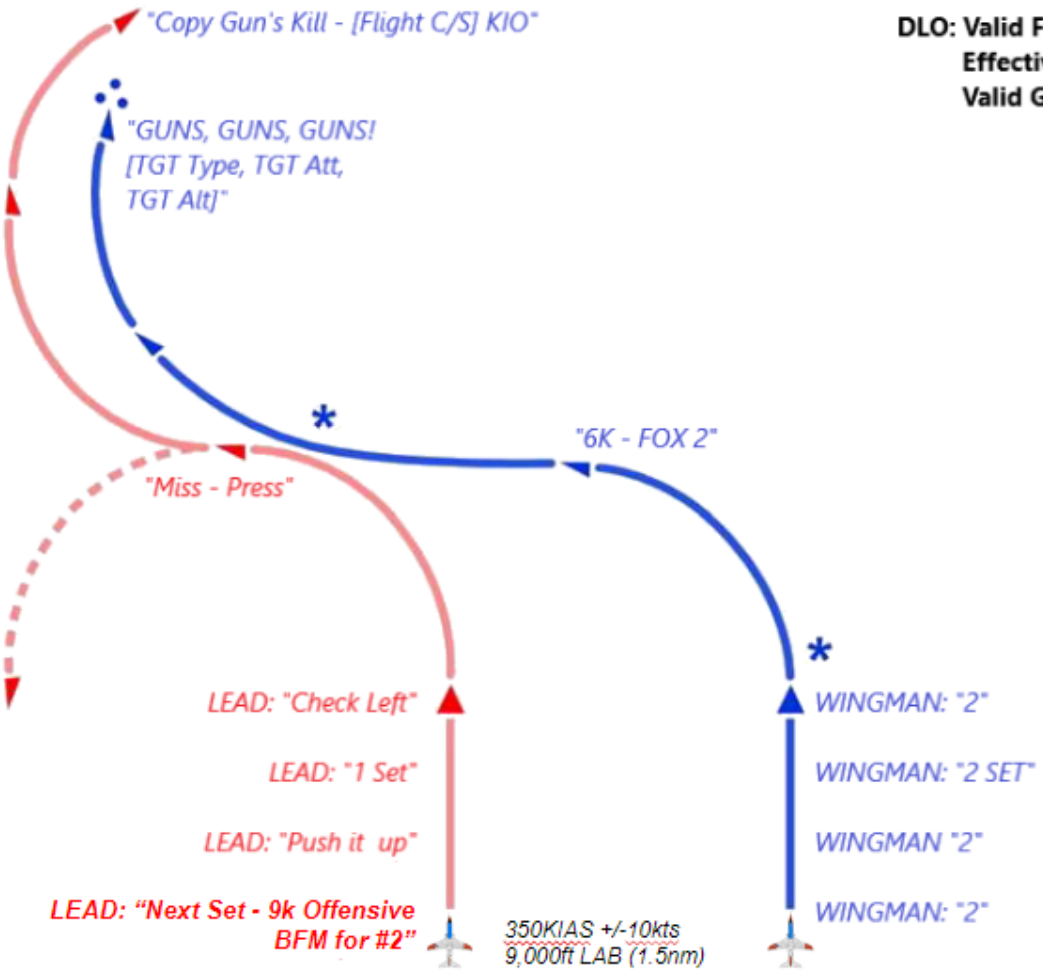


Figure 6.18 9,000 ft Perch Setup

6.17 9,000 FT Offensive Perch Set (9K)

Climb to PADS altitude + 2,500 ft at 300 KIAS abeam lead. To achieve 400 KIAS we will unload for the extra 100 knots. Lead will call to "unload for knots". Select MAX Power and unload to set 7 degrees nose low. Keeping lead on the horizon, adjust the throttle to maintain abeam and arrive at PADS altitude and airspeed. Once established, the flight lead will initiate the "speed and angels" call.

The 9k set positions you outside the bandit's bubble. While you are outside the bubble, the bandit will be able to generate angles via target aspect change prior to LOS rate explosion. Also, due to the range and misaligned turn circles, you will have two bubble entries. Weapons selection should be primarily the AIM-9. At 400 KIAS, you are close to corner airspeed, so care must be taken not to overstress the aircraft. Perform a smooth pull to target 7.0Gs, or a lift limit pull, during the OBT. With a nailed AWE and the bandit stable above the canopy bow, expect a flight path overshoot aft of the CZ with medium AON. Following the overshoot, you should recognize your second bubble entry. Take a follow-on shot and immediately go to lag in order to preserve your offensive advantage and drive to the new AW. From this point, the fight should look like the 6k set with the exception of greater AON. The resulting fight is more of a rate fight due to the larger AON. Therefore, you must ensure you are in your rate band and time your energy excursions with misaligned turn circles to take valid shots.

6.18 Offensive BFM Conclusion

When executed correctly, offensive BFM can be one of the most challenging and exhilarating experiences in your career. These flights can be made infinitely more enjoyable when you have a solid understanding of BFM concepts and mechanics. This is your first chance to employ the T-45 as an air-to-air weapon versus a hostile bandit. Keep in mind that your first priority is to *kill* the bandit. Over time you will develop your own techniques and skill sets in order to best employ your aircraft and its weapon systems ultimately to achieve the desired outcome of defeating the enemy in an air-to-air battle.

Conclusion:

The key to mastering offensive BFM is understanding and solving the three BFM problems: RAC. You must perform a timely and well-executed OBT, utilize proper redefinition follow-on mechanics, and intelligently perform an energy excursion to kill the bandit in a timely manner. This takes solid knowledge of the concepts, sound execution, and aggressiveness.

Learning Objectives offensive perch sets include:

1. AWE recognition/timing
2. OBT mechanics
3. Energy management
4. Fight redefinition recognition/follow
5. LAR/shot opportunity recognition
6. 100% valid shots

CHAPTER 7 - DEFENSIVE BFM

7.1 Overview

The concepts that we learned in OBFM also apply to Defensive BFM (DBFM). The difference is that we need to assess the BFM cues to create RAC problems for the bandit all the while looking over our shoulder. The better we can do this, the more successful we will be at achieving our DBFM objectives.

Defensive Objectives:

1. Defeat initial weapons employment.

2. Maneuver to deny follow-on WEZ.

3. Neutralize the fight.

4. Transition to HABFM.

NOTE

HABFM will not be executed until the first HABFM event.

Defensive maneuvering is hard work. While reading the following, you must remember that you cannot fight what you cannot see. In order to accomplish your goals defensively,

You must maintain sight.

There is a saying in the strike/fighter community, ***"Lose Sight, Lose the Fight."*** This concept cannot be overemphasized. If you lose sight of the bandit, you will get shot.

7.2 Sensor Nose:

The definition of "sensor nose" will change depending on that aircraft's radar and other advanced systems. It is likely that sensor nose may be greater than 45 degrees off the actual nose position of one's opponent. For our purposes while training in and against the T-45, we will define sensor nose as "nose on."

To execute your defensive BFM objectives, you must do the following:

- Keep sight/regain sight – you cannot fight what you cannot see. You will, however, lose sight at times. Think about the geometry of the fight and bias where you think the bandit should be. Be ready to execute the "Lost Sight Gameplan" found later in this section.

- Max perform the aircraft – don't just float your turn and become a target.

- Avoid the deck – this was a challenge during your offensive BFM training, but it's now more difficult due to the increased time you will be looking over your shoulder. A rapid inside outside scan is necessary. Being able to fly close to the deck gives the bandit less turning room to solve his angle problem.

Above all, no matter how dire the situation may seem, never give up!

Defensive Axioms:

- Survive
  - Deny sensor nose.
  - Defeat shots.
- Attacker moving forward on canopy = Keep pulling.
- TA decreasing = Increase pull to hold attacker's nose off.
- If the bandit is > 60º AOT and unable to perform steps 2 and 3, redefine.

When defensive, if the opportunity to leave the fight presents itself, it's time to disengage and "live to fight another day." However, you must "earn the right to bug." This requires you to meet certain bug criteria.

7.3 Bug Out

7.3.1 Bug out Criteria

1. ***150°-180° pass –*** setting up a neutral merge and bugging towards the bandit's 6 o'clock will maximize the amount of degrees the bandit has to turn to arrive in a valid WEZ.
2. ***500 ft pass –*** if below the bandit, climb to take out any turning room the bandit can use. If high, utilize the exclusive-use turning room and get nose-low just prior to the merge, to arrive at the merge with 500 ft of separation nose-low.

7.3.2 Bug out mechanics:

1. MAX Power
2. 40-50° nose-low (altitude dependent).
3. Unload – after pulling to the bandit's extended 6 o'clock in the nose-down attitude, unload to zero G. Very
4. Keep sight – position your wings to ensure they are not blocking your view of the bandit. As the bandit moves to your aft visual limit, perform a check turn to keep the bandit off your six.
5. Check turn – Check turn 20°-30° away from the bandit's nose, then unload again. Check turn no more than twice in order to maximize your separation from the bandit.
6. Assess bug – if you look over your shoulder and the bandit is inside 1.0 nm with less than 90 degrees of turn remaining, you will not escape. If greater than 1.0 nm, or with more than 90 degrees of turn remaining, you should be outside of his weapons envelope.

If you assess the bug is not valid, roll to place your lift vector on and perform a max performance break turn back into the bandit. Then apply DBFM principals as stated above.

If you assess the bug will be valid, finish unloading down to the deck, gaining extra separation. As the bandit turns nose-on, he will call a shot and announce his airspeed, i.e.: "Hammer 11, Fox-2, 300." When you hear this call, use your current airspeed and DME to determine if the bug was successful by using the "rules of two."

7.4 Rules of Two:

By quickly calculating the opening velocity between the two aircraft, and adding that to your range from the bandit, you can determine the success or failure of the bug attempt. The rules of two state that if your opening velocity plus your distance from the bandit equals the sum total of 2.0 or higher, the bug is successful and would kinematically defeat a missile launch. For example, if your airspeed is 400 KIAS and the bandit's is 300 KIAS, then you must be at least 1.0 nm away from the bandit for the bug to be successful. Conversely, if you are 1.5 nm from the bandit and his airspeed is 350 KIAS, your airspeed must be 400 KIAS or greater for the bug to be successful. If the sum total equals 1.9 or less, your bug was unsuccessful, and you can expect to be debriefed on which of the bug criteria weren't met, or if your mechanics were at fault. It is imperative that you sharpen your eyeball calibration for range in case your A/A DME (yardstick) is inoperative. See the below charts for further explanation.

SUCCESSFUL BUGS OUTS				
YOUR A/S	BANDIT A/S	V_c	RANGE	FORMULA RESULTS
390	300	0.9	1.1	2.0
410	270	1.4	0.8	2.2
400	250	1.5	0.8	2.3

UNSUCCESSFUL BUGS OUTS				
YOUR A/S	BANDIT A/S	V_c	RANGE	FORMULA RESULTS
390	310	0.8	1.0	1.8
410	290	1.2	0.7	1.9
390	300	0.9	0.8	1.7

As you can see in the preceding charts, changing just one parameter in the second table changes the outcome of the bug attempt. While bugging, you have two of the three numbers in front of you: your airspeed and the DME from the bandit. Strive to get a head start on the math to determine what airspeed you will need to hear in order to hit 2.0.

7.5 Lost Sight Gameplan:

If you have an idea of where the bandit was, max perform the jet in that direction. As you max perform, it will make a valid weapons solution for the bandit more difficult.

If on the deck, reorient your lift vector to remain unpredictable and defeat the POM of a potential gunshot. You should move out-of-plane approximately every 3-5 seconds, while attempting to regain sight by looking at your 5-7 o'clock position from high to level.

If you have excess altitude above the deck, stay in the direction that you were turning when you lost sight and max perform nose-low to the deck. This is usually a good bet as reversing your turn typically helps the bandit gain a weapons solution. Scan for the bandit, looking inside the turn from your aft visibility limit forward to your wing line.

If lost sight while on the bug, you must check turn at least one clock code, or 30°, in order to flush the bandit out from your 6 o'clock. If still no joy, break back into the fight.

7.6 Reversals:

Before we discuss reversal techniques we need to understand the circumstances leading up to the reversal. The question of when to reverse or redefine the fight can be difficult for novice aviators. We will start with the easy decisions and move to the harder ones later.

- ***3/9 Line Overshoot –*** if you are defensive and see somehow we have induced an overshoot in which the attacker moves ahead of our wing line (forward of abeam), then we reverse. The attacker has been neutralized or the roles have reversed and we can look to shoot and bug.
- ***In-Close Flight Path Overshoot (ICFPOS) –*** how close is "in-close?" If the overshoot occurs inside the forward limit of the CZ, we will consider it "in close." We also need high Angles Off Tail (> 60-degree AOT). If the defender does an immediate, aggressive reversal after the overshoot, he may be able to induce a 3/9 line overshoot from this flight path overshoot.
- ***Flight Path Overshoot –*** as the defender, if we observe a flight path overshoot where the attacker is in the CZ or aft and we attempt to reverse, we merely help his lag problem and aid in our own demise.

In order for the fighter to take advantage of the bandit's overshoot, all three criteria must be satisfied:

1. The bandit must have an ICFPOS (< 2,000 ft) with greater than 60 degrees TA.
2. The bandit must pass the extended six o'clock with a high line-of-sight rate.
3. You must be able to turn inside the bandit's turn radius.

You should know these criteria like boldface.

If ever in doubt, do not reverse!!

7.6.1 Reversal Technique:

Once the criteria have been met, perform an unloaded roll placing the lift vector on to slightly above the bandit, then perform a lift-limit pull, trading airspeed for angles and altitude to transition to scissor maneuvering. You are now pulling into a 1C fight, so you should bleed your airspeed down from 300 KIAS to hit your optimal 1C performance numbers. If you execute a break turn (21 units AOA), you will bleed airspeed while getting your nose position established. If you are already slow, a nibble of buffet pull might help you preserve some energy for the follow-on merge. Lift vector placement is crucial. Your lift vector needs to be on the bandit (or slightly high) in order to try to collapse the fight and flush the bandit forward of your 3/9 line. You must constantly reposition your LV to give the bandit as little turning room as possible. The use of speedbrakes is a technique that is often introduced here. You have now transitioned from a rate fight to a positional fight. Apply techniques discussed later in the scissor and roller sections to gain an offensive advantage and/or look to disengage.

7.7 Snap Shot Drill (SSD) As The Target

Although the geometry of the SSD will not change now that we have swapped roles, our mindset will change. Our goal now is to recognize what an impending gunshot will look like during the first four non-maneuvering sets and be able to defeat the shot by executing a proper guns defense during the last four maneuvering iterations.

Execution: As the target aircraft, you will tighten/ease G initially to maintain the shooter at the 10 or 2 o'clock position, then allow the shooter to drift aft. During the maneuvering sets, the target should evaluate the nose position of the shooter and execute a properly timed guns defense to defeat the impending gunshot.

Performing the Guns Defense (Defeating Plane of Motion): As the target during the maneuvering sets, we have two goals. First, we need to present the bandit with as little surface area as possible by placing our wingtip on the bandit. Second, we need to maneuver out of plane in a timely manner to deny his ability to solve for plane of motion.

Timing: It is imperative we time our guns defense (guns d) to defeat the shot. If we maneuver too late, we will fly through the shooter's pipper. If we maneuver too early, we are broadcasting our intentions, allowing the shooter to counter our maneuver and solve for POM. As the target aircraft, we developed a sight picture of the shooter's nose position during the "trigger down snap" call on the non-maneuvering sets. We will use this evaluation to time our guns d.

Maneuvering: We have three basic maneuvers we can perform to defeat impending gun shots: ●=Pro's / ○=Con's

1. ***Near wingtip on, max performance pull nose high*** –
    - ● May be your only option when on the deck.
    - ● Quick to perform and easy to maintain sight. Allows for good aircraft displacement and good follow-on BFM.
    - ○ Maneuvering against gravity.
    - ○ Need some airspeed (energy) to displace aircraft.

2. ***Near wingtip on, bunt –***
    - ● Quick and may fake the shooter into going nose-high.
    - ● Easy to maintain sight.
    - ○ Little displacement out of aircraft and may accelerate farther out in front i.e., poor follow-on BFM.
    - ○ Not an option when fighting less than 500 ft above the deck.
    - ○ The amount of negative G needed to displace the aircraft can be extremely uncomfortable.

3. ***Far wingtip, on max performance pull nose-low –***
    - ● Best aircraft displacement due to increased G available from gravity (i.e. "God's G").
    - ○ May broadcast intentions.
    - ○ Hard to maintain sight and may cause disorientation.
    - ○ Minimal option for follow-on BFM.
    - ○ Not an option when fighting on the deck.

When trying to max perform, it is imperative that we pull to the lift limit. If we pull too hard (past lift limit) or too weak, we will not achieve maximum aircraft displacement.

7.8 Defensive Flat Scissors

The scissor entry and mechanics will remain similar to offensive BFM. The bandit will however, begin moving his jet to an offensive position early (on the "2" of "3, 2, 1") so that when he calls "fight's on," roles are clearly established. We will be looking to deny shots, defeat shots, or redefine, if required. In order to accomplish these tasks we will now be looking to work out of phase with the attacker.

7.8.1 Reversal Timing:

If the bandit does not have his lift vector oriented towards you, continue to generate lateral separation. Once the bandit reverses and places his lift vector on you, you must honor this by placing your LV on the bandit. After the merge, time your defensive reversals with the following criteria in mind:

To work out of phase, reverse after the bandit crosses your extended six. This will help increase the lateral separation needed to work towards a high-aspect/neutral pass.

After maneuvering in the scissor, we may continue to find ourselves in a defensive position. We will summarize the positions in the following two situations with respect to energy and position:

Up and forward – work to get out of phase and attempt to stack the scissor to deny the bandit a gun's solution. If you sense the bandit is working into a weapons envelope, look to redefine or execute a gun's d.

Down and forward – with a small amount of nose-to-tail separation, attempt to work below the bandit, potentially masking his view of you while working to get in phase. If the bandit has a good amount of nose-to-tail separation, look to redefine into a 2C fight.

7.8.2 Redefining Nose-Low:

If the bandit is able to flush you out in front to the point where he can take snap-shots, or has worked in phase aft into your CZ for a possible tracking solution, it is time to get out of the flat scissors and redefine 2C. Remember, two valid snap shots equals a kill as does one second of tracking time. After a gun's-d, execute a ditch or positional deck transition (think 10% rule) if you do not have sufficient altitude to execute the ditch. This is not a bug, so do not level your wings. Once on the deck, assess the fight and execute your best defensive gameplan.

Learning Objectives (emphasis) for the scissor:

1. AOA/airspeed control
2. Lift vector placement
3. Recognition of offensive/defensive position
4. Reversal timing execution
5. Shot opportunity recognition/mechanics
6. Guns d recognition/mechanics
7. Fight redefinition

7.9 Defensive Rolling Scissors

Redefining a fight into a roller is not a bad gameplan if you find yourself defensive. If executed properly, the bandit will have to solve several BFM problems prior to being able to take a shot.

7.9.1 Redefining the Roller:

Slightly defensive (< 30 deg bandit advantage) – if you are slightly defensive and feel that staying in the roller or redefining into the scissor is not prudent, look to bug. Create vertical turning room by exaggerating your nose-high attitude and make the roller "loopy." Look to bug out of the top of the roller with the bandit near the deck and his nose coming up. With the bandit on or near the deck, he will have to perform a level bug follow, denying him the option of gaining airspeed quickly. Pull to create as many angles as possible and use the vertical room above the bandit to bug towards his 6 o'clock. In other words, instead of pulling your nose above the horizon and doing a pirouette at the top of the roller, pull level (to slightly nose-low) across the horizon in order to place your lift vector on the bandit as he comes through the bottom. By immediately putting your lift vector on the bandit, you are setting yourself up for a close aboard pass, denying the bandit turning room in order to give yourself the best chance for a successful bug. After the close-aboard pass, achieve 30-40 degrees nose-down (altitude permitting), initially unloading. Keep sight of the bandit until you are assured a good bug.

Defensive (> 30 deg bandit advantage) – if you are defensive, you are effectively in a 2C fight. Execute your best 2C defensive gameplan as discussed later in perch BFM.

Execution: The execution and maneuvering of the defensive roller will remain the same. The bandit will, however, maneuver to establish an offensive position prior to "fight's on."

Learning Objectives (emphasis) for the roller:

1. PADS set up
2. 100% adherence to training rules
3. Lift vector placement
4. AOA/airspeed control
5. Flight path projection
6. Fight redefinition

7.10. Defensive Perch BFM Overview

Now we will take a look at the defensive perch BFM. The sets are the same as the offensive perch sets, but with the roles reversed.

7.10.1 Execution:

After a "Set" call from both aircraft, lead will check the flight 50 degrees into the fighter. Pull 2-3 G's to the new heading and reverse, but strive to maintain PADS altitude. If you are slow or have a weak pull, the bandit will direct you to "reverse." Reverse your turn and maintain airspeed and altitude, pulling the bandit to 40° AOT. The bandit will call "[tactical call sign] in from X.X" and count down the range in tenths of miles while directing you to "tighten/ease your turn" to maintain 40° AOT. At the prescribed range, the bandit will call "Fox-2."

At the "Fox-2" call, select MRT, roll to place your lift vector on to slightly below the bandit, and perform a lift or G limit pull (Axiom 1: survive). A proper defensive break turn should keep the bandit the same distance above the horizon throughout the defensive break turn (if you misplace your lift vector and break slightly nose-high or too nose-low, do not try to correct back; simply capture what you have.) Next, assess the bandit's AWE:

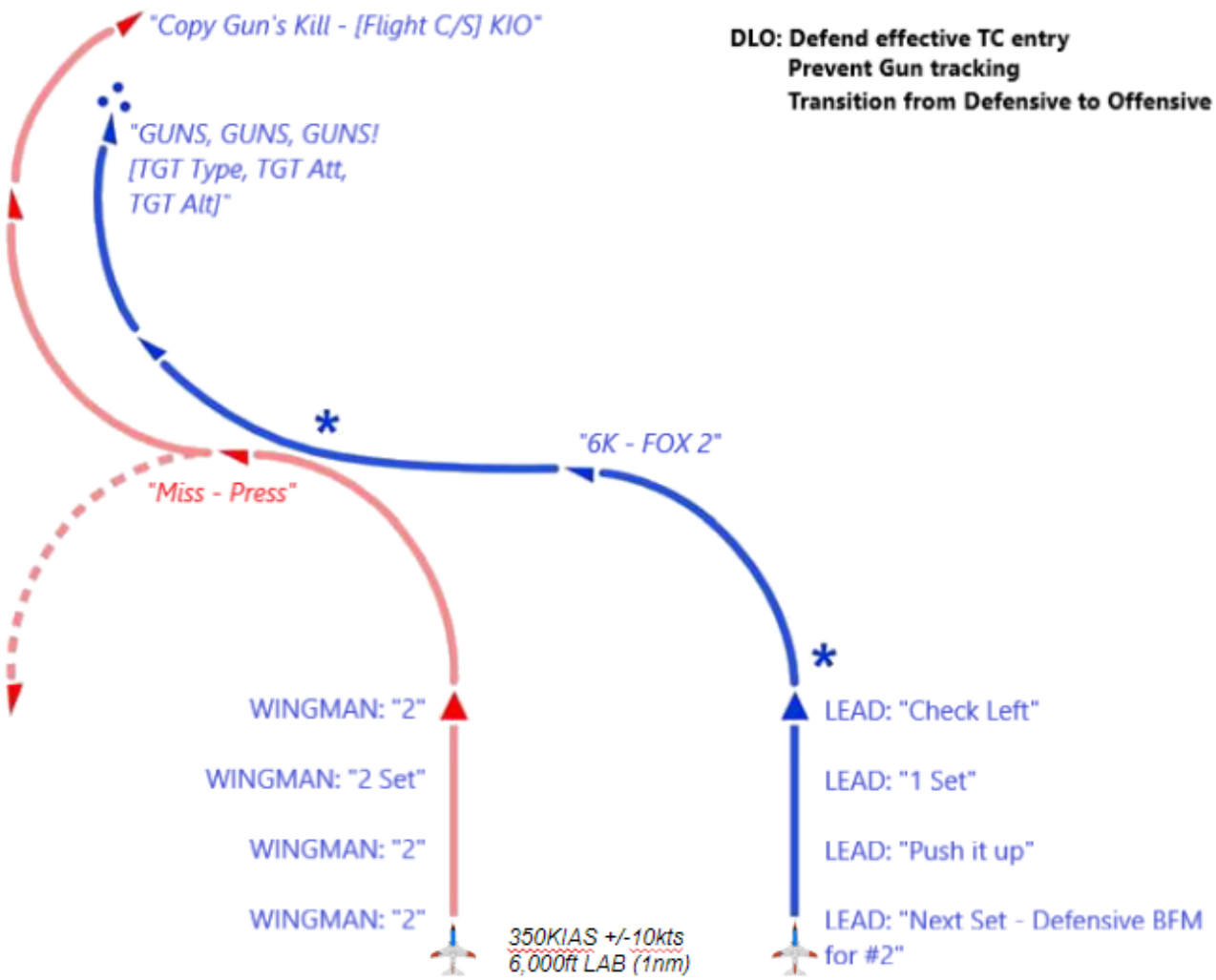


Figure 6-2 Defensive Perch Setup

1. Early AWE (decreasing target aspect) – the bandit will appear to be nose-on and you will be able to hold the bandit stationary or pull him forward on your canopy (Axiom 2: attacker moving forward on canopy = keep pulling). If able to pull the bandit forward of 60 degrees AOT, regardless of sensor nose, keep pulling. Call "chaff, flares" denying a missile shot, and assess if a guns-d is required. The fighter is defeating very low Pk shots from the bandit, while attempting to force an ICFPOS, effectively neutralizing the fight. If the bandit does not maneuver to fix the early AWE, this is good. As you create an angle and closure problem, keep max performing down to gun range. When you assess the bandit has closed into gun range, perform an appropriate guns d, and then reorient your lift vector back into the bandit, looking to force an in-close overshoot. If the bandit gets too greedy, you will force an in-close overshoot, and you should now apply your reversal mechanics. If the bandit prevents the overshoot by performing a nose-high maneuver, you have two options:

a. If you have vertical airspeed, match the bandit nose-high to collapse the range.

b. If you don't have airspeed to counter nose-high, continue in the current turn, 5-10 degrees nose-low, and execute follow-on DBFM looking for opportunities to ease and regain energy.

2. Late AWE (increasing target aspect) – you will be able to create greater fuselage misalignment and thus increase your time to live. Maintain your max performance pull down to the tactical rate band creating the greatest amount of angles possible. Assess AOT and TA:

a. With high AOT and high TA, fight your best rate war.

b. If low AOT and high TA, the bandit will still be able to benefit from MATC. The bandit will have a flight path overshoot. The greater the TA at the time of the overshoot, the longer it will take for the bandit's nose to threaten you. During the overshoot, you may lose sight of the bandit as he disappears behind your 6 o'clock. Prior to losing sight, if the bandit still has a high amount of TA, then ease your pull to maintain your airspeed in the rate band. If the bandit has a low amount of TA, then execute a max performance pull to deny sensor nose. MATC is working for the bandit when he reappears at your aft visual limit. If at this time the TA is decreasing, then execute a max performance pull. If with this pull you are able to hold the bandit in lag, continue your max performance pull, otherwise, redefine the fight.

3. Nailed AWE (stabilized target aspect) – you will only be able to pull the bandit forward while he is outside the bubble. The bandit will have a small flight path overshoot in, or aft of, the CZ. When the bandit reappears, max perform in order to hold off his nose (Axiom 3: TA decreasing = increase pull to hold attacker's nose off). If it looks like the bandit's nose is almost on, you are late and need to redefine (Axiom 4).

7.10.2 Redefinition:

If the bandit is so late to the AW that the fight becomes more or less neutral, you are now executing HABFM. Initiate a nose-low out-of-plane maneuver cutting across the circle. Left un countered, you should find yourself with an offensive advantage. If the bandit counters, you will arrive at a neutral merge on the deck or perhaps in a rolling scissors.

If you are unable to pull the bandit forward on your canopy (i.e. create angles) and the bandit's TA is decreasing, you need to redefine. The most common mistake is being late on the redefinition. Avoid this by redefining well before sensor nose becomes a factor. The sight picture for this is when the bandit has about 30 degrees of turn to go before coming nose on to you. You must force the bandit to choose between weapons employment and follow-on BFM. If you are no joy, it is better to go early than late when executing your redefinition.

Radius Defense (2C Redefinition) - A radius defense is used by aircraft with poor vertical turn performance and poor turn rate performance. Comparatively to most enemy aircraft, the T-45 meets both these criteria, so we must learn how to utilize smart BFM tactics to out-fly the bandit and exploit his weaknesses. A radius defense uses oblique nose-low out-of-plane maneuvering to minimize the aircraft turn radius while gaining energy for a 2C fight on the deck. The effect of minimizing the aircraft turn radius allows you, as the defender, to observe forward movement of the bandit on your canopy.

This is desirable since anytime the bandit is moving forward on our canopy, we are taking angles back. If the bandit does not execute a proper follow, the fighter can either gain angles, energy, or both, significantly increasing time to kill or perhaps neutralizing the fight.

The overall goal of the radius defense is to increase time to kill by attempting to hold the bandit on the edge of your bubble, or by gaining energy for a rate war on the deck. This prevents the bandit's nose from coming to bear, denying a weapons solution for a greater length of time. While a radius defense will not typically neutralize an attacker, it will significantly increase time to kill. Hopefully, this will allow enough time for your (notional) wingman to come help, or for the bandit to commit a BFM error of which you can take advantage. If the bandit fails to follow the redefinition correctly, more angles may be gained or a shot can be denied entirely. The radius defense is only useful if the bandit is acquired on the edge of, or outside of, our bubble (i.e. 6k set and 9k set).

The advantages of the radius defense in the T-45 are that it allows the ability to add energy even while using a lift limit pull, to slow the transition to the deck, and to maintain sight throughout the redefinition. Due to T-45 performance and visibility limitations, the radius defense is the primary defense and shall be used on the perch sets.

To execute the radius defense: Initially, perform a 135-degree overbank while maintaining a lift-limit pull (loaded rolls are ok) with the throttle at MRT. This will force the bandit outside of your bubble, allowing you to gain some angles back. Additionally, it will displace your aircraft below the horizon enough to force the bandit to choose between employing a weapon and follow-on BFM. This idea cannot be overstated enough. A weak overbank will result in the bandit being able to employ a weapon without sacrificing follow-on BFM. If you are visual when you initiate the overbank, the bandit should be two to three fists above the headbox, and forward of the opposite canopy spike. You should be able to see him, for example, in a left turn by placing your head to the right of the ejection seat headbox, and by looking up and aft. The bandit will typically be above your altitude, so you should see him above both the horizon and your lift vector.

If you are no joy, a mechanical 135-degree overbank will help pull the bandit forward and above your aft visibility limit. This should allow you to regain sight.

After the initial overbank, you must assess the bandit's redefinition follow. When executing a radius defense, the main objective is to overbank enough to force the bandit into lag, but not too much where you are fighting the deck and not the bandit. Maintain a maximum performance pull at MRT unless you have a good reason not to. Finally, attempt to hold the bandit in lag as long as possible, arriving on the deck with energy to survive, preferably within your 2C rate band.

1. ***If the bandit is early, you will see decreasing TA and forward LOS rates.*** This is due to the bandit's pursuit curve and is similar in concept to an early AWE described previously. Because you see forward LOS rates, you should raise your lift vector enough to stabilize the bandit on the canopy while maintaining a maximum performance pull at MRT. Use chaff/flares and a guns d as required, and attempt to force an ICFPOS. If the bandit fixes his early follow, you can ease the pull to gain energy while he is not pressuring you. From here, it will look similar to a late or nailed follow.

2. ***If the bandit is late, you will see increasing TA and forward LOS rates.*** This comes from the fact that you are "out rating" the bandit. You can raise your lift vector slightly, decrease AOB, and ease the pull to gain energy. Once the bandit turns to follow, tighten down to a maximum performance pull and vary AOB to keep the bandit on the same spot on your canopy. Because the bandit was late, you will see the bandit further forward than a nailed entry with greater TA, and you will have more energy for the rate war on the deck. All of these cues mean you are gaining angles back from the bandit. Remember, airspeed above your rate band can be turned into instantaneous turn rate, creating an overall increase in turn performance.

3. ***If the bandit nailed his follow, you will see stable TA.*** Simply adjust AOB to freeze the bandit's position on your canopy while maintaining a maximum performance pull at MRT. Remember, increasing AOB will stop aft motion and decreasing AOB will stop forward motion. This will result in about a 30-degree nose-low turn while your airspeed is increasing. You will have about five to ten seconds to manage the radius defense before the deck will become a factor. Don't forget to occasionally shift your focus inside the cockpit, scanning airspeed and altitude to intercept the 10% rule. Depending on how effective your lift-limit pull is, you can expect to have 330 to 350 KIAS on the deck.

Radius Defense Deck Transition and Fighting on the Deck: As the deck becomes a factor, you will have to decrease your AOB to avoid busting the deck. The 10% rule is the best tool for deck preservation, and it is recommended that you target stabilizing approximately 500 feet above the deck when defensive. This will provide options, minimizing turning room below the deck and allowing you to spend more time looking outside at the bandit vice hawking your altitude.

The radius defense will result in 2C flow on the deck. All the concepts and sight pictures that were discussed at the initial break turn apply on the deck now. If you see the bandit ease and track aft on your canopy, you should ease your pull in order to conserve your energy on the deck. If you see the bandit tighten down and his target aspect starts to decrease, you should tighten down as well. All the while, try to keep the bandit on the same spot on your canopy as it will keep the fight tight, making it more difficult for the bandit to bring his nose to bear. As you play out this game, you are attempting to manage your energy to best deny him weapons separation, a valid shot, and angles. Being in your rate band is not as important as adjusting your pull based on what you see the bandit doing. In the end, you are significantly increasing time to kill. Remember, reversal criteria are just as applicable when stabilized on the deck as they are at altitude.

7.10.3 Ditch:

The ditch is a pure nose-low maneuver that uses precise lift vector placement to complicate the bandit's BFM problem. A ditch is useful in aircraft that have a very small vertical turn radius, using it as an advantage in an attempt to neutralize the fight. A ditch in the T-45 is challenging due to the large turn radius and poor aft visibility. As such, ditching will be used only sparingly during your DBFM events but will play a significantly larger role in your fleet aircraft.

If altitude is available:

1. Perform a DBT to collapse the range and create as many angles as possible. It is optimum to have airspeed below 270 KIAS.

2. Roll, placing the bandit in the same place, but on the opposite side of the canopy (start by simply rolling inverted). Set a lift limit pull, and place your lift vector underneath the bandit. Throttle should be set to manage the BFM problem. If a closure problem is desired, select idle and consider using speedbrakes. If airspeed is desired for follow-on BFM on the deck, select MRT. Downrange travel will be greater with the throttle set to MRT, thus idle creates a closure problem which could result in an in-close overshoot if the bandit does not recognize it.

3. As your nose comes up to the horizon, turn to place your lift vector on the bandit to collapse the fight. If you lose sight, turn in the same direction in which you just performed the first ditch. Reversals can be used attempting to turn the bandit's lag into lead (1C redefinition).

An energy rate or positional deck transition typically follows a ditch. Ditches and positional deck transitions are 1C types of defense and involve reversals to maintain 1C flow, creating an angles and closure problem for the bandit. An energy rate deck transition typically results in neutral, to slightly defensive, 2C flow.

Deck Transitions Following a Ditch and Fighting on the Deck: If you do not have the altitude above the deck to perform a pure nose-low maneuver (i.e. ditch), you will have to perform a transition in the oblique to prevent busting the deck. First, you need to assess relative fuselage alignment. When arriving on the deck, fuselage misalignment translates into greater AOT.

1. ***With low fuselage misalignment (low AOT and low AON – i.e. you're still defensive),*** perform a Positional Deck Transition (PDT). This maneuver trades altitude for angles, and uses reversals to force 1C flow. Roll to place your lift vector below the horizon to intercept the 10% rule. Utilize a lift-limit pull with the objective of creating angles without regard to airspeed while you attempt to turn the bandit's lag into lead. As you reverse, execute a guns d if required. A closure problem may be your only chance at neutralizing the bandit and idle/speed-brakes may not be a bad option. Transition to HA or OBFM if appropriate. A flat scissors may also develop, so be prepared to fight this fight.

2. ***With high fuselage misalignment*** (high AOT and high AON – i.e. you anticipate arriving at a relatively neutral merge with little altitude delta), perform an Energy Rate Deck Transition (ERDT). This maneuver trades altitude for airspeed to ensure we arrive on the deck within our rate band. Target the 10% rule when committing nose-low. Adjust your lift vector and pull to arrive on the deck in your rate band. Greater airspeed is better, but don't ease the pull so much

CHAPTER 8 - HIGH-ASPECT BFM

8.1 Overview

High-Aspect BFM (HABFM) will call upon you to use all the skills you have learned thus far in perch BFM. The key to being successful in HABFM is recognizing what position you are in, or in which position you are likely to become, and fighting your best fight. This will take time, patience, and continuous assessment of angles and energy. The basics of LV placement, energy management, and controlling merges will aid you in molding your piece of art; no matter how well we execute those basics, the fight will quickly transition to offensive or defensive BFM, allowing you to then apply the principles discussed earlier to kill the bandit, or to live to fight another day.

HA Objectives (in order):

1. Deny weapons employment.
2. Achieve first weapons employment.
3. Gain positional advantage.
4. Employ follow-on shots.
5. Transition to OBFM/DBFM.
6. Separate or bug prior to becoming defensive.

HA Basics (tools to become successful):

1. LV placement combined with out-of-plane maneuvering.
2. Airspeed excursions (energy management).
3. Controlling merges.

In order to achieve our objectives we need to properly utilize the basics of HABFM.

8.2 Lift Vector Placement:

Generally you can utilize tactics involving placing your lift vector on the bandit and pulling. From that starting point, adjust your lift vector to achieve the desired effects on RAC:

Lead = collapse range and increase closure with no regard for angles.

Pure = utilized for weapons employment via collapsing range and closure, with little regard for angles.

Lag = manage RAC problem.

8.3 Energy Management:

Although not listed as a separate "basic" part of HABFM,, we need to manage our energy properly to ensure we have the ability to utilize airspeed excursions when needed. We can manage and preserve our energy utilizing the following performance pulls:

1. Max performance pull
2. Compromise pull
3. Unload

8.4 Airspeed Excursions:

You need to be smart about energy excursions. Due to the poor thrust-to-weight ratio in the T-45, we have limited ability to regain lost energy. That being said, we need to trade airspeed for angles/nose position only when we are attempting to achieve the following:

1. Take a shot.
2. Deny a shot.
3. Take or create *exclusive-use turning room.*
4. Deny exclusive-use turning room.

8.5 Controlling Merges:

Lastly, we need to control merges. That is, you need to assess altitude, airspeed and angles, then plan your actions prior to, at, and after the merge to take advantage of your situation.

1. ***Altitude*** - Look to utilize altitude to your advantage. If the fight is near the deck and you are low, the bandit is unable to commit nose-low, so the altitude to the deck becomes exclusive-use turning room for you. If high and slow, it is best to arrive at the merge stacked high which will yield an energy advantage to you.

2. ***Energy*** - Not only do you need to know your energy state, but also utilizing the BFM cues, you need to assess the bandit . The bandit may have an energy surplus over your own, allowing him to use the vertical; or, perhaps it would behoove you, in your current energy state (i.e. slow and on the deck), to force a 1C fight.

3. ***Geometry*** - Angles equal a BFM advantage, so look to take advantage of any angles you might have, or can gain, at the merge.

4. ***Turning room*** - Turning room belongs to whoever takes it. If you assess turning room exists, tighten down to take it out which will yield an angular advantage for you at the merge.

5. ***Check turn*** - As LOS rates take off, max perform across the bandit tail to create a flight path crossing in the CZ. Check turns will take out any turning room from the bandit and make it easier to see the bandit post merge. Remember to preserve the 500 ft safety bubble for training at all times.

8.6 Initiating Flows:

After controlling the merge geometry that is most advantageous to you, set the flow to take advantage of your situation.

8.6.1 In-plane (<45 degrees):

8.6.1.1 - 1C

For this flow, ensure you have enough energy to counter a pure nose- high maneuver, but not so much airspeed that when you set 1C flow, you will be unable to perform a lift-limit pull, and thus flush out in front of the bandit. Utilize a combination of lift vector placement and an energy excursion to attempt to tighten your turn radius inside the bandit . A good rule of thumb is to hit the merge with tactical vertical airspeed.

8.6.1.2 - 2C

It is best to be at corner airspeed. If you have an airspeed advantage at the merge, you will be able to create angles and turning room in the form of an energy excursion. If the bandit reverses 1C, and you assess that you will be defensive in the resulting in-plane 1C fight, counter with an out-of-plane (OOPI) nose-low or -high maneuver. Refer to the discussion below for your best 2C OOPI fight.

8.6.2 Out-of-plane (>45 degrees):

Out-of-plane will result in one aircraft nose-high and the other nose-low:

8.6.2.1 OOP 1C

Nose-low - this flow is optimum to force a low-to-high merge. Continue with your current direction of turn, utilizing a nose-low (approximately 45°) nibble of buffet turn to maintain energy on the jet, and to maximize turn rate. You need to maintain enough energy that you have the ability to pitch nose-high to meet the bandit at the next merge. Prior to 90° TA, place your lift vector slightly below the bandit and pitch up into the fight. By placing your lift vector below the bandit you are attempting to make the merge more vertical.

Nose-high - maintain a lift limit pull in order to tighten your turn circle inside the nose-low bandit. If you assess the bandit does not have the energy to come up to meet you, unload above the bandit to create exclusive-use turning room. If you assess the bandit can come up to meet you, keep pulling and get your nose below the bandit in order to flatten out the merge. Make sure you adjust nose position to meet the bandit at the next merge. Assess your airspeed at the merge, and determine whether the bandit is attempting an early turn.

8.6.2.2 OOP 2C:

Nose-low - it is best to be at corner airspeed. In most cases, performing nose low will be your best 2C flow (airspeed/altitude dependent). Tighten down the merge and utilize a max performance pull across the bandit s tail; then overbank, nose-low. This presentation does two things for you, it allows you to trade altitude for turn performance; and it achieves out-of-plane maneuvering. How nose-low you need to go is dependent on airspeed and altitude. Utilize a nibble of buffet pull. If you are above your rate band, maintain a more level turn to bleed your airspeed and preserve altitude. When approaching your rate band, commit nose-low to maintain your airspeed within the rate band. As the bandit pitches down to meet you, adjust your lift vector to make the next merge happen.

Nose-high - To initiate this flow you will need airspeed above the rate band, in excess of 370 KIAS. First, you need to max perform across the bandit s tail utilizing an oblique, nose-high pull; you will be trading airspeed for altitude. When your airspeed bleeds down to the rate band, overbank to maintain your airspeed and pitch down to meet the next merge.

8.7 Unique Merges

8.7.1 Merges with a significant vertical component (> 45 deg):

Low to high this is a desirable merge for the low fighter. You should attempt to make this merge as steep as possible by placing your lift vector underneath the bandit when pitching up into the fight. Ensure you have tactical vertical airspeed and execute an early turn prior to the merge while ensuring the 500 ft bubble is maintained, and you can keep the bandit in sight (i.e. no blind lead turns). Time your turn to have your nose on the horizon when the bandit passes through the horizon. If the bandit attempts to counter the early turn by pitching into the vertical prior to your early turn, look to extend momentarily in the vertical to deny the bandit exclusive-use turning room. Place your lift vector in lead, post-merge, to force 1C flow, and look to re-enter the b bubble. When the target aspect stabilizes (typically at 90 deg), maneuver to lag to maintain your positional advantage.

High to low although less desirable, there are steps you can take to preserve your advantage. Make an early attempt to shallow out the merge. Prior to the merge, place your lift vector, or nose, below the bandit, and then slowly recover from your nose-low attitude as best you can prior to the merge. The earlier you can execute this, the more you can shallow out the merge. If the merge still has a substantial vertical component and the bandit executes an early turn, counter by performing a lift limit pull as soon as you recognize the early turn. This will collapse weapons separation. If you see the bandit extending in the vertical, unload for vertical airspeed and attempt a pure nose-high maneuver. You might not be able to go pure nose-high, but the more vertical your maneuver the better the subsequent merge. Attempt to force 2C flow by turning away from the bandit. If the bandit does not adjust, you can negate the early turn advantage.

8.7.2 Slow-speed merges:

You want to delay executing a pure nose-low maneuver due to the shifting of the post, and increase in turning radius. If you go nose-low right away, you are effectively performing an in close overshoot pure nose-low; instead, pull across the horizon with the lift vector on, to slightly below the horizon. If the bandit commits

nose-low, wait until LOS accelerates, then roll to place your lift vector in front, and perform an aggressive nose-low lift-limit pull.

8.8 Game Plane Development

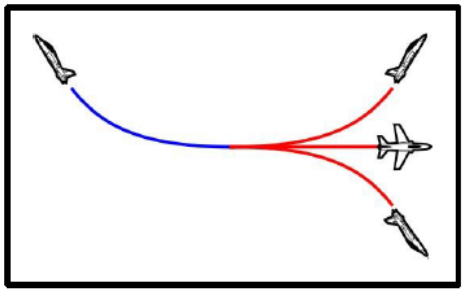
You should enter every high-aspect fight with a gameplan. Look to exploit the weaknesses of your adversary and capitalize on your strengths. Simply trying to get the first shot off without considering the implications of follow-on BFM is lacking in foundation and basic execution. Rather, consider an in-depth gameplan that continues beyond the first merge, such as looking to force 2C flow, and fight a reactive conservative pressure fight. Having a game plan gives you an idea of your desired initial energy package, how you would like to set up the merge, the follow-on flow, and your reactions based off the bandit's maneuvers. Finally, strive to think one merge ahead to develop a proactive fighting stance, instead of simply reacting to your adversary.

The following examples are not necessarily the best way to fight the T-45, but they are provided as discussion items to further your understanding of OOPI maneuvering and comparing advantages and disadvantages. In your future, you will see this similar discussion but it will compare dissimilar aircraft, where certain OOPI maneuvers will yield more advantages than others.

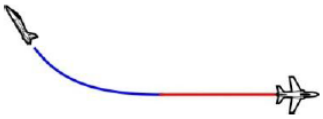
NOTE

For the following discussion, we will consider the maneuvers pure nose-high/-low/level.

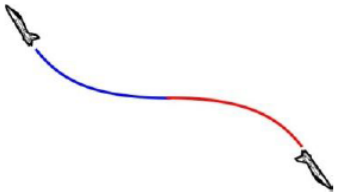
8.8.1 Fighter Nose-High vs.:



Bandit Nose-High: this is essentially a 1C fight in the vertical. The pilot that properly assesses the situation (i.e., the other aircraft s energy state and nose position), and adjusts his pull accordingly, should have a slight advantage at the follow-on merge. Look to max perform using a nibble of buffet pull. If you do not have an employment opportunity, look to extend in the vertical. You need to collapse the fight just enough to deny weapons employment. Then, momentarily unload with your nose above the bandit. As a technique, execute a vertical extension 20 degrees past pure vertical (e.g. after 110 degrees of pure nose high turn). When your canopy bow reaches the horizon, roll upright. To maintain deconfliction, do not place the bandit inside your HUD FOV. The result should be a slow-speed merge with exclusive-use turning room.

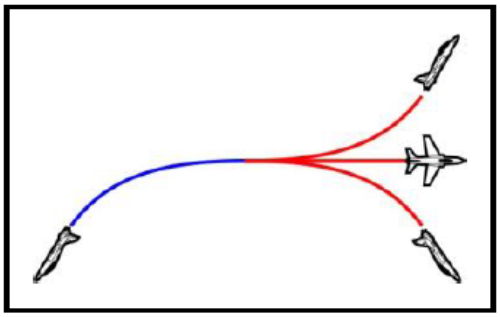


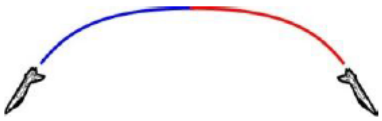
Bandit Level: this example is an uncountered OOPI maneuver. Initially, set your lift vector on the bandit executing a nibble of buffet pull. After coming over the top, shift your lift vector aft to create weapons separation. With weapons separation, reposition your lift vector in front of the bandit and aggressively pull for a shot. Left uncountered, this should result in 2C offensive flow.



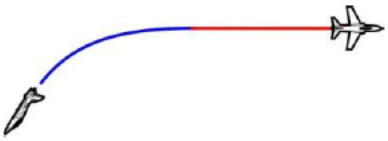
Bandit Nose-Low: This creates difficult flow for both aircraft due to the high probability of losing sight. You will initially gain angles after coming over the top but as the bandit comes up and you go down, the result is an extremely high-to-low follow-on merge. For this reason, look to come off in the oblique early to flatten out the follow-on merge.

8.8.2 Fighter Nose-Low vs.:

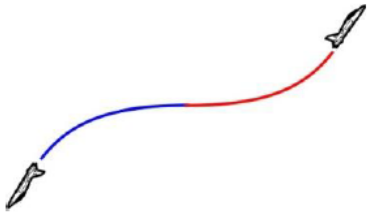




Bandit Nose-Low: This will most likely result in a neutral merge across the bottom. Look to gain exclusive-use turning room by repositioning your lift vector slightly off pure nose-low, which will displace your post above the b . Control altitude loss by selecting idle and speedbrakes. Re-select MRT and speed brakes in order to ensure you have tactical vertical airspeed. Against a pure nose-low bandit, you should have a stacked merge with the bandit below.

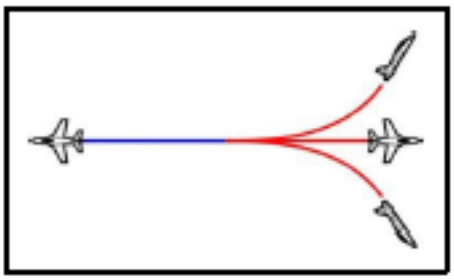


Bandit Level: This should result in an offensive advantage. Perform a lift-limit pull across the bottom. Consideration should be given to repositioning your lift vector into the oblique to minimize altitude loss, preserving turning room. Then, reposition your lift vector out in front of the bandit to align fuselages, and pull for a shot.



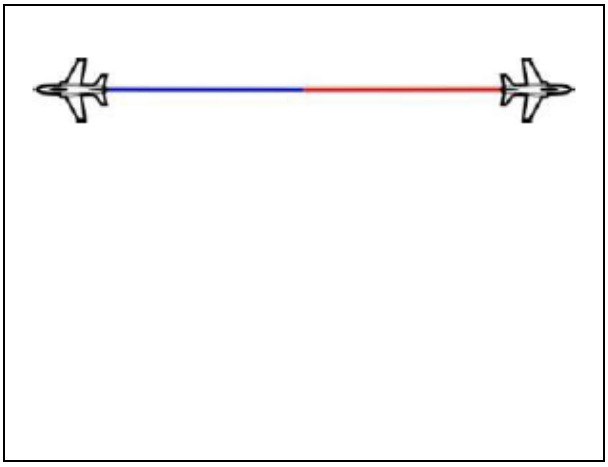
Bandit Nose-High: This flow is extremely difficult for both aircraft to maintain sight. Angles will be gained by the bandit when he is at the top. The follow-on merge should be an extremely low-to high merge. Look to early turn the bandit in the vertical for an offensive advantage.

8.8.3 Fighter Turns Level vs.:

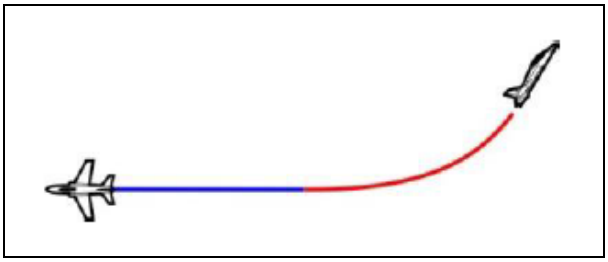


This is not optimal and should only be done with no other options available.

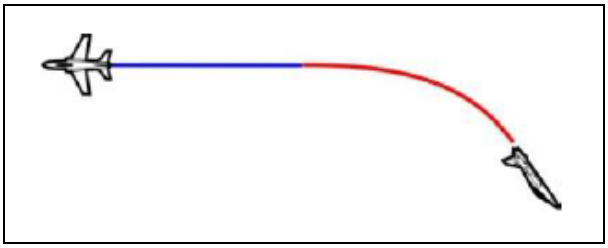
Fighter turning level is a reactionary game plan and does not put the fighter in a position to take advantage of the vertical component, and therefore unable to execute his best 1v1. It provides options to counter the bandit but does not typically yield an offensive advantage. Against an aggressive bandit, angles can still be lost in the long term because you are behind every move the bandit makes.



Bandit Level: This essentially will be a rate fight with an advantage going to the aircraft that manages his airspeed the best. If above your rate band, perform an energy excursion to bleed down to your rate numbers. In this pure rate fight, it would be best to initially target the tactical rate band (300-330 KIAS). However, if the bandit is gaining angles, it would be prudent to take an energy excursion down to 240 KIAS to deny him turning room at the next merge. Doing so denies the bandit angles but will not diminish your turn rate in the long run.



Bandit Nose-High: As you turn level across the horizon, a positional advantage will be yielded to the bandit. Look to force a low-to-high merge by pitching up into the bandit before he comes
down.



Bandit Nose-Low: Again, the bandit will gain a positional advantage in this fight by utilizing an OOPI maneuver.

8.9 Butterfly Setup

The objective of the Butterfly set is for each fighter to arrive at a neutral, co-altitude, 500-1000 ft merge with an unknown airspeed. Each pilot is free to modulate the throttle to achieve the airspeed desired at the merge to best suit them for their preferred post-merge gameplan. You

1. Both aircraft will climb to PADS altitude at 300 KIAS. When lead calls set 300, select MRT. Adjust the throttle to arrive at PADS altitude and airspeed. At this point, the flight lead will initiate speed and angels.
2. Lead will then call to take a cut away. Both aircraft will take a 30° cut away from each other. During the cutaway, each fighter is free to adjust airspeed for the desired merge gameplan.
3. At 3.0 nm or visual limits (whichever occurs first), lead will call turning in, which you will then echo. The fighters will turn into each other for a cooperative merge. You, as wing, will immediately call ROE to establish deconfliction for the merge.
4. Adjust your pull to set the neutral pass.
5. At 3/9 line passage, the flight lead will call and both fighters will begin executing their HA gameplan:

Bandit:	*"Set 300"*
	"1 set"
Fighter:	*"2 Set"*
Bandit:	*"Take a Cut away"*
	"1 turning in"
Fighter:	*"2 turning in"*
	"Left-to-left/Right-to-right"
Bandit:	*"Left-to-left/Right-to-right"*
	"Fights On" (at merge)
Fighter:	*"Fight's On"*

Butterfly lost sight gameplan: if you go blind during the turn in, call it immediately. Lead will talk you to the merge. Listen to his directions and execute them, essentially letting lead fly your jet. Once the tally is regained, call it. If both aircraft are blind, lead will climb 1,000 ft and wing will descend 1,000 ft with a KIO call from lead.

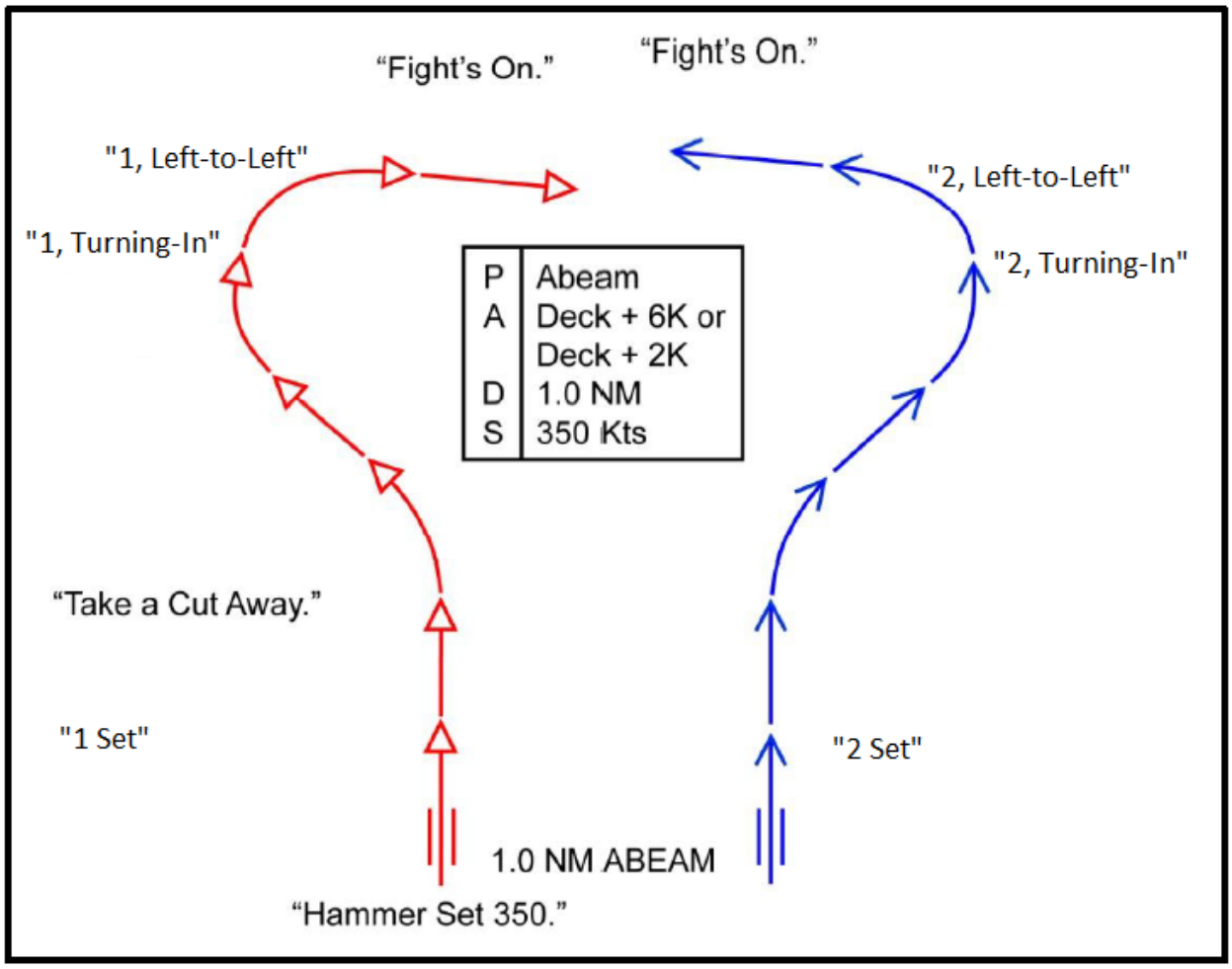


Figure 8.1 Butterfly Setup

8.10 Abeam Setup

For the Abeam set, the fight is on right away and is a neutral, known airspeed start. The initial abeam setup merge need no longer be co-altitude, allowing the fighters to add/subtract energy through the use of descending or climbing pre-merge. This allows each fighter to execute their respective BFM gameplan. Look to control that first merge so you can execute your HA gameplan.

1. Both aircraft will climb to PADS altitude in combat spread at 300 KIAS. When lead calls set 350, select MRT. Adjust the throttle to arrive at PADS altitude and airspeed. At this point the flight lead will initiate speed and angels.
2. Following this call, lead will initiate the fight by calling 3, 2, 1 fight on
3. On the "3" both aircraft will select Max Power.
4. At "Fights On" both aircraft are free to maneuver.
5. Wing will echo and call ROE for the first merge immediately.

Bandit:	"Set 350" "1 Set"
Fighter	"2 Set"
Bandit	"3, 2, 1 Fights On"
Fighter:	"Fights On" "Left-to-Left / Right-to-Right"
Bandit:	"Left-to-Left / Right-to-Right"

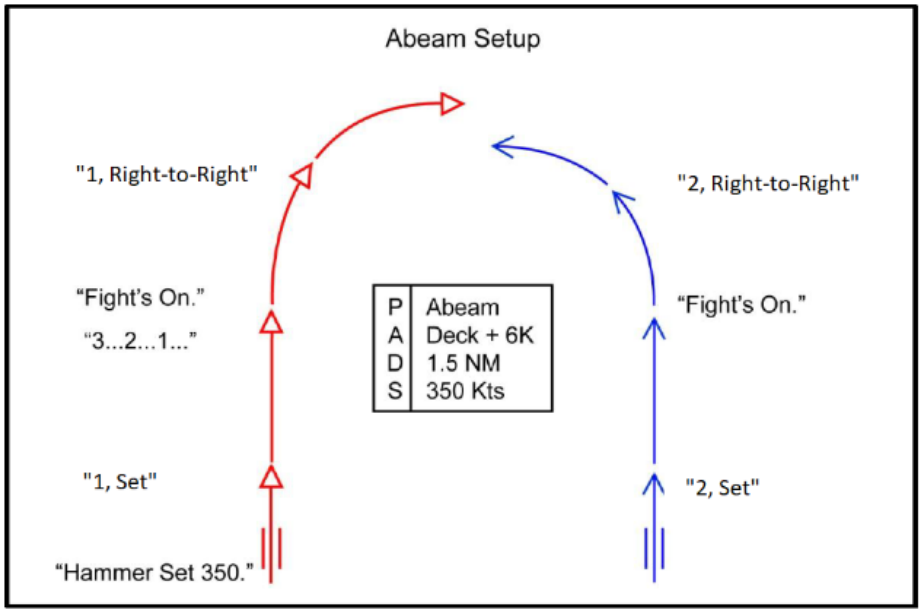


Figure 8.2 Abeam Entry

8.11 High-Aspect BFM Conclusion

In conclusion, the BFM stage is designed to give you a solid foundation of concepts and definitions, as well as start you on the road to applying them in the air. While your next platform will be much more advanced in both performance and weapons systems, the lessons you learn here provide the fundamental basis for BFM engagements in any platform. BFM will make you a better pilot. Your utmost goal should be to master these skills, as you will expand upon them throughout your entire career.

BASIC SURFACE ATTACK FUNDAMENTALS

CHAPTER 9 - BASIC SURFACE ATTACK THEORY

9.1 Introduction

This chapter will discuss the general theory behind Basic Surface Attack, as well as Common Range SOP's and BSA techniques. Topics covered will be the bombing triangle and its components, factors affecting weapons trajectory, and Z-Diagram development / basic weaponeering.

9.2 The Bombing Triangle

The bombing triangle is composed of altitude, slant range from the aircraft to the target, and the down range travel of the weapon. Aircraft flight path in the dive is also called the "wire."

Definitions Relating to the Bombing Triangle

1. ***Flight Path.*** The path of the aircraft throughout the dive. The Velocity Vector in the HUD depicts aircraft Flight Path.
2. ***Flight Path Angle.*** The angle between the horizon and the Flight Path of the aircraft.
3. ***Aim-Off Distance.*** The distance measured from the target to a point the flight path intersects the ground.
4. ***Aim-Off Point.*** A ground feature or point on the ground that represents the aim-off distance.

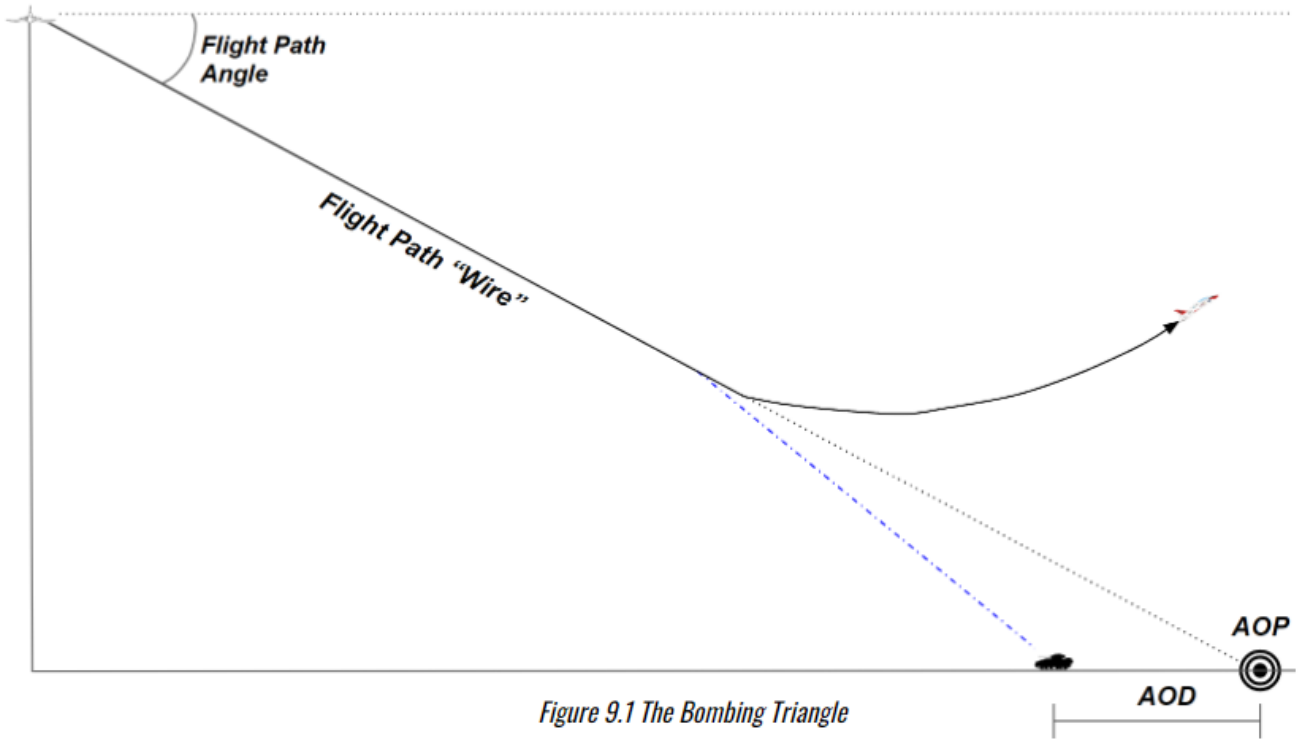


Figure 9.1 The Bombing Triangle

5. ***Initial Sight Picture (ISP).*** The initial placement of the Velocity Vector on the AOP above the target upon rollout at the beginning of the tracking run.

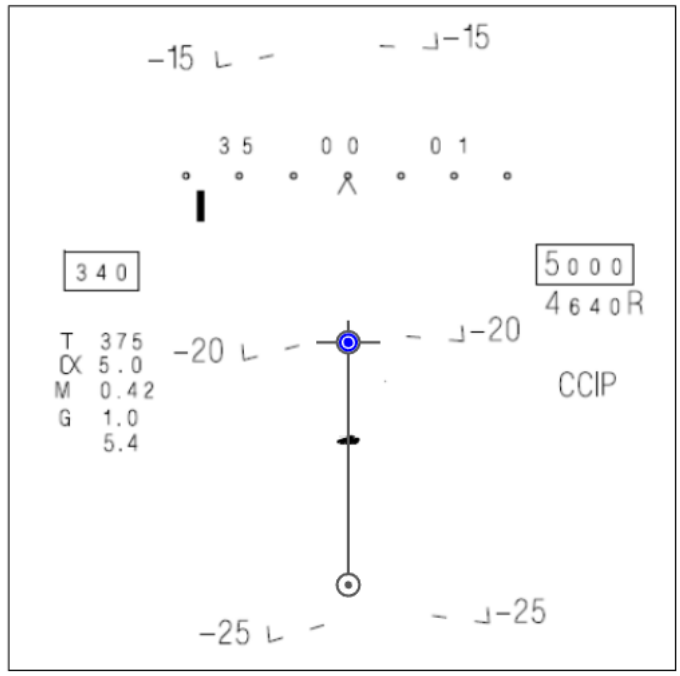


Figure 9.2 Initial Sight Picture

9.3 Common Bombing Modes

3rd Generation Fighters and newer, have weapons delivery computers that continuously calculate the geometry of the attack taking into consideration the exact attitude, altitude, airspeed, and ballistics of the selected weapon, at multiple times a second. There are two modes that are essentially universal are CCIP and CCRP.

CCIP(Continuously Computed Impact Point) - Is a mode where the computer is continuously calculating and displaying the impact of the weapon if it were to be released at that moment. This allows us to utilize the aim-off angle method of bombing and is the primary method of dive-bombing used in combat aircraft. Aim-off angle bombing focuses on setting the proper aim off angle immediately once established in the dive while making smooth corrections in order for the armament system to generate a valid release solution.

CCRP(Continuously Computed Release Point) - Is a mode where the computer is continuously calculating the release point of a weapon in order to impact on a designated target point. The pilot 'consents' to allow the computer to release the weapon(s) when its calculations arrive within a given set of parameters. Most commonly used for Level-Attacks on known target areas, or GBU type weapons.

For the context of BSA and learning basic techniques, this guide will be referencing CCIP type systems.

9.4 Factors Affecting Trajectory (Unguided Weapons)

Yaw - A skid or sideslip can also affect the trajectory of the weapon by causing a false sight picture. This occurs when the balance ball is not centered. When a bomb is released, it travels along the same flight path over the ground as the aircraft represented by the uncaged Velocity Vector. Any yaw or sideslip will create lateral deviations in hits.

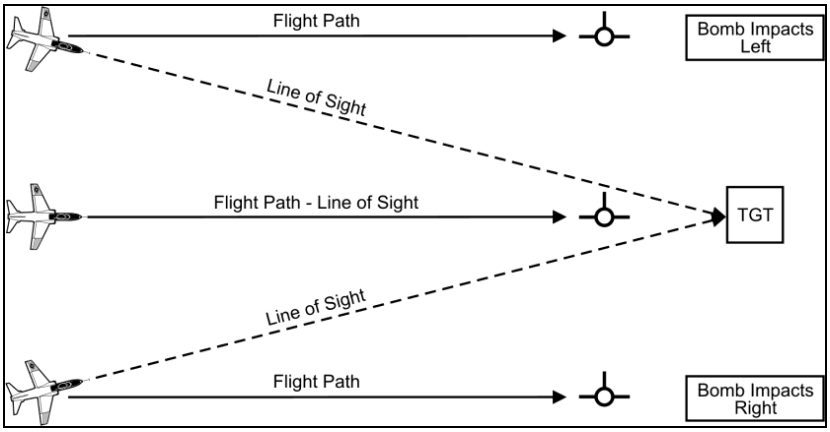


Figure 9.3 Yaw

Bank Angle - Any angle of bank at release will cause a false sight picture particularly in the manual mode of employment. This error is caused by the pendulum effect (Figure 9.4). If the aircraft is in a roll to the left, the reticle will appear to move to the right along the ground. If a bomb is released with the reticle on the target while the aircraft is in a right bank, the hit will be to the right and short.

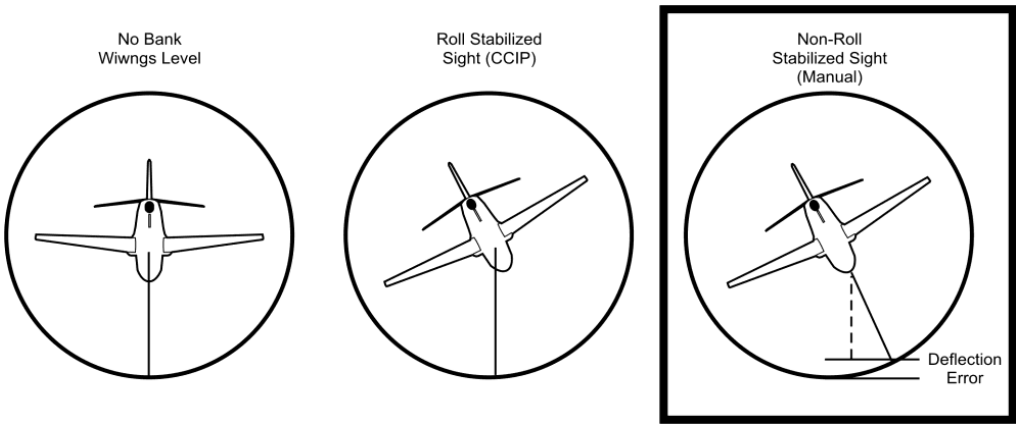


Figure 9.4 Bank Angle

G at Release - Proper G at release depends on dive angle. For a 30-degree delivery, approximately 0.87 G is required to maintain a consistent flight path. A 10-degree dive requires approximately 1 G. Excessive G will cause an early sight picture. If excessive G is applied to obtain the proper sight picture with other parameters correct, the bomb will impact short of the target. Insufficient G will cause a long hit. Too much G will shallow the dive angle, and insufficient G will steepen it.

Maintaining the Velocity Vector on the appropriate dive angle will result in the proper G at release. A common error in early strike sorties is not being properly trimmed for release and allowing the Velocity Vector to “creep” up as the aircraft seeks 1 G flight.

9.5 Basic Weaponeering

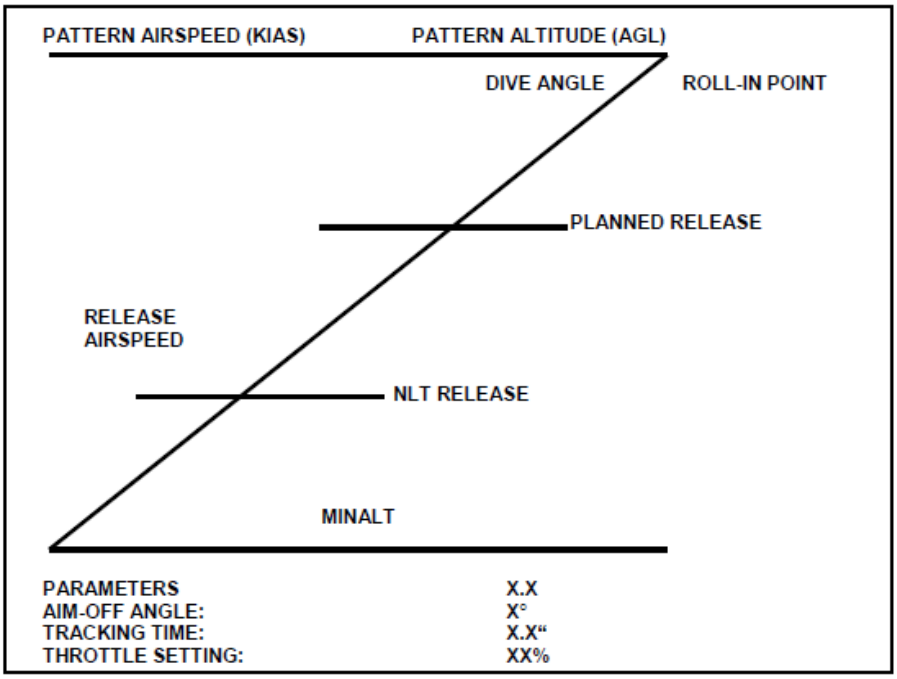


Figure 9.5 CCIP Z-Diagram Components

9.5.1 The Z-Diagram

Z-Diagrams are presentations of weaponeering information included on briefing boards and kneeboard cards. Z-Diagrams are excellent tools for flight planning and setting-up yourself, and your flight, for mission success. It is critical to understand the concepts of weaponeering and the basic components of the Z-Diagram so you can apply those concepts to follow-on training in other tactical aircraft.

The first step in building a Z-Diagram is to determine the MINALT or Minimum Altitude. There are four factors that determine how low we can go and why we do not want to continue below the MINALT. The most critical of these will drive our tactics and be the determining factor of calculating MINALT. They are:

- ***Enemy Threat.*** Target attack planning should craft a solution to avoid or minimize time spent in the simulated enemy threat envelope, thereby increasing chances of survivability while decreasing enemy survivability.
- ***Weapon fragmentation.*** Fragmentation from the weapon's explosion ascends and has the potential to impact our aircraft if we find ourselves below the apex of the weapon's fragmentation pattern. It is critical to calculate our MINALT and release altitudes to recover the aircraft above this "frag pattern."
- ***Weapon Arming Time (fusing).*** If release occurs too low, the time of fall of the weapon decreases and the fuse may not have time to arm causing the weapon to "dud." The MK 76 has an instantaneous type of fuse that causes the smoke charge to detonate upon impact.
- ***Terrain.*** In the Training Command, since enemy threat on a raked range target is highly unlikely, the MK 76 does not explode (but may bounce or skip), and fusing is not a factor, hitting the ground with our aircraft becomes our number one threat and consideration.

- ***Planned Release altitude, or PR***, is the altitude at which the release solution will occur given the aircraft is on planned dive angle and airspeed with the correct aim-off angle set. Releasing at PR also guarantees that the aircraft can be steep (up to 10º steep for high-angle, or 5º steep for low angle bombing) and up to 50 knots fast and still recover above MINALT when a 4 G pull is initiated within 2.5 seconds.

- ***No Lower Than release altitude, or NLT release,*** is the lowest calculated safe release altitude. Release at this altitude guarantees the ability to recover above MINALT when on planned dive angle, and up to 50 knots fast. Releasing below the NLT Altitude is not tolerated. If upon reaching NLT release a valid solution has not been reached, ABORT.

- ***Aim-Off Angle*** is shown below the Z-Diagram. This is how far past the target the Velocity Vector needs to be in order to compensate for the trajectory drop of the weapon. All altitudes on the Z-Diagram are depicted in AGL. A space is allotted on the Z diagrams to add target elevation to the AGL altitudes thereby deriving the MSL altitudes flown in the aircraft.

- ***Release Power Setting*** is the power setting prior to roll-in that achieves planned release airspeed. Realize that these throttle settings are approximate and do not substitute for an effective airspeed scan.

Manual and Aim-Off (CCIP) Delivery diagrams differ slightly in depiction. Manual Z-Diagrams contain an additional "checkpoint" altitude during the dive that CCIP Aim-off diagrams lack.

9.6 Communications

9.6.1 Positional / SA

Similar in nature to the SOP in a typical airfield landing pattern. Communication announcing your position or intention within the attack pattern is standard practice. E.g. Hammer 11, downwind;

9.6.2 Non-Positional / SA

Say Pos - This is requesting the position of the other aircraft in your flight. Many times this process can facilitated with the release

Abort, Abort, Abort - If you hear abort, abort, abort with aircraft nose pointed at the target, immediately recover the aircraft until a positive rate of climb is established. Set the MASTER ARM to SAFE and call (c/s), aborting.

9.7 Types of Attacks

9.7.1 Visual Level Attack

This type of delivery is commonly flown using CCRP, and when the weather or threat precludes steeper dive angles. a level delivery is planned, simply arrive at the target on your proper altitude with the CCIP pipper properly positioned. This type attack can be done at Low or High Altitude, with low or high drag munitions.

9.7.2 High Altitude Dive Bombing (HADB) (30º–45º)

This delivery is designed for high angle delivery of low-drag weapons in a high threat environment.

9.7.3 Low Angle Strafe (<20º)

This is the typical approach for a Gun or Strafe pass. The lower angle allows for a lower Min altitude and closer approach is needed for accurate placement of rounds from a Cannon attack.

9.7.4 Pop-Up Attack

The Pop-Up attack is designed for the attacking aircraft to approach the target area at low level and then initiate a "pop-up" climb to achieve enough altitude to achieve the desired dive angle, and typically a low level egress out of the target area. The types of attacks typical done from low level area:

- **Pop-Up to High-Angle (HADB)(30º)**
- **Pop-up to Low Angle High-Drag (LAHD)(<25º)**
- **Pop-up to Low Angle Low-Drag (LALD)(<25º)**

CHAPTER 10 - STANDARD ATTACK PATTERNS

10.1 Introduction

This section will cover the 2 basic range patterns used in the training range area. The *conventional wheel pattern*, and the *low altitude Pop-up*. Both begin with the "Fence in" call and end with the "Fenced out" call. The ultimate difference between the patterns will be altitude and range of base leg to target. But the overall fundamental concepts, and techniques will be consistent and applicable to both. The techniques and comm's habits built with these patterns will be applicable in both training and in live attack.

10.5 Pattern Objectives

The conventional pattern allows orderly, repetitive weapons delivery practice for up to four aircraft on the range. It is designed to allow you to get from one pass to the next as efficiently as possible to maximize learning basic diving weapons delivery.

10.2 Range Check in procedures

10.2.1 Range Area Check-In

Approaching the Target Range area, the flight lead will switch the flight to the target frequency. The flight lead will then check-in with the target after ensuring a positive check-in by all wingmen.

HAMMER 11(PRI): "*Loom Lobby, Hammer Flight, flight of 4 T-45s, 8 x MK76 a piece, to work the main bull for the next 0+40.*"

LOOM LOBBY(PRI): "*Hammer Flight, Loom Lobby, you are cleared into the target area, cleared hot at flight lead discretion, lead assumes range safety.*"

10.2.2 The Spacer Pass

The primary objective of the Spacer Pass is to over-fly the target at release altitude and airspeed ensuring that the aircraft is properly trimmed.

Approaching the target area, the flight lead will call out the target location and set up for the spacer pass. With about 45 to 90 degrees of turn to go before the run-in heading, the flight assumes right or left echelon depending on the direction of the pattern (ex. right echelon for a left pattern). Echelon should be set with double the normal cruise interval.

On the Spacer Pass, scan release altitude winds on the HSI. This provides a reference for bomb drift post release. Passing over the target, everyone should take a moment and visually clear the target, ensuring there are no unwanted visitors in the target area. If you see something that does not look right, speak up. Situational Awareness is a habit, use this opportunity to re-enforce it.

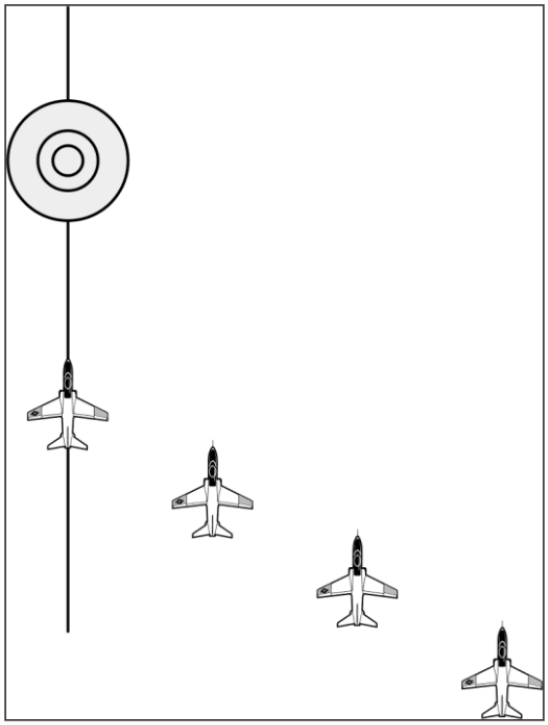


Figure 10.1 The Spacer Pass

10.2.3 The Break into the Pattern

Slightly before the target, the flight lead will call out "Hammer One One, breaking, (Wheel/Low) pattern." Pattern break interval will be 8 seconds, regardless of number of A/C in flight.

After making your "breaking" call into the pattern, roll the aircraft roughly 45 degrees AOB, smoothly apply approximately 3-4 G, set MRT and fly the jet to the Downwind position. The initial 90° of turn typically requires 3–4 G, with the second 90° of turn being a gradual reduction from 3 G to 1 G.

Once the last aircraft in the flight has broken into the pattern, the flight lead will make their position call with fuel state. Dash 2 and Dash 3 will call out their position and fuel state in order. Dash 4 will hold their position call until the flight lead calls "Hammer One One, off safe," then the normal comm cadence begins.

Example:

HAMMER 11-14:	PRI: "*Hammer (c/s), breaking, (type) pattern.*"
HAMMER 11-13:	PRI: "*Hammer (c/s), (pattern position), (fuel state).*"
HAMMER 11:	PRI: "*Hammer One One, In, Heading one four three.*" PRI: "*Hammer One One, Off Safe.*"
HAMMER 14:	PRI: "*Hammer One Four, (pattern position), (fuel state).*"
HAMMER 12:	PRI: "*Hammer One Two, In, Heading one four three.*"

10.3 Conventional Pattern

10.3.1 Overview

The conventional pattern is similar in structure to a standard landing pattern, with the following segments: crosswind, downwind, base, and final (Figure 10.2). While the basic pattern remains the same between different events, altitude and base position will change to accommodate the various release altitudes and dive angles. Depending on the event, a complete "lap" around the pattern will take only 1 to 2 minutes. In addition to the required tasks for each segment of the pattern, you will have to maintain briefed altitude, airspeed, and ground track.

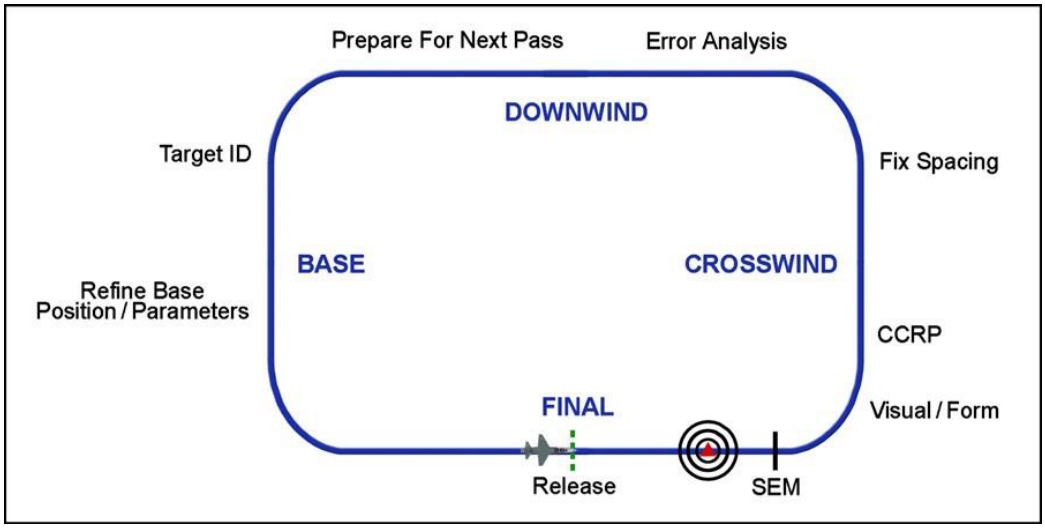


Figure 10.2 Conventional Pattern.

10.3.2 Crosswind.

The first priority in the crosswind is to (re)gain visual on the preceding aircraft. With 8,000 feet of pattern spacing, the preceding aircraft should be near 10 o'clock and hold steady on the canopy until rolling out on. You will be looking at almost a tail-on aspect making the visual tougher to reacquire. When turning crosswind (or any other place in the pattern), realize that you may be turning inside the preceding aircraft (the "coffin corner"). Look outside as well as inside your turn until you are sure your turn is clear.

10.3.3 Check Spacing.

After finding the aircraft in front of you, assess your pattern spacing; you should be 6,000 to 9,000 feet behind the preceding aircraft. The AAT can be used to back up a visual assessment of 6,000 to 9,000 feet. If you are close or wide, then adjust your turn to downwind to either increase or close range. If you are adjusting your downwind turn, orient your downwind leg so that you will arrive over the briefed ground track at your turn to base. If you are Number 2 or Number 3 of a four ship, avoid airspeed deviations as they will affect the aircraft behind you; instead use geometry. Prior to "cutting" any corners, you must be visual or have SA with comm with all of the preceding aircraft. This will prevent an unaware, belly-up pull on the preceding aircraft that can create a midair collision potential in the form of a "coffin corner."

10.3.4 Downwind.

Lead will establish the downwind leg ground track in the brief. This is not a fixed position and may be varied by individual pilots if required to adjust spacing. Use the time on downwind to prepare for the next pass and analyze errors from the previous pass.

Prepare for the Next Pass - While not all-inclusive, the following checks cover the minimum and highest priority tasks while on downwind. In addition, continue to evaluate pattern spacing and analyze winds; adjusting as necessary to fly the correct ground track for the planned weapons delivery and spacing. The following techniques help the aircrew develop habit patterns that can be applied in future aircraft. The individual checklist items are discussed in this chapter.

T-A-G - An easy to remember acronym to aid in accomplishing downwind checks is T-A-G:

T – Target/Weapons Program.
A – Attack Numbers.
G – Gas (complete Ops Check)

W-A-M-O-E. The W-A-M-O-E check is another common technique. It includes error analysis, which reminds aircrew to think through adjustments for the next pass.

W – Weapons Mode (A, B, C...).
A – Arm.
M – Master Mode (A/G, CCIP).
O – Ops Check.
E – Error Analysis.

10.3.5 Base

For accurate weapons delivery, base position is crucial. There are three major conditions required to begin a successful roll in: airspeed, altitude, and base distance. To arrive on the planned wire, base distance and altitude must be accurate. Airspeed deviations on base will cause you to devote excessive time on final to airspeed corrections. Hit your desired base parameters.

Base References - The proper base distance can be achieved via two sources: ground reference and canopy codes. Using ground references in a commonly used pattern is advantageous for learning the basics of surface attack and establishing canopy codes. In a more tactical environment, you will have to use canopy codes to visually assess your base position. If a ground reference is available, select a lead point to begin the base turn so as to roll out pointing toward the reference (Figure 10.3). Select MIL power, and execute a level turn with G to hold airspeed. While refining parameters on base, acquire the target. Another method used to set base distance is a visual assessment of the planned wire. This involves setting the correct target-to-canopy reference or "sight picture" while wings level on base (Figure 10.3). For no wind, put the target 1 1/2 fist widths above the canopy rail for a 10°, a fist width above for a 20°, on the canopy rail for a 30°, and for a 45°, the target will be a fist width below the canopy rail. These references are only valid when wings level, at the appropriate base altitude. These methods can be combined to help build the base sight picture and refine your base distance. For either method, the target should be your primary reference for planning the roll in.

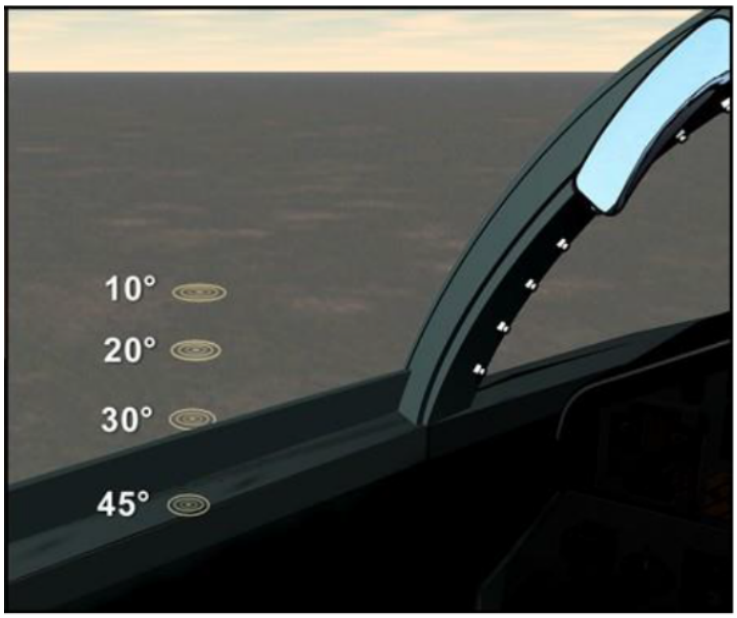


Figure 10.3 Canopy Code

Base Ground Track Corrections - To make a correction, angle in or out from the target, and then roll out. Once the picture is set, if time allows prior to the roll in, return to the original base ground track that is perpendicular to the planned attack heading. Generally, there is time for one correction on base. While base position may be slightly altered to adjust pattern spacing, it is discouraged as this requires changes to the roll in to get to the planned wire on final. If you are excessively close to the preceding aircraft, consider using a normal base position and go through dry on final. Subsequently, adjust your pattern spacing on downwind.

Wind Corrections in the Conventional Pattern - When dealing with winds in the pattern, three adjustments need to be made: the lead point for your turn to base, the base position itself, and the heading to hold that ground track. For a headwind (on final), you will need to turn base slightly earlier compared to no wind. In addition, adjust the base distance closer to the target, and roll out with a crab into the wind. The opposite is true for a tailwind (on final). This will also affect the canopy references, so the target should be slightly closer to the canopy rail for a headwind or slightly further away for a tailwind. One finger width correction for each 10 knots of head/tailwind is a good ROT. For crosswinds (on final), adjust your roll in earlier or later, and expect to crab into the wind to achieve proper parameters.

10.3.6 Roll In.

Communications - Upon cracking wings for the roll in, call

C/S In (Heading) Hot - Transmitted after the position call and includes the heading the aircraft is tracking after rolling in. This should normally correspond to run-in heading ±15°

Hammer One Two, in, heading one four three , Hot

C/S In, (Heading), Dry - Transmitted when there is no intention of dropping on that pass, but the aircraft has ordnance remaining.

Hammer One Two, in, heading one four three , Dry

You should use the target as your reference for when to roll in; attempt to lead turn so as to roll out on final at the planned attack heading. Roll-in pacing will vary based on altitude and airspeed at the roll in. The lower and/or faster the aircraft is prior to roll in, the earlier the roll in should be. The roll in is used to transition from base to the planned wire, arriving on final at the planned attack heading, flying to the AOP. It is essential that the attacking aircraft's POM remain on the AOP throughout the roll in.

Roll-In Mechanics. - While the target is your primary reference, eyes should transition from the target to the AOP in the roll in. The goal is to set the LV to start the aircraft tracking towards the AOP and then refine the LV to keep POM on the AOP. Adjust the LV as required during the end of the roll in to have the AOP set as precisely as possible prior to roll out.

If rolling in from an incorrect base position without correcting it or noticing it until time to roll in, it is possible to adjust the roll in LV to compensate. If the base position appears too far out, the turn should be flown level for the first 30° to 45° before over rotating toward the AOP. If the base position appears too tight, slightly over rotate (by 5° to 10° of bank) for the first portion of the turn, and then readjust the LV towards the AOP.

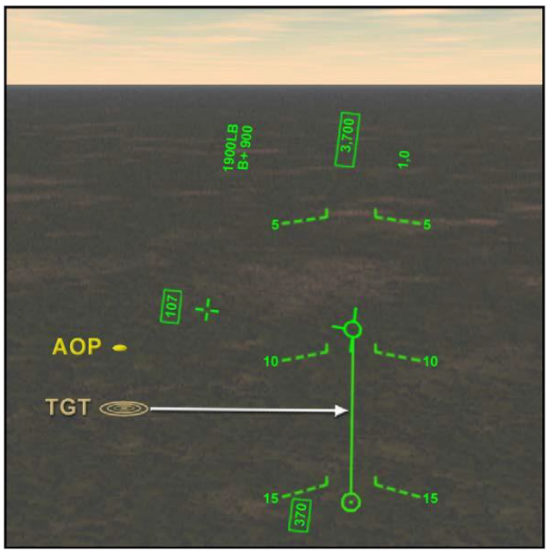


Figure 10.4 Roll-In Mechanics Sight Picture

Initial LV Reference and Bank Angle. A good visual rule of thumb for roll angles:

- 10: LV 5° above the horizon (equates to approximately 100 ° of bank)
- 20: LV on the horizon (equates to approximately 110° of bank)
- 30: LV 10° below the horizon (equates to approximately 120° of bank)
- 45: LV 30° below the horizon (equates to approximately 135° of bank)

Note:

These references are good for understanding where the LV should be for an accurate POM; however, in execution your attention should be on the AOP. Concentrate on pulling the gun cross or FPM toward the AOP and not directly to the target. Precise base parameters followed by a repeatable roll in are the best way to build the experience to "see" and fly to the planned wire.

10.3.7 Final.

Communication SOP:

- ***C/S, [Weapon type code], [Number of Weapons released]*** - Transmitted as weapons are released.

  Hammer One Two, Pickle One

  PICKLE (Unguided Bomb) / ***PAVEWAY*** (Guided Freefall)
  RIFLE (A2G Missile) / ***MAGNUM*** (Anti-Radiation Missile
  PISTOL (Rockets)

Once rolled out on the final attack heading, there are numerous items to cross- check and adjust in a relatively short amount of time (approximately 5 seconds).

Fly to the AOP - If the base, roll in, and rollout portions of the pattern have been flown well, the aircraft should arrive on or near the planned wire and be pointing at the wind corrected AOP. Flying towards the AOP will help keep the aircraft on the planned wire and fly it to the correct point in space at release producing the desired weapons effects. If base distance or the roll in weren't flown perfectly and the aircraft ends up off of the planned wire at rollout, adjustments can be made to converge back towards the appropriate wire to arrive as close as possible to the desired release point. Visually, the FPM should remain on the AOP through pickle.

Confirm Target Location - During any attack, make certain that the correct target has been identified; if unsure, abort the pass.

Power Modulate - Build awareness and modulate the throttles as required. The weapons release parameters to have enough energy to successfully execute a SEM after weapons release is with an airspeed window of 400 to 440 knots at weapons release.

Correct 3/9 - The target should be on or very near the BFL. Make a small change in bank to put the target on the BFL and roll out. Avoid 'S'ing through final by attempting one small correction. Hold a small amount of forward stick pressure or trim so as not to let the FPM run during 3/9 corrections. If a big 3/9 correction is required, bank into the target pulling the BFL back to the target and roll out. A small amount of bank at pickle is acceptable but not ideal. Make big 3/9 corrections quickly as positive G on final will cause the nose to drift up away from your AOP.

BFL Delay Cue - There are times when the pipper is HUD limited (due to being excessively high, slow or due to heavy headwinds on final). In this case, the entire BFL is not displayed in the HUD. Real-time this is indicated to the pilot by the presence of the delay cue on the BFL.

Pipper Placement - Once you have started flying good parameters, you can begin to assess where you pickled. Did you pickle where you intended? If not, then on the next pass, do so while flying an on-parameters pass. If the pipper was on target, work to improve it by changing the spot that you pickle.

Release Altitude - The release altitude will change depending on what weapon system is being employed. E.g. Gun Strafe will be lower than a bombing run with a MK-84 (2,000lb class) bomb. The T-45 uses the BDU-33 training munition, which emulates the ballistics of a MK-82LD bomb. For the context of this training we will use 4,000ft AGL as the planned release altitude and 3,500ft AGL as the NLT Altitude.

10.3.8 SEM.

The objective of the Safe Escape Maneuver (SEM) is to allow the aircraft to clear the explosive fragmentation pattern of the employed weapons. The minimum recovery altitude or the lowest altitude the aircraft can be to safely escape the frag pattern is dependent on the weapon system, but typically ranges from 500ft (Gun) - 2,000ft (LD Bombs) AGL.

Communication SOP:

- ***Off Safe*** - Given after recovering from the target attack.
- ***Winchester*** - This call is added to the "off safe" call after the final bomb has been released.
- ***No Drop*** - This call is added to the off safe call when the aircraft did not drop but has ordnance remaining.
  Ex. *"Hammer Three Four, off safe, no drop."*

The SEM can be completed in numerous ways, either in the vertical plane (Pull-up) or horizontal plane (Turning), but the objective is the same: clear the frag pattern.

Pull-Up SEM: The pull-up SEM is a smooth back pressure pull of 4-5G's to 20 degrees nose high climb (indicated by the Velocity Vector reaching the 20º pitch ladder) at MRT.

Turning SEM: The Turning SEM is a 4-5G turn, while in a -5 to -10 degrees descent (indicated by the Velocity Vector being in between the -5º and -10º pitch ladder) to the desired escape heading and altitude.

Use caution on steeper events; airspeed errors and dive angle increase over-G potential. Rapid G application is not necessary; you have 2 seconds to blend to 4 Gs. It is a good technique to complete an SEM anytime you commit your nose to the target, even if the decision is made not to release ordnance.

MAXIMUM BOMB FRAGMENT TRAVEL						
Munitions	***Altitude (FEET) Density Altitude***		***Horizontal Range (FEET) Density Altitude***		***Time of Flight (SEC) Density Altitude***	
	SL	***5,000'***	***SL***	***5,000'***	***SL***	***5,000'***
Single Warheads						
Mk-82 all types	*2140*	*2500*	*2550*	*2900*	*24.4*	*25.9*
MK-84 all types	*2770*	*3150*	*3260*	*3715*	*28.0*	*29.7*
GBU-15/27	*3465*	*3915*	*4230*	*4795*	*30.3*	*32.1*
Intact Cluster Munitions						
MK-20 Rockeye	1380	1575	1645	1850	19.4	20.6
CBU-87 / WCMD-103	1895	2140	2290	2595	23.0	24.4

10.4 Types of Attacks from a Conventional Pattern

10.4.1 High Altitude Dive Bombing (HADB) (30º–45º)

This delivery is designed for high angle delivery of low-drag weapons in a high threat environment. During mission planning, aircraft configuration must be taken into account to ensure this type of approach is feasible, i.e., two wing tanks with six MK 82s may not be an option for high 45º delivery.

At the Roll-In, the aircraft will be at or nearly inverted, so care must be taken to roll out with the proper AOD. Attacks should be planned to provide 5 seconds of tracking/designate time prior to arriving at the release altitude. For CCIP deliveries, roll out with the target approximately two thirds of the way down between the FPM and CCIP pipper.

10.4.2 Visual Level Attack

This type of delivery is commonly flown using CCRP, and when the weather or threat precludes steeper dive angles. a level delivery is planned, simply arrive at the target on your proper altitude with the CCIP pipper properly positioned.

10.5 Tactical Pattern

10.5.1 Purpose

Like the conventional pattern, the tactical pattern allows "canned" delivery pattern training. In the tactical pattern you will perform popup or Low Level-Attack and High Level-Attack. Popup or low-level attacks are flown when weather or threats force you to ingress the target at low altitude.

Communications. At the initial point, as you roll the wings onto the run-in heading, call [C/S IP Inbound], all other communication calls are the same.

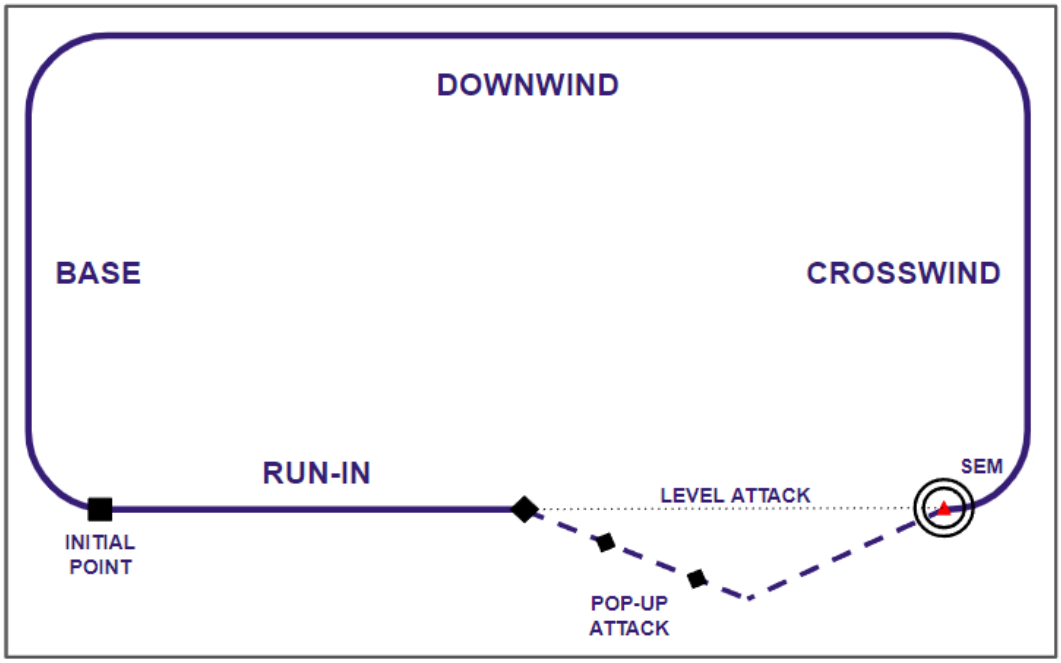


Figure 10.5 Low/Level Altitude Pattern

10.5.2 Terms and Definitions

Some specific terms that apply to the Tactical Pattern.

- ***Initial Point (IP)*** - The point where you begin the Run-In to the target. Similar to the RIP in a conventional pattern
- ***Run-In*** - The portion of the attack that is between the IP and (a) Target (Low-Level Attack) or (b) Action Point(Pop-Up)

10.5.3 Low Altitude Level-Attack

Low Altitude Level Attacks are exactly like the high altitude version only flown at Low Altitude. The Low Level-Attack is done when threats/weather dictate a low altitude approach and attack. Typically done with high-drag weapons. The typical altitude for a Low Level-Attack is at 500 ft AGL or lower. The level pattern is similar in shape to the conventional “wheel” pattern except that the base leg is spaced further away from the target (as briefed by the flight lead), and the RIP is replaced with the Initial Point.

Pay particularly close attention to precise release parameters and to the fuze arming/pull-up anticipation cue to ensure adequate fuze arming time-of-fall, fragmentation clearance and ground avoidance. The recovery portion of this delivery must be emphasized to ensure safe escape criteria from your munition—know your recovery procedure cold and fly it!

10.5.4 Pop-Up Pattern Types Overview.

There are three types of pop-up attacks that are flown: Direct, Offset and Indirect. All three start with a low altitude run-in and involve a “pop-up” to visually acquire the target and gain the altitude for the dive angle of the attack.

Direct Pop-up attack is when the Run-in is direct to the Pop-Up point which is in-line with the target.

Offset Pop-up attacks involve a run-in directly to the target followed by an "action" where a turn is made a specific distance from the target to create an offset (15-90° off heading) prior to rolling in.

Indirect Pop-up attacks are constructed so that the offset heading is flown immediately from the IP.

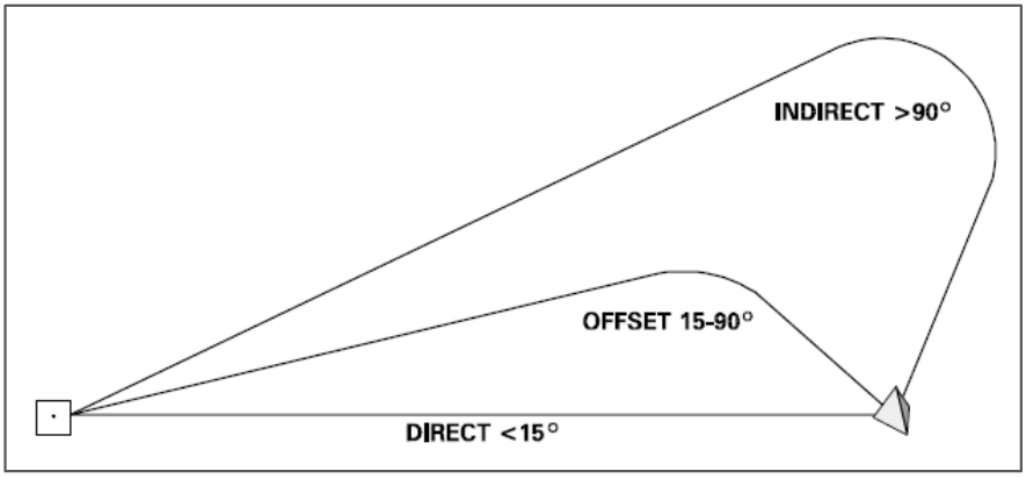


Figure 10.6 Pop-Up Attack Types

10.5.5 Run-in (IP-Inbound)

The cross-check during the run-in should start with airspeed and altitude. Accelerate to and maintain the planned airspeed for the action and stay at the briefed altitude above the ground (typically 500 ft above ground level [AGL]). After initial adjustments to airspeed and altitude, bring range to the target (in the NAV block in the bottom right corner of the HUD) and heading into your cross-check. As the distance measuring equipment (DME) counts down to within 0.2 NM of planned action or pull-up range, attention should stay on the range to the target to ensure a timely action.

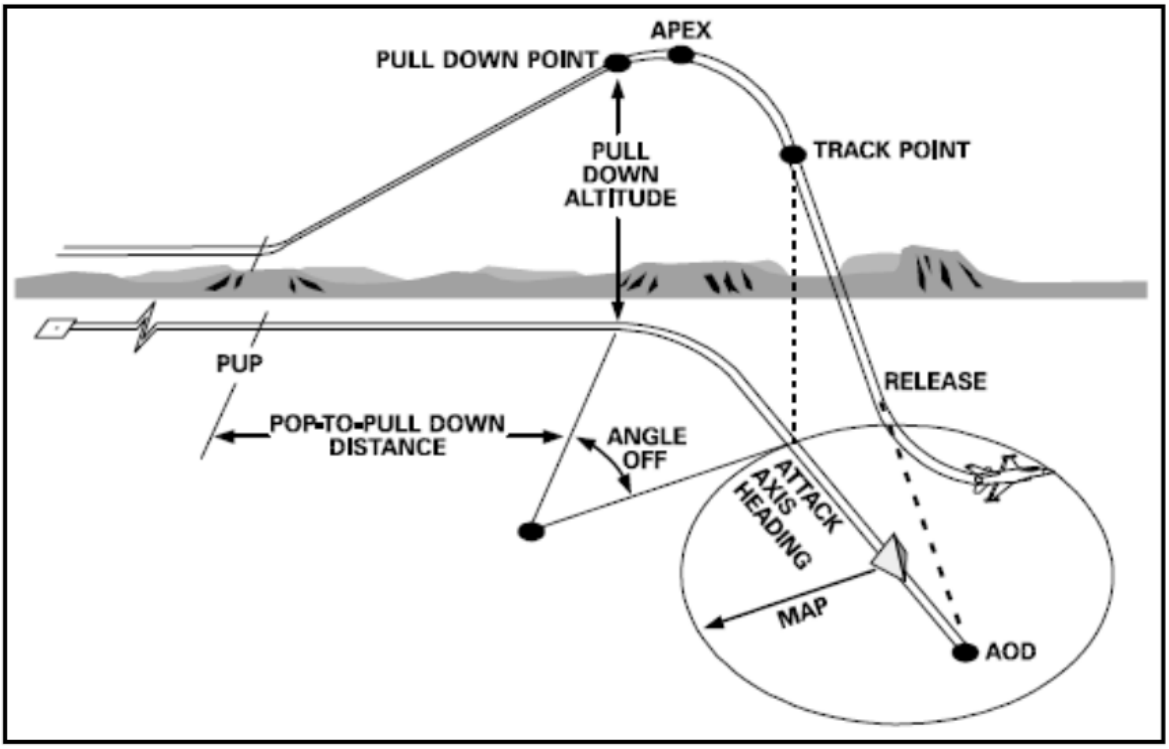


Figure 10.7 Pop-Up Attack Diagram

10.5.6 Action Point

Call "*C/S Action [Left/Right indicating what direction your check turn is]*". For direct/offset pop-up's, the check turn at the action point is designed to set the target at a known angular distance off the nose.

At the specified range, select MIL power, and execute a 3 to 4 G level turn for the appropriate amount of check angle and roll out. Several ground references may exist in the pattern to confirm the accuracy of the action point, the action heading, and/or the popup point. Attention should be outside with the priority being the ground.

For indirect pops, there is no action; fly directly from the IP turn to the popup point (Figure 10.6).

10.5.7 Pop-up Point

Call Call "C/S POP UP." The goal is to precisely fly the “climb wire,” acquire the target, and be ready for a timely pulldown.

Select MRT power and execute a 3-G pullup to the appropriate climb angle:

- 15° for a 10 delivery
- 30° for a 20 delivery
- 45° for a 30 delivery.

Climb Angle. It is important to double-check the FPM is at the desired climb angle after acquiring the target. It is common for it to drift high or low while you are finding the target. This leads to deviations in the “climb wire,” which in turn make it harder to roll out on final on the planned wire for weapon release. Trim as a technique to combat this effect.

Target Acquisition. As noted above, after the climb angle is initially set, the next task is to find the target. The target should be just behind the canopy bow, slightly below the mirror. From there it will drift down and aft.

Cross-Check Pacing. Start with the FPM/pitch ladder, transition to the target, look back inside at the FPM, and finally, check altitude. For both the 10 and 20 pop patterns, this pacing will get your eyes through the required items and back to altitude about 2 seconds prior to pulldown altitude.

- ***Pop-Up Point*** - A position at which the pop-up attack is initiated. The point where climb is initiated.
- ***Climb Angle*** - The angle of climb to be achieved following the initiation of the pop-up.
- ***Pop-to-Pull-Down Distance*** - Distance from the pop point to the pull-down point. This distance is predictable for a specific set of delivery parameters.
- ***Pull-Down Point (PDP)*** - A maneuver point where you transition from the climbing to the diving portion of a pop-up delivery.
- ***Dive Angle*** - The selected angle of dive for weapons delivery.

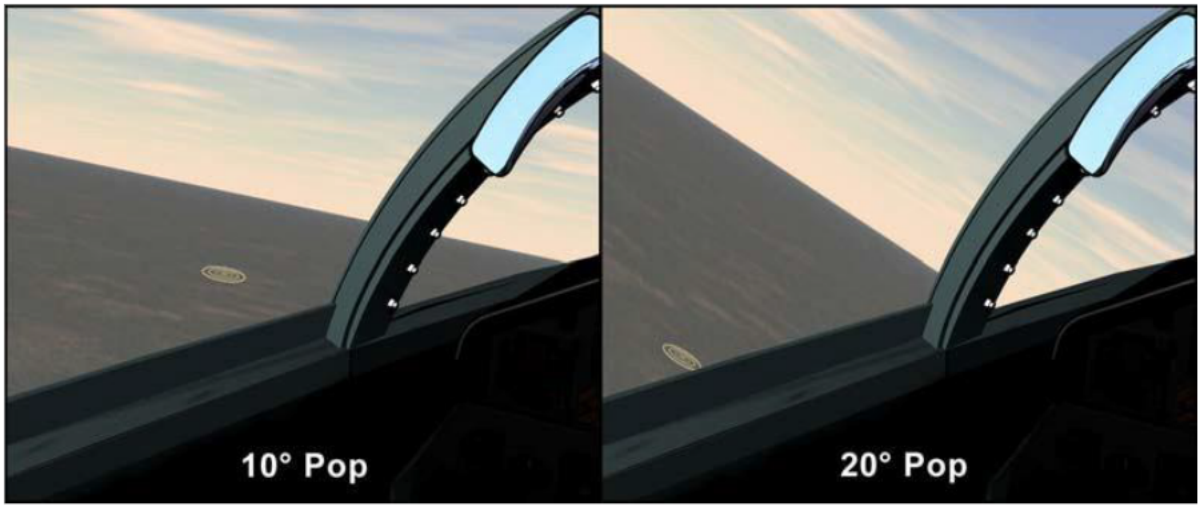


Figure 10.8 Pull-Down-Point Canopy Codes

10.5.8 Pulldown Point.

Visual marker for when pulldown altitude is reached (Figure 10.8):

10° pop-up the target will be in the "pocket" formed by the canopy rail and canopy bow intersection.

20° pop-up, the target will be further aft and on to just under the canopy rail at pulldown .

Anticipate the pulldown altitude, but there is no need to lead it. At pulldown altitude, execute an unloaded roll to put POM long of the target on the AOP, and start a 4-G pull.

Pulldown LV placement. Your pulldown LV should be placed to keep your POM on the AOD, just like the conventional pattern. For the 10 pop, initially, this will equate to about 100 to 110° of bank (LV just past the horizon). For the 20 pop, you will have to over-rotate further to about 135° of bank.

Rolling Out on Final. Just like the conventional pattern, as the target approaches the edge of the pitch ladders, begin a smooth rollout so that once wings level the target is centered in the pitch ladders. On the 20 attack, a rollout of ~135 is required to get back to wings level. It is important that the roll is unloaded; if this roll is loaded, the FPM may run well long of the AOP prior to finishing the rollout. Additionally, be aware that, compared to the conventional pattern, there are more opportunities to induce errors prior to rolling out on final that will put the aircraft somewhere other than on the exact planned wire. Knowing this, strive to be as precise as possible with airspeed, action/pullup range, G, climb angle, and pulldown altitude, as deviations in any of these areas can lead to follow-on problems.

10.5.9 Final.

Once rolled out on final, the pop-up pattern finals are identical to those of the conventional pattern. Procedures from this point through the SEM are the same as the conventional pattern roll in through final and are discussed in paragraph 10.3.8. A Turning SEM to egress Altitude is what is typically used.

10.6 Types of Attacks from a Pop-Up

10.6.1 Pop-up to High Angle Dive Bombing (HADB) (30º)

The approach to the target is normally at 500 KCAS (minimum) to an action point 4–5 NM short of the target. At this point, a check turn between 20º–30º is required to obtain the necessary offset. At the desired pop point, a 4 G pull-up is initiated to the planning climb angle (usually dive angle plus 15º) in full AB. Once the pop-up is established, time should be devoted to target acquisition which can be difficult since you will be looking down over the canopy rail. Monitor the altimeter as the pull down altitude approaches due to the rapid climb rate to ensure correct parameters. At the apex, the aircraft will be at or nearly inverted, so care must be taken to roll out with the proper AOD. After this point, it is identical to a HADB from a conventional pattern.

10.6.2 Low-Angle Attack

10.6.2.1 Low-Angle Strafe (LAS)(>20º)

Although the planned angle-off from the target can vary, normally the approach to the target is planned to be 15º–30º from the desired attack heading at a minimum of 450 KCAS. At the planned pop point, select military power and begin a 3–4 G pull-up to the desired climb angle. This is normally planned to be equal to the planned delivery dive angle plus 5º. At the preplanned pull-down altitude, roll the aircraft and begin a pull-down to achieve the desired dive angle. Monitoring the HUD pitch lines in relation to the target will simplify achieving the planned dive angle. Make an unloaded roll out with the CCIP pipper approximately 100' short of the target.

10.6.2.2 Low-Angle High-Drag (LAHD)(<30º)

This attack maneuver is very similar to that of low-angle strafe. It is designed for low-angle delivery of high drag weapons. The approach to the target is normally planned to be made from a run-in heading offset 15º–30º from the attack heading at a minimum of 450 KCAS. At the desired pop point, a 3–4 G pull-up is initiated to the planned climb angle (usually dive angle plus 5º). At the preplanned pull-down altitude, the aircraft should be rolled towards the target and the nose pulled down to roll out just as you would in any low angle bomb delivery. Normally, this type of delivery is planned to allow 3–5 seconds of tracking/designate time prior to arriving at planned release altitude. For CCIP deliveries, roll out with the target approximately one-third down between the FPM and CCIP pipper.

10.6.2.3 Low-Angle Low-Drag (LALD)(<30º)

The delivery is designed for low-angle delivery of low-drag weapons. Exercise care in computing release altitudes to assure fuze arming and safe escape. Planned angle-off for this type of delivery can vary from 15º–90º, although optimum angle is approximately 2 x climb angle. Accomplish pull-up to the planned climb angle (15º + 5º and 20º + 10º) and pull-down at the preplanned pull-down altitude. Take care to properly monitor the altimeter to determine the proper pull-down point since the apex altitude for a LALD delivery is considerably higher than for a LAHD delivery and visual cues can be deceiving. For CCIP deliveries roll out with the target approximately halfway between the FPM and CCIP pipper.

10.7 Conclusion

Your instructors will provide you with many techniques as well as other keys to success that will aid in developing effective bombing mechanics. Incorporate techniques that work for you only after fully understanding the concepts described thus far. With time and consistency throughout the flights, you will develop the skills necessary to move to the next level

Attachment 1 - ABBREVIATIONS, ACRONYMS, AND SYMBOLS

AA.....aspect angle

A-A.....air-to-air (master mode or TACAN)

AAA.....anti-aircraft artillery

AAM.....air-to-air missile

AB.....afterburner

ACAL.....altitude calibration

ABCCC.....airborne battlefield command and control center

ACM.....air combat maneuvering or air combat mode (radar mode)

AD.....arming delay

ADC.....air data converter

ADI .....attitude director indicator

AFAC.....airborne forward air controller

AFTO.....Air Force Technical Order

AG.....air-to-ground switch position

A-G .....air-to-ground (master mode)

AGL.....above ground level

AGM.....air-to-ground missile

AGR.....air-to-ground ranging

AHC.....aircraft handling characteristics

AI.....air interdiction

AIM .....air intercept missile (e.g., AIM-9L/M)

ALB .....air land battle

ALO.....altitude low mnemonic

ALOW.....automatic altitude low warning

ALT .....altitude

AMRAAM.....advanced medium range air-to-air missile

AOA.....angle of attack

AOD.....aim-off distance

APC.....armored personnel carrier

API.....armor piercing incendiary

AR.....action range

ARCT.....air refueling contact time

ASAP..... as soon as possible

ASOC..... air support operations center

ATA..... antenna train angle

ATC..... air traffic control

ATO ..... air tasking order

ATT..... attitude

AUTO..... automatic

AWACS..... airborne warning and control system

AZ ..... azimuth

BA ..... burst altitude

BARO..... barometric

BATR..... bullets at target range

BCN..... beacon mnemonic

BDA..... battle damage assessment

BDU..... bomb dummy unit

BFL ..... bomb fall line

BFM..... basic fighter maneuver

BL ..... bomb live

BLK ..... block

BLU..... bomb live unit

BORE..... boresight

BP..... bypass

BR ..... bomb range

BSU ..... bomb stabilizing unit

BUC..... backup fuel control

BVR..... beyond visual range

C3I..... command, control, communications, and intelligence

CADC..... central air data computer

CARA..... combined altitude radar altimeter

CAS..... close air support or calibrated airspeed

CAT..... category

CATA..... collision antenna train angle

CBU..... cluster bomb unit

CCD ..... camouflage, concealment, and deception

CCIL.....continuously computed impact line

CCIP.....continuously computed impact point

CCRP.....continuously computed release point

CENTAF.....Central Air Forces

CENTCOM .....Central Command

CEP.....circular error probable

CLM .....climbing safe escape maneuver

COMSEC.....communications security

cos .....cosine

CRC.....control and reporting center

C.S. .....call sign

CSAR.....combat search and rescue

CTVS.....cockpit television sensor

CZ.....cursor zero

DB.....dive bomb

DBS.....doppler beam sharpening

DED .....data entry display

DEG.....degree

DEST .....destination

DGFT.....dogfight (master mode)

DIR .....direct aim

DME .....distance measuring equipment

DMPI.....desired munitions point of impact

DNIF.....duty not involving flying

DR.....dead reckoning

DTC .....data transfer cartridge

DTOS.....dive toss

Es .....specific energy

ECM .....electronic countermeasures

ECS.....environmental control system

EEGS.....enhanced envelope gunsight

EID.....electronic identification

EL BAR.....elevation bar

ELV .....elevation

EO.....electro-optical

EOR.....end of runway

EPU..... emergency power unit

EU ..... electronic unit

FAC..... forward air controller

FCC..... fire control computer

FCNP..... fire control navigation panel

FCR..... fire control radar

FEBA ..... forward edge of the battle area

FEDS..... firing evaluation display system

FL..... flight level

FLCS..... flight control system

FLIR..... forward looking infrared

FM..... frequency modulation

FMU..... field maintenance unit

FO ..... flame out

FOV..... field of view

FPM ..... flight path marker/feet per minute

FPS/fps ..... feet per second

FRAG..... fragmentation

FRL. ..... fuselage reference line

FSCL..... fire support coordination line

FTIT..... fan turbine inlet temperature

FTT ..... fixed target track

FWD..... forward

FZ..... freeze

g..... in math formula (32'/sec2)

G..... total G on aircraft/pilot

GBU ..... guided bomb unit

GCI ..... ground controlled intercept

GE..... General Electric

GFI..... ground forces intelligence

GFIS..... ground forces intelligence survey

GLOC ..... G-induced loss of consciousness

GLO..... ground liaison officer

GM..... ground map

GMT ..... ground moving target
(MFD mnemonic for GMTI)

GP ..... general purpose

GPS ..... global positioning system

GR.....radial G

GS.....ground speed/glide slope

HADB.....high altitude dive bomb

HARTS.....horn awareness and recovery training series

HCA.....heading crossing angle

HEI .....high explosive incendiary

HHQ.....higher headquarters

HOM.....home mnemonic

HSI.....horizontal situation indicator

HST.....target history mnemonic

HUD.....head-up display

IAW .....in accordance with

IMC .....instrument meteorological conditions

INS.....inertial navigation system/set

INSM .....inertial navigation system memory

IP.....initial point or instructor pilot

IPP .....initial pipper placement

IR.....infrared

JETT.....jettison

JFS.....jet fuel starter

JMEM.....Joint Munitions Employment Manual

KCAS.....knots calibrated airspeed

KIAS.....knots indicated airspeed

KIO.....knock it off

KTAS.....knots true airspeed

Kt(s) .....knot(s)

LAB .....low angle bomb

LADD.....low altitude drogue delivery

LAHD .....low angle high drag

LALD.....low angle low drag

LANTIRN.....low altitude navigation and targeting infrared night

LAS.....low angle strafe

LAT/LNG.....latitude/longitude

LCOS.....lead computing optical sight

LDGP.....low drag general purpose

LLLD.....low level low drag

LMD..... left miscellaneous display (FCNP mnemonic)

LOC ..... line of communication

LOS..... line of sight

LUU..... launch unit universal

M..... fuze designator

MM..... millimeter

MAP..... minimum attack perimeter

MD..... miss distance

METRO..... pilot to metro voice call

MFD..... multifunction display

MFL..... maintenance fault list

MiG..... Mikoyan Gurevich (Soviet aircraft designator)

MIL..... military power

mil(s) ..... milliradian(s)

min ..... minute or minimum

MISC..... miscellaneous

MK..... mark (Navy weapon designation)

MPC..... mission planning cell

MRA..... minimum release altitude

MRGS..... multiple reference gunsight

MSA..... minimum safe altitude

MSL ..... missile mode or missile or mean sea level

MSS..... mission support system

MTR..... moving target reject

MTT..... multi-target track

NAM..... normal air mode

NAV ..... navigation mode

NB ..... narrow band

NLT..... not later than

NM..... nautical miles

NORDO ..... .no operative radio

NORM..... normal

NSTL..... nose/tail arming mnemonic

NVP..... navigation pod

NWS..... nose wheel steering

OA1..... offset aimpoint #1

OA2..... offset aimpoint #2

OAP..... offset aimpoint

OPSEC..... operations security

OPT .....option

OVRD.....override

PDP.....pull-down point

PIREP.....pilot report

Pk.....probability of kill

Ps.....specific power

PGM .....precision guided munition

POM .....plane of motion

PUP.....pull-up point or pop-up point

PW.....Pratt and Whitney

R.....turn radius

RCP.....radar control panel

RDR.....radar

RDY.....ready mnemonic

REL .....release mnemonic

REO.....radar/electro-optical

RMD.....right miscellaneous display (FCNP mnemonic)

ROE.....rules of engagement

RP .....release point

RTB .....return to base

RTN TO SRCH ...return to search (switch position)

RTS.....return to search

RWR.....radar warning receiver

RWS.....range while search

SA .....surface attack or situation(al) awareness

SACM.....selectable air combat mode

SAM.....surface-to-air missile

SBC.....symbology, brightness, and contrast

SCAN.....AIM-9L/M nutating mode mnemonics

SCP .....stores control panel

SEA.....sea search mode

SEAD.....suppression of enemy air defenses

SEL.....select or selective

SFO.....simulated flameout pattern and approach

SGL.....single

SID ..... standard instrument departure

SIM ..... simulated

sin. ..... sine

SLAV..... slaved AIM-9L/M SMS mnemonics

SMS..... stores management system or set

SNAP..... snapshoot

SOI..... sensor of interest

SPOT..... AIM-9L/M non-nutating mode

SS ..... snapshoot

SSLC ..... snapshoot & lead computing optical sight mnemonic

STBY..... standby mnemonic

STRF..... strafe mnemonic

STT ..... single target track

TACAN..... tactical air navigation

TAS ..... true air speed

tan ..... tangent

TCTO..... time compliance technical order

TD ..... target designate

TDA..... tactical decision aid

TF..... terrain following

TFR..... terrain following radar

TGP..... targeting pod

TGT..... target

TIMS..... time/inertial/map/scope

TLL..... target locator line

TOF..... time-of-flight; time-of-fall

TOS..... time over steerpoint or time on station

TOT..... time over target

TWS..... track-while-scan

UAP..... upwind aimpoint

UFC..... upfront controls

UHF..... ultra-high frequency

V..... velocity

Vc ..... closing velocity

VAH..... velocity/altitude/heading (switch)

VHF .....very high frequency (radio)

VID .....visual identification

VIP.....visual initial point

VIP-TO-PUP .....visual initial point to pull up point (DED page)

VIP-TO-TGT.....visual initial point to target (DED page)

VMC.....visual meteorological conditions

VR.....visual reconnaissance

VRP.....visual release point

VRPCRP.....CCRP with a VRP (F-16C HUD mnemonic)

VRPLAD.....LADD with a VRP (F-16C HUD mnemonic)

VRP-to-PUP..... visual reference point to pull up point

VRP-to-TGT ..... visual reference point to target

VRP/VIP ..... visual release point/visual initial point

VTR..... video tape recorder

VVI..... vertical velocity indicator

WB..... wide band

WEZ..... weapons employment zones

WOC..... wing operations center

WPN..... weapon (mnemonic)

WPN DEL..... weapon delivery (switch position)

WR..... weapon release

Attachment 2 - GLOSSARY

The following is a glossary of terms and definitions commonly used in air combat.

ACA (Airspace Coordination Area)	A three-dimensional box in the sky defined by grid and/or land references and an altitude block (AGL). The intent of an ACA is to allow simultaneous attack of targets near each other by multiple fire support means, one of which is air.
ACBT Air Combat Training;	a general term which includes (D)BFM, (D)ACM, and (D)ACT.
Acceleration Maneuver	An offensive or defensive maneuver, flown in the vertical plane, if possible, designed to increase or reduce distance from an object. A low yo-yo is an acceleration maneuver.
ACM	Air combat maneuvering; training designed to achieve proficiency in element formation maneuvering and the coordinated application of BFM to achieve a simulated kill or effectively defend against one or more aircraft from a preplanned starting position.
ACO	Airspace Control Order; document that details all approved airspace requests. The ACO will complement the ATO cycle and serve as a single planning document for airspace considerations.
ACT	Air combat tactics; training in the application of BFM and ACM skills to achieve a tactical air-to-air objective.
Adverse Yaw	The tendency of an aircraft to yaw away from the applied aileron while at high angles of attack.
Advisory Control	A mode of control in which the controlling agency has communications but no radar capability.

Aerodynamic Center	(A point on the wing chord through which aircraft lift is directed.) This definition is really for the center of pressure. The aerodynamic center is usually defined as the point on the longitudinal axis of the airplane where the lift vector is centered. The distance between the aerodynamic center and the center of gravity is static margin, and is the major factor affecting the longitudinal static stability if the aircraft.
AHC	Aircraft handling characteristics; training designed to gain proficiency in and to exploit the flight envelope of the aircraft, consistent with operational and safety constraints.
Air Refueling Time	Planned lapsed time from the ARCT to drop off.
Air Refueling Track	A flight path designated for air refueling.
Airborne Order	A command authorization for tactical flight (departure time will be specified).
Angle of Attack (AOA)	The angle between the mean chord line and the relative wind.
Angle Off	The angle formed by the extension of the longitudinal axes of two aircraft. Angle is measured from defender's six o'clock. Also called track crossing angle.
Arcing	Flying a circular flight path which allows another aircraft the use of cutoff to gain closure.
ARCP	Air refueling control point; the planned geographic point over which the receiver(s) arrive in the observation/precontact position with respect to the assigned tanker.
ARCT	Air refueling control time; the planned time that the receiver and tanker will arrive over the ARCP.
ARIP	Air refueling initial point; a point located upstream from the ARCP.
Armament Safety Check	Action taken by an aircrew to review armament selection switches to preclude the inadvertent launch/release of armament (switches safe).
Aspect Angle	Angle between defender's longitudinal axis and the line of

	sight to the attacker. The angle is measured from the defender's six o'clock. Attacker heading is irrelevant.
Attack Restriction	Ingress, ordnance delivery, or egress restrictions depending on situation, i.e., threats, weather, terrain, training rules, etc.
BFM	Basic Fighter Maneuvers; training designed to apply aircraft handling skills to gain proficiency in recognizing and solving range, closure, aspect, angle off, and turning room problems in relation to another aircraft to either attain a position from which weapons may be employed, deny the adversary a position from which weapons may be launched, or defeat weapons employed by the adversary.
BRA	Bearing, range, and altitude of the target.
Break Away	Tanker/receiver call indicating immediate vertical and horizontal separation between tanker and receiver is required.
Broadcast Control	A mode of control that passes target information by referencing a designated location, series of locations, or grid system.
Buffer Zone (BZ)	Airspace of defined dimension and adjacent to or near orders which may have special restrictions.
CAP	Combat Air Patrol; Refers to either a specific phase of an air-to-air mission or the geographic location of the fighter's surveillance orbit during an air-to-air mission prior to committing against a threat.
Center of Gravity (CG)	That point along the horizontal axis, fore and aft of which airplane weight is equal.
Chaff	Chaff is a passive form of electronic countermeasures used to deceive airborne or ground based radar.
CL Max	Maximum coefficient of lift; occurs at that angle of attack at which lift is maximum, thereby creating the maximum turn rate and maximum G loading for any condition of flight.
Clock code	Description of position using the aircraft as a reference; the nose is twelve o'clock, the tail is six o'clock.

Close Control	A mode of control varying from providing vectors to providing complete assistance including altitude, speed, and heading.
Closure	Relative velocity of one aircraft in relation to another.
Collision Course	A flight path along which an aircraft is directed towards a point at which it will collide with another aircraft.
Comm Jamming	Attempt to interrupt communications.
Comparison Diagram	A chart comparing turn rate, radius, and excess power for two different aircraft.
Compass Call	A C3CM platform.
Composite Force Training	Scenarios employing multiple flights of the same or different types of aircraft, each under the direction of its own flight leader, and performing the same or different roles. Requires a minimum of three different types of aircraft in three different mission roles.
Condition of Vulnerability	A condition with the defender in the lethal envelope of the attacker's weapon system. It is possible for combatants to arrive at a mutual condition of vulnerability, particularly during a head-on pass.
Corner Velocity	The minimum airspeed at which the maximum allowable aircraft G limit can be generated.
Defensive Maneuvering	Maneuvers designed to negate the attack/ordnance of a threat.
Defensive Spiral	A descending, accelerating dive using high G and continuous roll to negate an attack and gain lateral separation.
DR	Dead reckoning; navigation technique estimating position based on last known position, heading, speed, and time.
E-Pole	The range from a threat aircraft that a drag must be accomplished to kinematically defeat any missile the bandit could have launched or is launching.
ECM	Electronic countermeasures; actions taken to prevent or reduce the effective use of the electro-magnetic spectrum.

Element	A flight of two aircraft.
Engagement	Maneuvers by opposing aircraft attempting to achieve/prevent weapons firing positions.
F-Pole	The distance from the launching aircraft to the target at missile impact.
HCA	Heading crossing angle; the angle formed by the intersection of the fighter's present heading and the target's present heading.
High Angle (Snap) Shot	A gun shot made with a high track crossing angle, normally attempted because a tracking shot was not possible or desired.
Hostile	A contact positively identified as enemy in accordance with command rules of engagement.
Hunter-Killer	Flight mix of F-4G Wild Weasel and other aircraft employed in SEAD operations.
Intercept	A phase of an air-to-air mission between the commit and engagement.
Jinking	Aircraft maneuvers designed to change the flight path of the aircraft in all planes at random intervals (usually to negate a gun attack).
Lag Pursuit	An attack geometry that will cause the attacker to fly behind the target.
Lateral (Pitch) Axis	A reference line running left and right through the center of gravity of an airplane.
Lead Pursuit	An attack geometry that will cause the attacker to fly in front of the target.
Lethal Envelope	The envelope within which the parameters can be met for successful employment of a munition by a particular weapons system.
Line of Sight	A line from the pilot's eye to the object (usually target) being viewed.
Line of Sight Rate	An image's rate of movement across the canopy.
Line Up	Fighter briefing to a FAC.

Longitudinal (Roll) Axis	A reference line running fore and aft through the center of gravity of an airplane.
Lufberry	A circular stagnated fight with no participant having an advantage.
Maneuverability	The ability to change direction and/or magnitude if the velocity vector.
Maximum Performance	The best possible performance without exceeding aircraft limitations.
Maximum Rate Turn	That turn at which the maximum number of degrees per second is achieved.
MiG	Fighter aircraft designed and produced by the Mikoyan Gurovich Aircraft Bureau.
Military Crest	A position along a ridge or hill two-thirds the distance from the base to the summit.
Mixed Force	The employment of a single flight of different types of aircraft, performing the same tactical role, under the direction of a single flight leader.
Mutual Support	The coordinated efforts of two or more aircraft to provide combined firepower and survivability.
Off-Station	Not in position.
Offensive Maneuvering	Maneuvers against an opponent to achieve weapons parameters.
On-Station	In position, ready for mission employment.
Ops Check	Periodic check of aircraft systems performed by the aircrew (including fuel) for safety of flight.
Popeye/IMC	Flying in clouds or area of reduced visibility.
Primary Force	The flight(s) that are being protected/escorted.
Pure Pursuit	An attack geometry that will cause the attacker to fly directly at the target.
Radial G	Effective "turning" G.
Rate of Turn	Rate of change of heading, normally measured in degrees per second.

Relative Wind	The oncoming, instantaneous wind. For practical purposes, the direction of the relative wind is exactly opposite the flight path of the airplane.
Sandwich	A situation where the defending aircraft/element finds itself in between the attacking element.
Sanitize	Area clear of threats.
Scissors	A maneuver in which a series of hard turn reversals are executed in an attempt to achieve the offensive after an overshoot by an attacker.
Scramble	Takeoff as quickly as possible.
Scramble Order	Command authorization for combat flight establishing an immediate departure time.
SEAD	Suppression of enemy air defenses.
Semi-Active	A system wherein the receiver uses radiation or reflections from the target which has been illuminated by an outside source.
Separation	Distance between an attacker and defender; can be lateral, longitudinal, or vertical.
Slice	Maximum performance, nose-low turn. Usually performed at or near maneuver speed (corner velocity) with nose lowered sufficiently to maintain airspeed. This maneuver falls between a horizontal turn and a split-S.
Sorting	Using any available information such as radar presentation, GCI information, etc., to determine which bandit to attack.
Specific	Energy Total Mechanical energy per pound. Can be loosely described as an airplane's total energy resulting from airspeed and altitude.
Specific Excess Power (Ps)	A measure of an airplane's ability to gain or lose energy in terms of altitude, airspeed, or combination thereof. Also called energy rate and expressed in feet per second or knots per second.
Split-Plane	Maneuvering Aircraft or elements maneuvering in relation to one another, but in different planes and/or altitudes.

Strike	An attack which is intended to inflict damage, seize, or destroy an objective.
Suppressor	Aircraft designated to employ ordnance against defenses.
TAC-A (Tactical Air Coordinator-Airborne)	An airborne agency located far enough away from threats and jamming to provide a communications relay between fighters, FACs, and ground agencies. Typically aboard a FAC aircraft, ABCCC, or AWACS.
Tactical Control	A mode of control similar to close control with regard to type information provided except vectors are not provided to the aircrew by the weapons controller.
Velocity Vector	A line representing the direction and magnitude of the path of travel.
Vertical (Yaw) Axis	A reference line running up and down through the center of gravity of an airplane.
Vertical Rolling Scissors	A defensive descending rolling maneuver in the vertical plane executed in an attempt to achieve an offensive position on the attacker.
Weapons System	In regard to an airplane, weapons system refers to the combination of airplane/pilot/ordnance/ground crew/avionics, etc. (See USAF Glossary of Standardized Terms for complete definition.)
Whifferdill	A maneuver used to change direction approximately 180°. Nose is raised 30° to 60°, then 90° + bank is used to reverse direction of flight and pull nose down below horizon.
Wild Weasel	Dedicated radar defense suppression aircraft.
Willy Pete	A white phosphorus smoke, rocket, grenade, or artillery round used to provide a ground reference. Can be employed as a bomb to provide a smokescreen.

Attachment 3 - CODE AND BREVITY WORDS

The following is a list code and brevity words for use during combat and daily training flights. It is intended to provide common understanding and minimize radio transmissions. This common understanding is dependent on the following rules:

- These lists are not all inclusive.
- Words listed below should be used in lieu of words or phrases with similar definitions.
- Some words are informational in nature while others are intended to direct action.
- When a flight lead makes directive calls, the wingman must respond with the directed action to the best of his ability.
- If the wingman uses a "directive" term/word, it is a request and the flight lead reserves the right to approve/deny the wingman's requested action.
- When working with allied nations, remember that some of the terms/words listed here may have different meanings.

ABORT	Directive to cease action/attack/event/mission.
ACTION	Directive to perform a pre-briefed attack sequence or maneuver.
ALPHA CHECK	Request for bearing and range to described point.
ANCHOR	Orbit about a specific point; ground track flown by tanker. Information call indicates a turning engagement about a specific location.
ANGELS	Height of aircraft in thousands of feet.
APEX/ALAMO	Training term used to denote simulated launch of enemy, all-aspect radar missile.
ARM/ARMED (Safe/Hot)	Select armament (safe/hot), or armament is safe/hot.
AS FRAGGED	Fighter, FAC, mission package, or agency will be performing exactly as stated by the air tasking order.
ASPECT	Request/comment regarding target aspect information.
APHID/ARCHER	Training term used to denote simulated launch of enemy heat seeking missiles.
ATTACK/ATTACKING ( )	Indicates air-to-surface attack on a specific ground target.
AUTHENTICATE ( )	To request or provide a response for a coded challenge.
AUTONOMOUS	Aircrew is operating without benefit of GCI/AWACS control.

BANDIT (Radar/Heat/Striker)	Known enemy aircraft and type ordnance capability, if known.
BASE (Number)	Reference number used to indicate such information as headings, altitudes, fuels, etc.
BEAM/BEAMER (Direction)	Aircraft maneuvering stabilized within 70—110° aspect; generally given with cardinal directions; east, west, north, south.
BELLY CHECK	A momentary unloaded bank to check the blind side of a turning aircraft.
( ) BENT	Identified system inoperative.
BINGO	Fuel state at which RTB must commence.
BLIND	No visual contact with friendly aircraft; opposite of term "VISUAL."
BLOW THROUGH	Directive/informational call that indicates aircraft will continue straight ahead at the merge and not turn with target/targets.
BOGEY	A radar/visual contact whose identity is unknown.
BOGEY DOPE/DOPE	Request for target information as briefed/available.
BONE	Term used to indicate the formation will remain in a racetrack-type holding pattern (with all wingmen's turns into lead); exit formation must be specified by lead.
BOX	Groups/contacts/formations in a square or offset square.
BRACKET	Indicates geometry where aircraft will maneuver to a position on opposing sides either laterally or vertically from the target.
BREAK (Up/Down/Right/Left)	Directive to perform an immediate maximum performance turn in the indicated direction. Assumes a defensive situation.
BREVITY	Term used to denote radio frequency is becoming saturated/degraded and briefer transmissions must follow.
BROADCAST	Request/directive to switch to broadcast control.
BROKE LOCK	Loss of radar/IR lock-on (advisory).
BUDDY LOCK (Position/Azimuth)	Receiving friendly AI RWR.
BUGOUT (Direction)	Separation from that particular engagement/attack; no intent to re-engage.
BULL'S EYE	An established reference point from which the position of an aircraft can be determined.

BUMP	A fly-up to acquire line of sight to the target or laser designation.
BURNER	Directive to select/deselect afterburner.
BUZZER	Electronic communications jamming.
CAP/CAP (Location)	An orbit at a specified location. Establish a combat air patrol at (location).
CHAFF	Call indicating chaff has been detected or to deploy chaff.
CHAMPAGNE	An attack of three distinct groups with two in front and one behind. The leading two groups are attempting to bracket with the trailing third group flying up the middle.
CHATTERMARK	Begin using briefed radio procedures to counter comm jamming.
CHECK ( )	A directive statement made to momentarily monitor (specified items/systems). No response is required if status is normal.
CHECK (°Left/ °Right)	Turn ( ) degrees left/right and maintain new heading.
CHICKS	Friendly fighter aircraft.
CHRISTMAS TREE	Directive to briefly turn on exterior lights to enable visual acquisition.
CIRCLE ( )	Flight lead directed defensive maneuver in which the flight establishes a circular holding pattern for mutual support.
CLEAN	No radar contacts.
CLEARED	Requested action is authorized (no engaged/support roles are assumed).
CLEARED DRY	Ordnance release not authorized.
CLEARED HOT	Ordnance release is authorized.
CLOSING	Bandit/bogey/target is getting closer in range.
COLD	In context; attack geometry will result in a pass or roll out behind the target; or, on a leg of a CAP pointed away from the anticipated threats. Air-to-surface, dry or no ordnance attack.
COMEBACK (Left/Right)	Directive to reverse course.
COME OFF (Left/Right/High/Low)	A directive to maneuver as indicated to either regain mutual support or to deconflict flight paths for an exchange of engaged and supporting roles. Implies both "visual" and "tally."
COMMITTED/COMMIT	Fighter intent to engage/intercept; weapons director continues to provide

	information.
CONTACT	Radar/IR contact at the stated position; should be in bearing, range, altitude (BRA), bull's eye, or geographic position format.
CONTINUE	Maneuver for attack; does not imply clearance to engage or expend ordnance.
COVER	Directive to assume briefed support position and responsibilities.
CRANK (Direction)	F-pole maneuver; implies illuminating target at radar gimbal limits.
CROSS TURN/CROSS	A 180° heading reversal by a flight where aircraft turn into each other.
CUTOFF	Request for, or directive to, intercept using cutoff geometry.
DEADEYE	Informative call by an airborne laser designator indicating the laser is inoperative.
DEFENSIVE (Spike/Missile/SAM/Mud/AAA)	Aircraft is in a defensive position and maneuvering with reference to the stated condition. If no condition stated, maneuvering is with respect to air-to-air threat.
DEPLOY	Directive for the flight to maneuver to briefed positioning.
DIVERT	Proceed to alternate mission/base.
DOLLY	Data link equipment.
DRAG/DRAGGING (Direction)	Aircraft maneuver to 60° or less aspect.
ECHELON (Cardinal Direction)	Groups/contacts/formation with wingman displaced approximately 45° behind leader's wing line.
ELEMENT	Formation of two aircraft.
ENGAGED	Maneuvering with the intent of achieving a kill. If no additional information is provided (bearing, range, etc.), engaged implies visual/radar acquisition of the target.
ESTIMATE	Using information available to provide required data; implies degradation.
EXTEND (Direction)	Directive to gain energy and distance with the possible intent of returning.
EYEBALL	Fighter with primary visual identification responsibility.
FADED	Previous radar contact lost.
FAST	Target speed is estimated to be 600 knots ground speed, Mach 1 or greater.

FEET WET/DRY	Flying over water/land.
FENCE	Boundary separating hostile and friendly area.
FENCE CHECK	Set cockpit switches as appropriate.
FEW	Two to four aircraft.
FLANK/FLANKING	Target with a stable aspect of 120—150°.
FLOAT	Directive/informative to expand the formation laterally within visual limits to maintain a radar contact or prepare for a defensive response.
FLUSH/FLUSHED	Precautionary launch or aircraft for survival.
FOLLOW DOLLY	Follow data-link commands.
FOX	Air-to-air weapons employment.
FOX ONE	Simulated/actual launch of semi-active radar-guided missile.
FOX TWO	Simulated/actual launch of IR-guided missile.
FOX THREE	Simulated/actual launch of an active radar-guided missile.
FURBALL	A turning fight involving multiple aircraft.
GADGET	Fire control radar.
GIMBALS (Direction)	Radar target is approaching azimuth or elevation limits.
GO ACTIVE	Go to briefed Have Quick net.
GO SECURE	Directive to activate secure voice communications.
GORILLA	Large force of indeterminable numbers and formation.
GREEN (Direction)	Direction determined to be clearest of enemy air-to-air activity
GROUP	Radar target(s) within approximately 3 NM of each other.
GUN (Direction)	Visual acquisition of gunfire, AAA site, or AAA fire.
GUNS	An air-to-surface gunshot.
HARD (Direction)	High G energy sustaining turn.
HEADS DOWN	Call to inform aircrew that leader/wingman is head down in the cockpit and leader/wingman is responsible for clearing.

HEADS UP (Direction/Altitude)	Enemy/bogey got through; no kill.
HIGH	Target between 25,000 MSL and 40,000 MSL.
HIT	Radar return in search (air-to-air). Weapons impact within lethal distance (air-to-ground).
HOLD DOWN	Directive to key transmitter for DF steer.
HOLDING HANDS	Aircraft in visual formation.
HOME PLATE	Home airfield.
HOOK (Left/Right)	Directive to perform an in-place 180° turn.
HOT	In context; attack geometry will result in roll out in front of the target; or on a leg of the CAP pointing toward the anticipated threats (air-to-air). Ordnance employment authorized, expected, or completed (air-to-ground).
HOTEL FOX	HF radio.
ID	Directive to intercept and identify the target; also aircrew ID accomplished, followed by type aircraft.
IN PLACE (Left/Right)	Perform indicated maneuver simultaneously.
JINK	Unpredictable maneuvers to negate a tracking solution.
JOKER	Fuel state above bingo at which separation/bugout should begin.
JUDY	Aircrew has radar/visual contact on the correct target, has taken control of the intercept, and only requires situation awareness information; weapons director will minimize radio transmissions.
JUDY ANGLE	Aircrew is taking control of intercept in azimuth only; weapons director continues to provide range information.
KILL	Directive to commit on target with clearance to fire; in training, a fighter call to indicate kill criteria have been fulfilled.
LADDER	Three or more groups/contacts/formations/aircraft side-by-side.
LINE ABREAST	Two groups/contacts/formations/aircraft side-by-side.
LOCKED (BRA/Direction)	Final radar lock-on; sort is not assumed.
LOW	Target altitude below 5,000 feet AGL.
MAGNUM	Launch of AGM-88 HARM by Wild Weasel.
MANY	Five or more aircraft.

MARKING	Leaving contrails or otherwise marking aircraft position.
MEDIUM	Target altitude between 5,000 feet AGL and 25,000 feet AGL.
MERGED	Informative that friendlies and targets have arrived in the same visual arena. Call indicating radar returns have come together.
MICKEY	Have Quick time of day (TOD) signal.
MIDNIGHT	Initiate advisory control (due to loss of GCI-type radar).
MIL	Directive to select military power.
MUD (Direction)	Indicates RWR ground threat displayed; followed normally by clock position.
MUSIC	Electronic radar jamming. On AI radar, electronic deceptive jamming.
NAKED	No RWR indications.
NO JOY	Aircrew does not have visual contact with the target/bandit; opposite of "TALLY."
NOTCH (Direction)	All-aspect missile defensive maneuver to place threat radar/missile near the beam.
OFF (Direction)	Informative that attack is being ceased and repositioning in the indicated direction.
OFFSET (Left/Right)	Informative call indicating maneuver in a specific direction with reference to the target.
PACKAGE	Geographically isolated collection of groups/contacts/formations.
PADLOCKED	Informative that aircrew cannot take eyes off another aircraft/ground target without losing tally.
PAINT	Friendly AAI/APX interrogation return.
PARROT	IFF transponder.
PICTURE	Situation briefing which includes real-time information pertinent to a specific mission.
PIGEONS (Location)	Magnetic bearing and range to a specified point.
PITCHBACK (Left/Right)	A call for fighter/flight to execute a nose-high heading reversal to

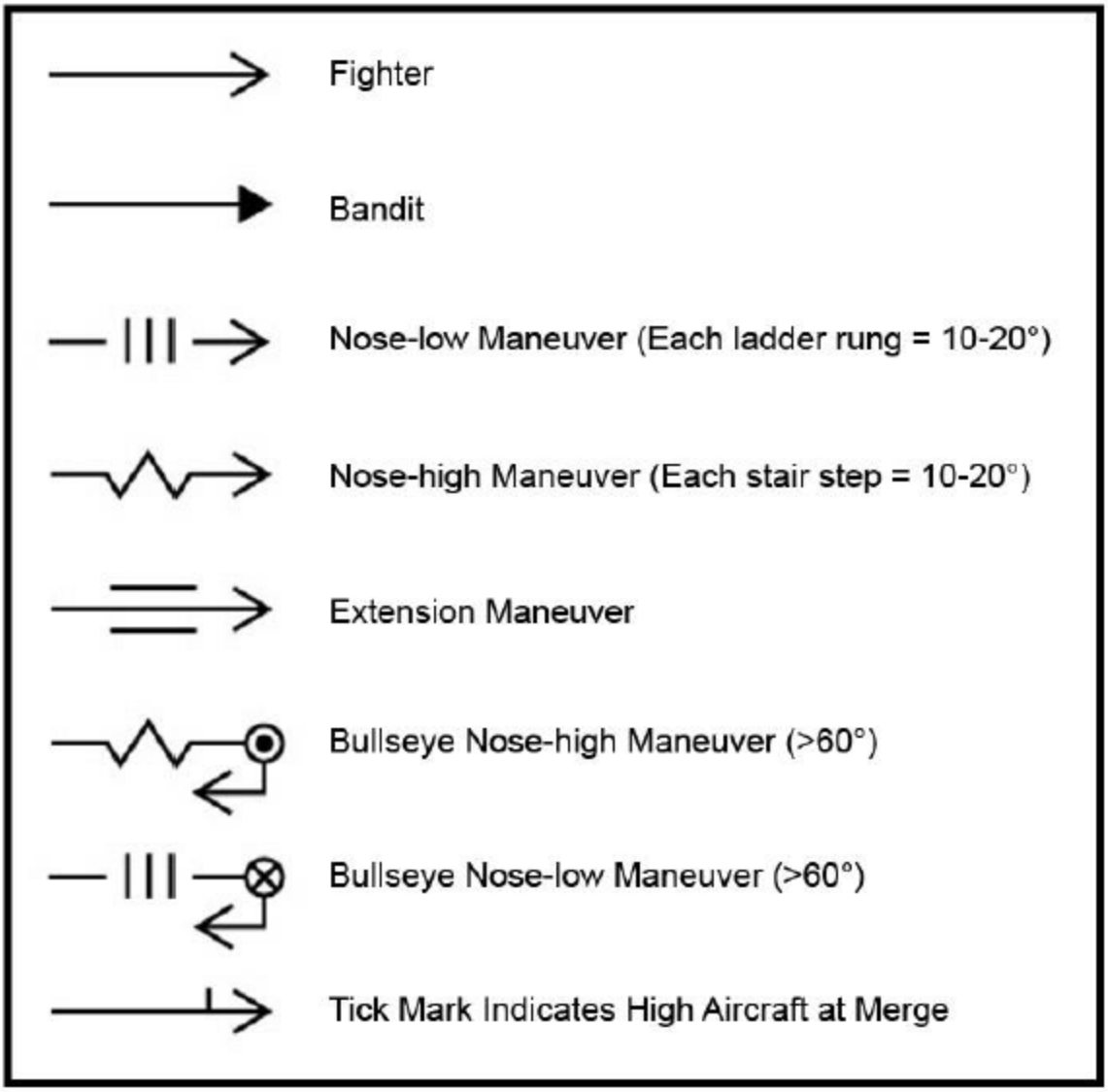
	reposition as stated.
PLAYTIME	Amount of time which aircraft can remain on station.
POINT	Directive for an element to turn towards each other either as a defensive response or to reestablish a mutually supportive formation.
POP	Starting climb for an air-to-surface attack.
POPEYE	Flying in clouds or area of reduced visibility.
POSIT	Request for position; response normally in terms of a geographic landmark, or off a common reference point.
POST ATTACK (Direction)	Weapons director's transmission to indicate desired direction after completion of the intercept/engagement.
POST HOLE	Rapid descending spiral.
POWER	Reminder to set the throttles appropriately considering the IR threat and desired energy state.
PRESS	Directive to continue the attack; mutual support will be maintained. Appropriate engaged and supporting roles will be assumed.
PUMP	Directive to perform a pre-briefed sequential maneuver to stop relative forward motion while maintaining situation awareness on the threat.
PURE	Call indicating pure pursuit is being used or directive call to go pure pursuit.
PUSH (Channel)	Go to designated frequency.
RANCH HOUSE (Altitude)	Informative or directive indicating subject fighters will/should return to CAP.
REFERENCE (Direction)	Directive to assume stated heading.
RIFLE	AGM-65 launch.
ROGER	Indicates aircrew understands the radio transmission; does not indicate compliance or reaction.
SAM (Direction)	Visual acquisition of a SAM or SAM launch. Should include position.
SANDWICHED	A situation where an aircraft/element find themselves between opposing elements.
SAUNTER	Fly at best endurance.
SEPARATE	Separation from a specific engagement.

SHACKLE	One weave; a single crossing of flight paths; maneuver to adjust/regain formation parameters.
SHADOW	Follow indicated target.
SHIFT	Directive to illuminate second target with laser designator.
SHOOTER	Aircraft designated to employ ordnance.
SHOTGUN	Launch of antiradiation (SHRIKE) missile by Wild Weasel.
( ) SICK	Described equipment is degraded.
SILENT	"GO SILENT" directive to initiate briefed EMCON procedures.
SKIP IT	Veto of fighter commit call; usually followed with further directions.
SLICE (Left/Right)	Directive to perform a high G descending turn in the stated direction; usually 180° turn.
SLOW	Target with ground speed of less than 300 knots.
SNAP SHOT	High angle/high LOS gun shot.
SNAP ( )	An immediate vector (bearing and range) to the group described.
SORTED	Criteria have been met which ensure individual flight members have separate contacts; criteria can be met visually, electronically (radar) or both.
SPARKLE	Target marking by a gunship or FAC using incendiary rounds.
SPIKE	RWR indication of an AI threat in track, launch, or unknown mode. Include bearing and clock position/azimuth and threat type if able.
SPITTER (Direction)	An aircraft that has departed from the engagement.
SPLASH	Target destroyed (air-to-air); weapons impact (air-toground)
SPLIT	Request to engage a threat; visual may not be maintained; requires flight lead acknowledgment (airto- air). Also, directive to begin pre-briefed maneuver/attack.
SPOOFING	Informative that voice deception is being employed.
SPOT	Informative that laser target designation is being received.
SQUAWK ( )	Operate IFF as indicated or IFF is operating as indicated.

STACK	Two or more groups/contact/formation with a high/low stack in relation to each other.
STATUS	Request for an individual's tactical situation; response is normally "offensive," "defensive," or "neutral." May be suffixed by position and heading.
STERN	Request for, or directive to, intercept using stern geometry.
STINGER	Formation of two or more aircraft with a single trail.
STRANGER	Unidentified traffic that is not participant in the mission.
STRANGLE ( )	Turn off equipment indicated.
STROBE	AI radar indications of noise radar jamming.
SUNRISE	A minimum of broadcast control is available (due to return of weapons director's radar).
SUPPORTING	Act of assisting the engaged fighter in killing the bandit while maintaining overall battle situation awareness.
SWITCH/SWITCHED	Indicates an attacker is changing from one aircraft to another.
TALLY	Sighting of a target/bandit; opposite of "NO JOY."
TARGET	Specification of sort responsibility. Directive call that may not necessarily follow the sort contract.
THREAT (Direction) (GCI/AWACS)	Informative that an untargeted bogey is within 10 NM of a friendly.
TIED	Positive radar contact with an element/aircraft.
TRACK	A series of related contacts indicating direction of travel.
TRACKING	Stabilized gun solution.
TRAIN (Formation)	Tactical formation of two or more aircraft following one another.
TRAILER	The last aircraft in a formation.
TUMBLEWEED	Indicates limited situation awareness; no tally, no visual, a request for information.
UNIFORM	UHF/AM radio.
VERY HIGH	Target altitude above 40,000 feet MSL.
VERY LOW	Target altitude is below 300 feet AGL.

VIC	Three groups/contacts/formations with the single closest in range and an element in trail.
VICTOR	VHF/AM radio.
VISUAL	Sighting of a friendly aircraft; opposite of "BLIND."
WALL	Three or more groups/contacts/formations line abreast/side by side.
WEAVE	Continuous crossing of flight paths.
WEDGE	Tactical formation of two or more aircraft with the single in front and the other aircraft laterally displaced on either side behind the leader's wing line.
WEEDS	Indicates that aircraft are operating close to the surface.
( ) WELL	Described equipment is functioning properly.
WHAT LUCK	Request for results of mission/tasks.
WHAT STATE	Request for armament/fuel status; reported as follows: ( ) Radar = # radar missiles remaining. ( ) Heat = # heat missiles remaining. ( ) Fuel = pounds of fuel or time remaining.
WILCO	Will comply with received instructions.
WINCHESTER	No ordnance remaining.
WORDS	Pertinent mission information.
WORKING ( )	Wild Weasel is gathering electronic order of battle on a designated emitter.
ZIPPER	Acknowledge radio transmissions with two clicks of the mike button.

Attachment 4 - WHITEBOARD BFM DEBRIEFING ICONS



Attachment 6 - REFERENCE DOCUMENTS

US AIR FORCE DOCUMENTS

AETCTTP 11-1, *4 SEPTEMBER 2009*

(USAF) MCH 11-F16 Vol 5, *10 May 1996*

(USAF) TO 1 F-16CM-1, *15 JULY 2007*

US NAVY DOCUMENTS

CNATRA P-825 (07-14) BASIC FIGHTER MANEUVERING (BFM) & ALL WEATHER INTERCEPT (AWI), *01 JULY 2014*

CIVILIAN DOCUMENTS

ART OF THE KILL, Pete Bonanni, *1991*

FIGHTER COMBAT: Tactics and Maneuvering, Robert L. Shaw, *1985*