NAVAL AIR TRAINING COMMAND

NAS CORPUS CHRISTI, TEXAS CNATRA P-825 (07-14)

BASIC FIGHTER MANEUVERING (BFM) AND ALL WEATHER INTERCEPT (AWI)

FLIGHT TRAINING INSTRUCTION ADVANCED UMFO T-45C/VMTS

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1. CNATRA P-825 (Rev.07-14) PAT, "BASIC FIGHTER MANEUVERING (BFM) AND ALL WEATHER INTERCEPT (AWI)" is issued for information, standardization of instruction and guidance for all flight instructors and student aviators within the Naval Air Training Command.

2. This publication shall be used as an explanatory aid to the Advanced Strike Fighter Undergraduate Military Flight Officer (UMFO) Training System curriculum. It will be the authority for the execution of all flight procedures and maneuvers therein contained.

3. Recommendations for changes shall be submitted via CNATRA TCR form 1550/19 in accordance with CNATRAINST 1550.6E.

4. CNATRA P-825 (Rev. 09-10) PAT is hereby cancelled and superseded.

M. B. TATSCH
By direction

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FLIGHT TRAINING INSTRUCTION

FOR

ADVANCED UMFO

BASIC FIGHTER MANEUVERING (BFM)
AND
ALL WEATHER INTERCEPT (AWI)

T-45C/VMTS

(P-825)

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INTERIM CHANGE SUMMARY

The following Changes have been previously incorporated in this manual:

CHANGE NUMBER	REMARKS/PURPOSE

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INTERIM CHANGE NUMBER	REMARKS/PURPOSE	ENTERED BY	DATE

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100. INTRODUCTION

No other phase of aviation places greater demands on the aircrew/aircraft combination than Basic Fighter Maneuvering (BFM). The skills required in BFM (situational awareness, crew coordination, lookout doctrine, performance of complex procedures under stress, etc.) are common to every tactical aircraft in the fleet. BFM training is extremely dynamic, challenging and fun. Student Naval Flight Officers (SNFOs) often find this portion of the T-45C syllabus the most enjoyable and rewarding flying to date.

1. Definition of Basic Fighter Maneuvering (BFM)

BFM is one aircraft vs. one aircraft (1v1) air-to-air combat training utilizing canned maneuvering drills for the purpose of gaining proficiency in solving range, angle, and closure problems in order to achieve a positional advantage and either employ a weapon or deny an opponent a shot opportunity. BFM encompasses just one portion of the larger arena called Air Combat Maneuvering or ACM.

2. Purpose of Learning BFM

Although 1v1 Air Combat Maneuvering (ACM) training is enjoyable, there are other reasons why it is important that strike fighter aircrew continue to study and train in 1v1 air combat:

a. Combat Lessons Learned - Despite operating in an era of all-aspect, beyond visual range (BVR) missiles, history has continuously proven the majority of air battles are fought and won in the visual arena. Even in the largest multi-plane engagements, for that brief moment when the decision is made to engage an opponent, aircrews are involved in a 1v1 engagement. Strike fighter aircrew MUST be proficient at 1v1 ACM to minimize time-to-kill and ensure they leave merges unscathed.

b. Develops Fundamental Tactical Skills — Aircrews are able to practice briefing, debriefing, communications, crew coordination and tactical decision making in a high stress, dynamic environment. The development of these core tactical skills and the confidence gained in maneuvering the aircraft throughout its flight envelope enhance performance in other strike fighter missions. The fundamental tactics and maneuvers of air combat have changed little in the last 70 years. In this stage, we will introduce the classic fighter versus fighter maneuvers and discuss how to employ them in staged and dynamic situations. It is incumbent upon all strike fighter aircrew to have a sound understanding of 1v1. The 1v1 ACM discussion will use a building block approach, progressing from basic aerodynamic review to a look at the maneuvering capabilities of our aircraft, offensive and defensive sight pictures and execution and finally to 1v1 game plan development and execution.

3. Tactical Role of the NFO

A thorough understanding of BFM principles in both cockpits is required for the crew to succeed. During the execution phase of an air combat engagement, each aircrew will have distinct responsibilities. While the pilot will be actively engaged in maneuvering the aircraft to gain a positional advantage or deny an advantage to our opponent, the SNFO, through solid crew coordination, will be a Situation Awareness (SA) enabler that serves to increase the overall combat efficiency of the Strike Fighter Team. As such, the basic ACM skills that each SNFO needs to master are:

a. Visual Lookout – SNFOs are responsible for searching from the six o'clock position to the wingline, aft and inside the section

b. Sensor Nose Recognition – recognizing when the opponent's nose is in a position to employ a weapon

   i. SNFO should call "*Break L/R" (ICS), "Flares*" (PRI) when opponent is within 30 degrees of target aspect (TA) and within 2 NM. These parameters equate to 20 degree of missile field of view and 1.5 seconds of instantaneous turn rate to pull for a shot.

   ii. SNFO should call "*Guns 'D'*" prior to the opponent solving lead, range, and plane of motion for a gun shot.

c. Deck Awareness – SNFOs are responsible for recognizing the "*Hard Deck*" (simulated ground).

   i. When less than 6K feet above the deck, "*Watch the deck*" calls are required if the 10 percent rule is broken

   ii. The 10 percent rule governs nose position, and limits nose position to 10 degrees nose-low for every 1,000 feet above the deck; i.e., 4,000 feet above the deck dictates no more than 40 degrees nose-low

   iii. Adhering to 10 percent rule provides a smooth deck transition with a high energy package

   iv. If the "*Hard Deck*" is ever broken, a "*Knock-it-Off*" call is required

d. Basic Airwork Recognition (BAR) – Performance calls are vital to crew coordination

   i. Nose-high attitude – Airspeed calls are made by SNFO over ICS

   ii. Nose-low attitude – Altitude calls are made by SNFO over ICS

101. ACM ENVIRONMENT

The ACM environment, like any other arena, has measurable dimensions with rules and limitations. Even though it is larger and more dynamic than a simple arena, it is a three-dimensional environment through which aircraft will maneuver in an infinite number of planes, ranging from the pure vertical, through the oblique, to the pure horizontal. The limitations stem from a combination of the effects of gravity, energy state and airspeed, aircraft limitations and the individual situation. When combined, these form a "snapshot in time" during an engagement.

Most fighter aircraft bleed energy as they maneuver and do not have a thrust-to-weight ratio greater than one. Their energy package is finite. ACM is a series of tradeoffs; a continuous series of decisions based on what is known about the aircraft involved and the situation.

1. **Horizontal Maneuvering**

The most basic of all aerodynamic principles states that an aircraft must generate exactly 1G to overcome the effects of gravity and maintain straight and level flight. Because the amount of lift required to maintain 1G flight is based on the weight of the aircraft (excluding the effects of drag), the vector representing gravity remains constant as long as the weight of the aircraft remains constant.

An aircraft in a turn at any angle of bank (AOB) must generate additional load factor in order to realize the same effective lift. The load factor increases because the lift vector is moved out of the pure vertical. Because the effective lift of the aircraft opposes gravity (which is a constant force), the load factor will vary according to how tight of a turn is desired.

Figure 1-1 shows two aircraft in level turns at a constant true airspeed (TAS). Aircraft A is in an 80 degree AOB turn and Aircraft B is in a 60 degree AOB turn. Because Aircraft A is turning at 80 degrees AOB, the load factor is greater than Aircraft B turning at 60 degrees AOB. Because gravity and the effective lift remain constant, the resultant vector, referred to as "radial G," actually turns the aircraft. Radial G is the horizontal component of lift; pulling harder increases the load factor. Simply put, the larger the radial-g vector, the better the turn performance. However, this greater load factor produces greater induced drag, resulting in a higher energy (airspeed) loss.

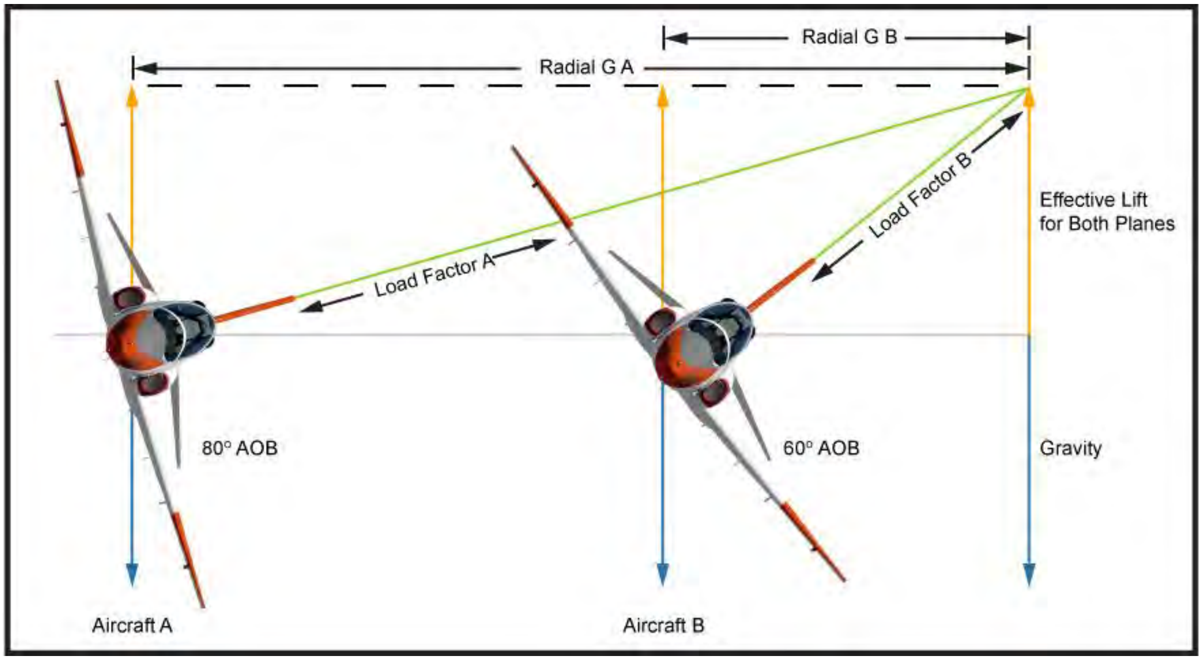

Figure 1-1 Horizontal Maneuvering

2. **Vertical Maneuvering**

Figure 1-2 represents a theoretical loop ("tactical egg") in the vertical plane at constant TAS and constant indicated G. Unlike a purely horizontal turn, turn performance in a purely vertical turn is affected differently depending upon location in the turn. When the aircraft lift vector is above the horizon (at the bottom of the egg), radial G decreases because gravity opposes the load factor of the aircraft, resulting in a larger turn radius and a lower turn rate. When the lift vector is below the horizon (at the top of the egg when the fighter is inverted), radial G increases because gravity assists the load factor and lift, resulting in a smaller turn radius and faster turn rate. When the aircraft is pure vertical (side of the egg) the load factor is parallel to the horizon and equals radial G, indicating an intermediate turn performance.

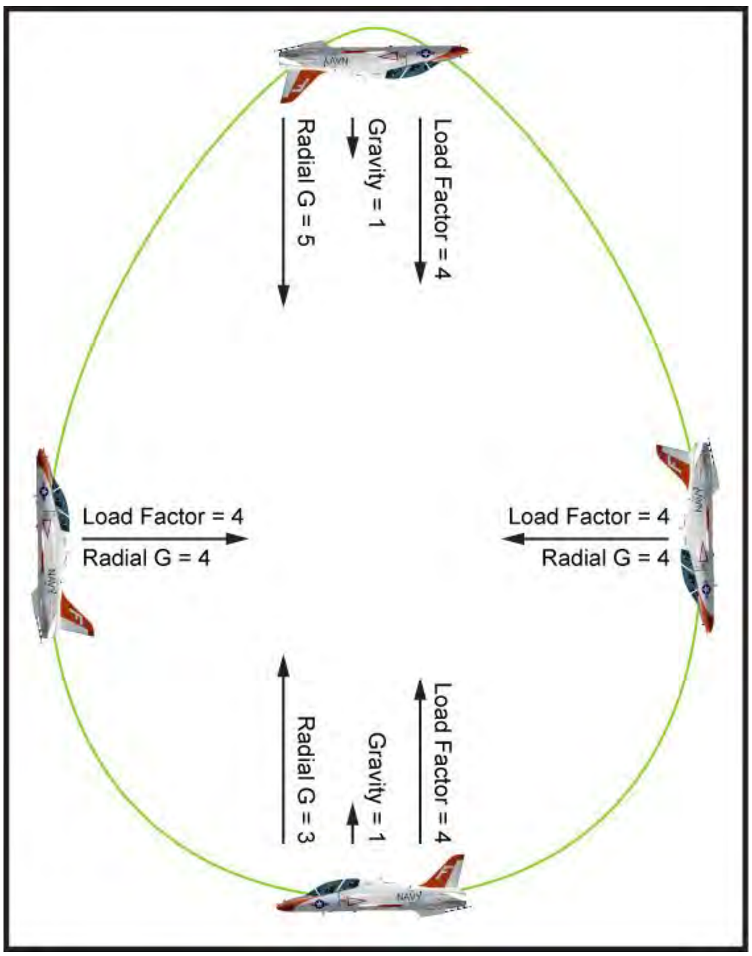

Figure 1-2 Vertical Maneuvering

3. **Energy Management (E-M Diagram)**

Other than gravity, the greatest parameter affecting the amount of radial G an aircraft can generate is its energy package, or Total Energy. Total energy (TE) is the combination of the aircraft's altitude (Potential Energy - PE) and airspeed (Kinetic Energy - KE). The Energy-Maneuvering (E-M) diagram is a graphical comparison of the aircraft's turn performance capability in relation to its energy state. The E-M Diagram is a mosaic of several graphs, overlaid on a Cartesian Plane, depicting Turn Performance (in degrees per second) versus Airspeed (in KIAS). Load Factor (G) and Turn Radius curves are also depicted because they are related to airspeed and turn rate. The E-M Diagram is the blueprint by which aircraft are employed in the BFM arena. Figure 1-3 is an E-M Diagram for a T-45C in the clean configuration, at MRT power at 10,000' MSL.

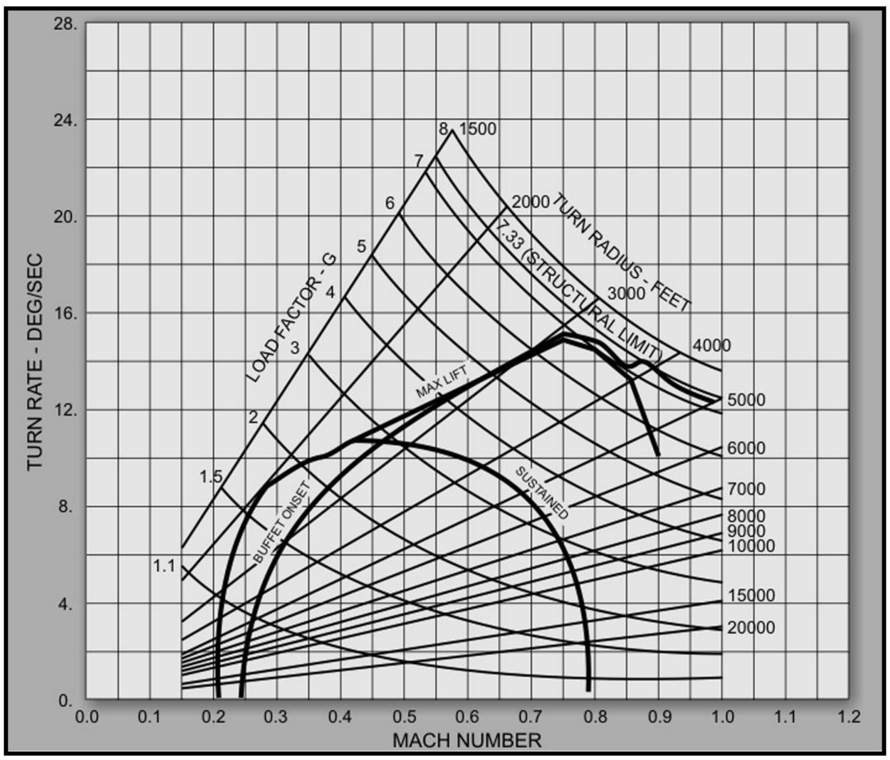

Figure 1-3 E-M Diagram (10,000 MSL)

The T-45 E-M Diagram is unique with regard to its depiction of aircraft performance in the clean configuration. The inability of the T-45 to use maneuvering devices/flaps, found in most fighter aircraft, in the high AOA regime results in a maneuvering curve that is atypical of most fleet aircraft. Notice that the lift limit curve does not intersect the structural limit curve of 7.33 at 10,000' (indicating that the aircraft cannot be overstressed at 10,000' MSL). At high airspeed and AOA, the horizontal stabs stall due to blanking of the control surfaces. This unique effect results in the characteristic T-45 "pitch buck" which in turn, is a direct result of the lack of maneuvering devices (flaps/slats). In fact, the corner airspeed of 410 KIAS is reflected by the peak of the lift limit curve at 6.5 Gs. For the purposes of discussing the E-M Diagram, a more generic representative model will be examined.

4. **Lift Limit**

The first component of the E-M Diagram is the intersection of the Lift Limit curve and the Load Limit curve (Figure 1-4). The airspeed at which this intersection occurs is called "Corner Airspeed." Corner airspeed for the T-45C is 410 KIAS. When operating below corner, the lift limit will be reached before the G limit. This means that overstress cannot occur below corner airspeed. It is possible that a significant onset rate could cause the aircraft accelerometers to overshoot, but the aircraft's structural limit will not be exceeded at those airspeeds. Additionally, the highest turn rate/turn performance is realized at corner airspeed, which is the point at which the curves intersect. At any airspeed below corner, pulling more than 24 units AOA, regardless of power setting, will cause an accelerated stall. By easing the pull to below the lift limit, the aircraft will immediately recover from this stalled condition.

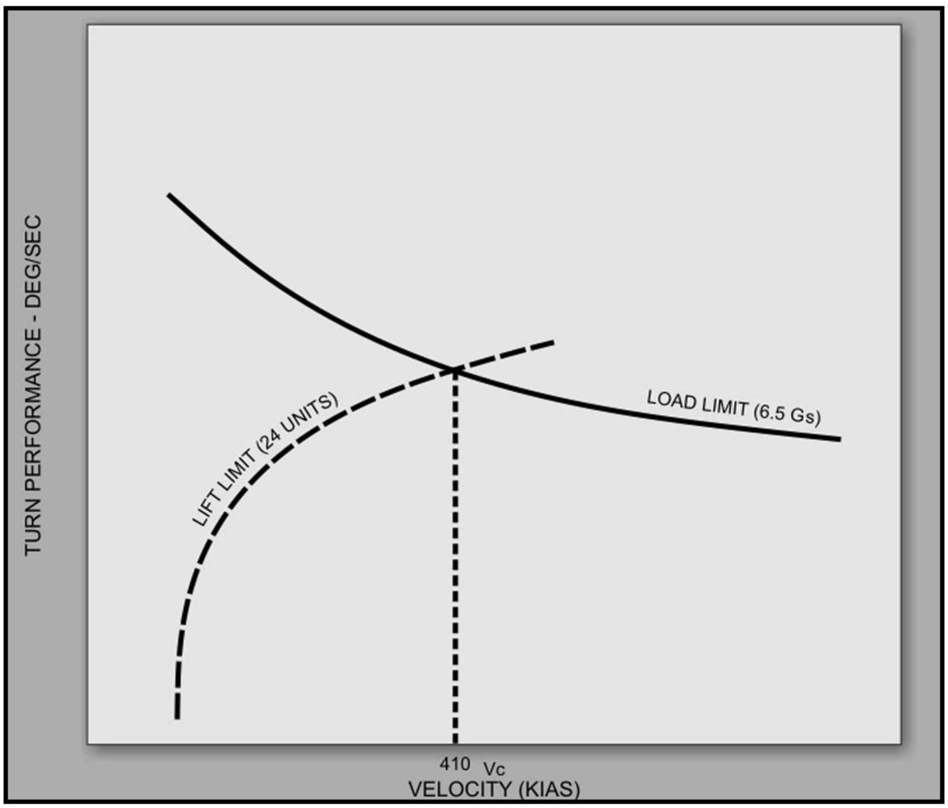

Figure 1-4 Lift Limit and Corner Airspeed

5. **Max G Available**

As depicted in Figure 1-5, there are an infinite number of G curves that parallel the G-limit curve, each intersecting the Lift Limit at subsequently lower airspeeds. From this depiction, it is easy to see that with a decrease in airspeed, G available also decreases because the Lift Limit is reached at a lower G and turn rate. As a general rule of thumb, 1 G is lost for every 50 KIAS below Corner. As airspeed decreases, the ability to generate radial G and turn performance also decreases.

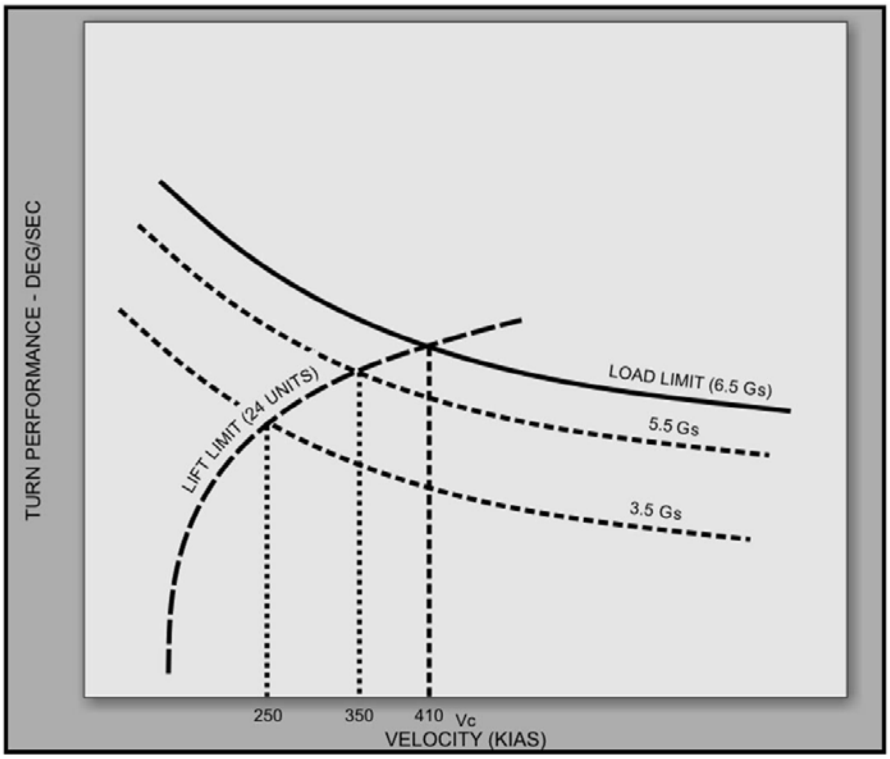

Figure 1-5 G Available

6. **Max Instantaneous Turn Performance**

The best turn performance at any given airspeed is defined by the Lift Limit and Load Limit curves. Above corner, the best turn performance is realized at the G-Limit. Below corner, the best turn rate is realized at the Lift Limit. The maximum instantaneous turn performance is realized at corner, which yields the best turn rate but at the expense of energy. Even though the maximum turn performance for a given airspeed occurs at the Lift Limit, the aircraft will bleed energy because it is operating very near a stalled condition. For that reason, the Lift Limit is considered the point at which the aircraft achieves "max performance." Above corner airspeed, the Lift Limit cannot be reached due to the structural limit of the aircraft; "arcing" (turning wider than optimum) occurs. Unfortunately, due to the lack of leading edge maneuvering devices, the T-45C tends to generate un-commanded wing rock at its Lift Limit, making lift vector control difficult. Due to the instability of the aircraft's roll performance at 24 units, 19-21 units are targeted in order to "Max Perform."

7. **Sustained Turn Performance**

An aircraft cannot maintain a stabilized energy state while operating at its Lift Limit. In fact, as an aircraft continues to "Max Perform," airspeed and turn performance decay as it follows the Lift Limit curve to the left. There are an infinite number of turn performance curves relating to AOA that parallel the Lift Limit curve. Each reduced AOA curve results in a lower turn rate; however, less energy bled during the turn. The turn rate that can be sustained without any energy loss, either in altitude or airspeed, is defined by another set of graphs overlaid on the E-M Diagram. These are called the P_s curves.

Like the AOA and G curves, there are an infinite number of P_s curves. Each curve relates to a specific turn performance and stabilized energy change. The P_s curves are defined by the loss in airspeed (KIAS/second) to maintain the corresponding turn performance; although it is important to note that energy loss can be either in airspeed or altitude. The curve that is of most concern is the $P_s = 0$ curve. The $P_s = 0$ curve yields the best sustained turn performance without any loss of energy.

The $P_s = 0$ curve usually plateaus across a range of airspeeds, and in the case of the T-45, this occurs between 250 and 330 KIAS. The best sustained turn performance for the T-45 occurs at airspeeds in this range. At the upper end of this plateau, at approximately 300 KIAS, the $P_s = 0$ curve intersects the 14 unit AOA curve. Sustained turn performance is approximately one degree per second higher at 250 KIAS than 300 KIAS. However, the ability to perform other tactical maneuvers such as a break turn or vertical maneuver, and retain post maneuver turn performance, requires additional airspeed. 300 to 330 KIAS is targeted to optimize the sustained turn performance. This airspeed range is called the "Rate Band." Figure 1-6 depicts the sustained rate band for the T-45C.

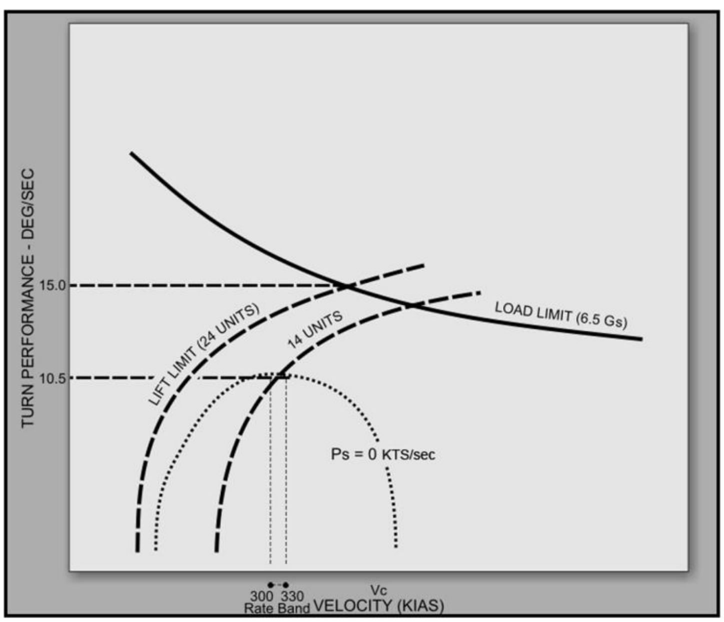

Figure 1-6 Turn Rate Band

The minimum turn radius for any given airspeed occurs along the Lift Limit. The radius curves on the E-M Diagram generally parallel the Lift Limit curve and vary by less than a couple of hundred feet of radius. This is consistent all the way to Corner Airspeed. While it is true that the smallest turn radius occurs between 130 and 150 KIAS, at that airspeed, few other options exist should the need to "Max Perform" occur (i.e. break turn, vertical counter). A "Radius Band" of 150 to 300 KIAS (Figure 1-7) should be targeted. Extending the radius band up to 300 IAS provides a rate benefit as well as the ability to go into the vertical without sacrificing much in terms of radius. No matter the airspeed in that band, "Max Performing" at 19-21 units AOA will yield the smallest turn radius.

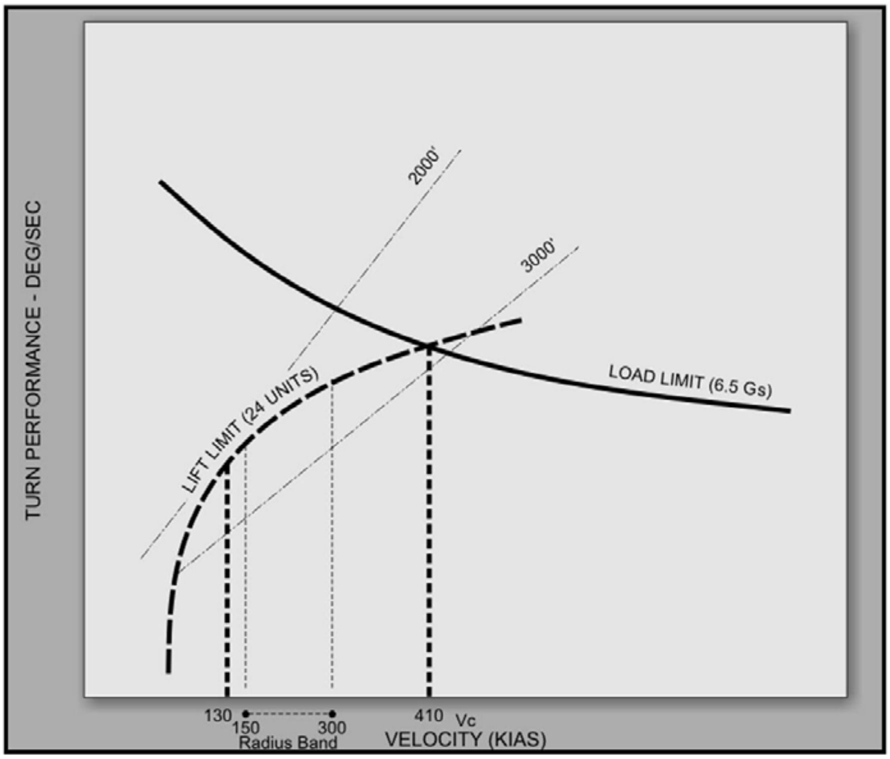

Figure 1-7 Turn Radius Band

Figure 1-8 summarizes the T-45C key performance characteristics. These numbers are derived from the E-M diagram.

Terminology	Performance	Airspeed	AOA
Radius Band	Smallest Turn Radius	150-300 KIAS	19-21 Units
Rate Band	Best Sustained Turn Rate	300-330 KIAS	13-14 Units
Hard Turn	Compromise Performance	N/A	16-18 Units
Break Turn/Max Perform	Max Instantaneous Turn	410 KIAS	19-21 Units
Extension/Unload	Optimum Energy Addition	250 KIAS	5-10 Units
Min Vertical Airspeed	Oblique Vertical	250 KIAS	16-18 Units
Tactical Vertical A/S	Pure Tactical Vertical	300 KIAS	16-18 Units

Figure 1-8 T-45C Performance Table

102. BFM GEOMETRY

The goal of BFM is to arrive in a Weapons Engagement Zone (WEZ) or mitigate the opponent's angular advantage. In order to do this, an understanding of the three dimensional geometry associated with an ACM engagement is necessary.

1. **Range, Angle-off, and Closure Rate (RAC)**

BFM revolves around the management of three spatial relationships: Range, Angles, and Closure.

a. Range – The linear distance between two aircraft, generally stated in thousands of feet or nautical miles. All weapons envelopes are defined in terms of range. Range also determines available maneuvering room relative to an opponent.

b. Angle-off the Tail (AOT) – The angular position off the bandit's tail. Figure 1-9 illustrates different AOTs referencing a target aircraft. AOT is generally a measure of fuselage alignment and is a primary indicator of offensive advantage. Weapons envelopes are also defined in terms of angle-off.

c. Closure (Vc) – The relative change in separation between aircraft, generally measured in knots. Without air-to-air radar to measure closure, the fighter crew must be able to discern changes in range. Closure must be controlled in order to achieve or maintain a positional advantage.

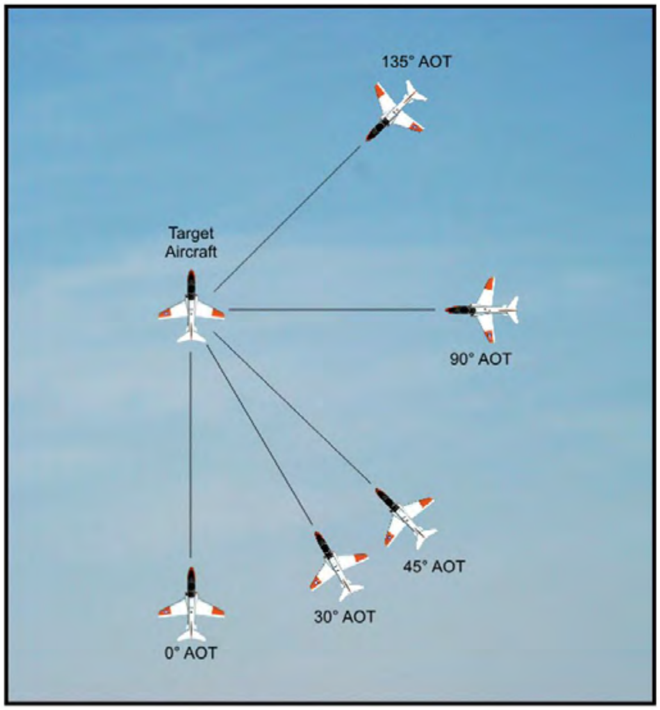

Figure 1-9 T-45C Angle-off the Tail (AOT)

2. **Turn Circle Components**

As an aircraft maneuvers in the ACM arena, there are three basic turn circle components that must be considered: Bubble, Control Zone, and Attack Window (Figure 1-10).

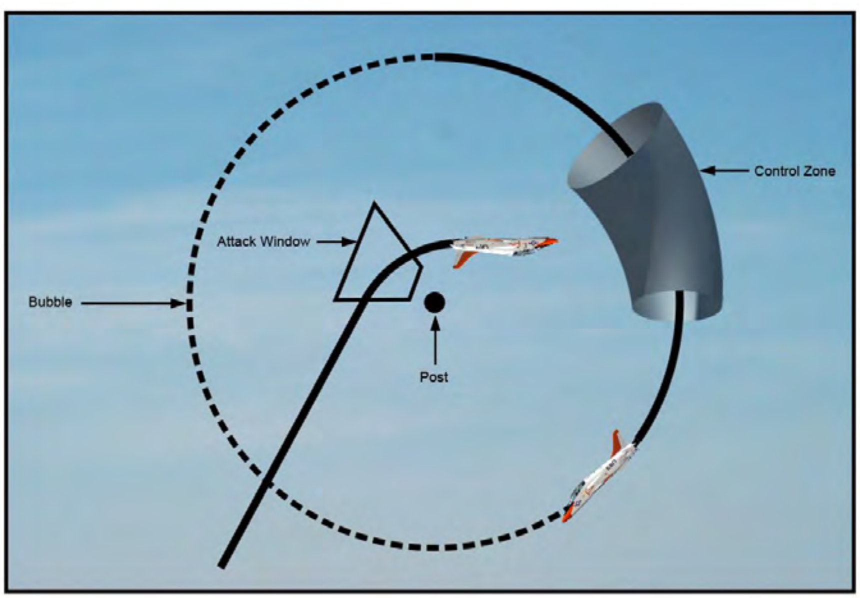

Figure 1-10 Bubble, Control Zone, and Attack Window

3. The Bubble

While an aircraft's "Turn Circle" is the circular path an aircraft scribes through the sky at any given time, "the Bubble" is more correctly defined as the turn circle associated with “Max Performing” the aircraft for any given airspeed. That means the smallest turn radius and greatest turn rate for that airspeed. This is significant because if we are defensive and the opponent is inside our bubble (assuming similar performing aircraft), we cannot deny turning room no matter how hard we pull. Likewise, if the opponent is outside our bubble, we can take angles away from him. Another way to think about it is outside the bubble, we can pull the opponent back towards our nose to a 180 AOT, neutral pass.

So how do we know if the opponent is inside our bubble? Sight picture is the key. If our opponent is outside our bubble, we can take away angles and pull the aircraft forward on our canopy towards our nose. When our opponent stabilizes on our canopy and starts to drift aft during our pull, our opponent has achieved bubble entry. Likewise, if we are offensive and outside our opponent’s bubble, any pull our opponent makes will appear as target aspect change as the opponent denies us angles. As we enter our opponent’s bubble, target aspect change will transition to a line of sight (LOS) change, a sign our opponent can no longer deny us angles. Bubble entry is one of the most important concepts of both offensive and defensive BFM and will be discussed in more detail later.

4. Control Zone

The “Control Zone” is an area in space where we can counter any maneuver a defensive aircraft performs and remain in a controlling, offensive position. This idea assumes similar aircraft with similar energy states. The control zone is roughly one third of a turn diameter in length, centered on the control point, one half of a turn diameter behind the defensive aircraft. For example, for the T-45C with an average turn diameter of 6,000 feet, the control zone extends from roughly 2,000 feet to 4,000 feet behind the defensive aircraft. On the near side, the control zone is roughly 20 degrees either side of flight path extending to 40 degrees either side of flight path on the far side. As the attacker, we strive to arrive in the defender’s control zone; as a defender, we try to deny control zone entry.

5. Attack Window

The “Attack Window” is defined as the point in space where, as the attacker, we will arrive in the defender’s control zone with angles and closure under control if we max perform the aircraft. The attack window is commonly explained as a geographic window in space behind the post. The attack window is actually a line of sight cue that varies based on the angle at which we enter the bubble. From a 40 degrees AOT scenario, the line of sight cue may correspond to a position behind the post. But, if we are entering the bubble from the forward quarter, or elsewhere, the attack window LOS cues may not be as obvious or correspond with the exaggerated offensive scenario of 40 degrees AOT. The intricacies of attack window entry and mechanics timing will be discussed later during the perch scenarios.

6. Maneuvering and Plane of Motion

Plane-of-Motion (POM) can be summarized as the target's track across the sky relative to the horizon. We will define out-of-plane maneuvering as any time our plane-of-motion is greater than 45 degrees above or below our opponent's POM. If we are within 45 degrees of our opponent's POM, we are considered to be in-plane with our opponent. We also reference Out-of-Plane (OOP) Maneuvering relative to the horizon; for example, if we execute an OOP maneuver, it would be a maneuver that is more than 45 degrees nose-high or nose-low (Figure 1-11).

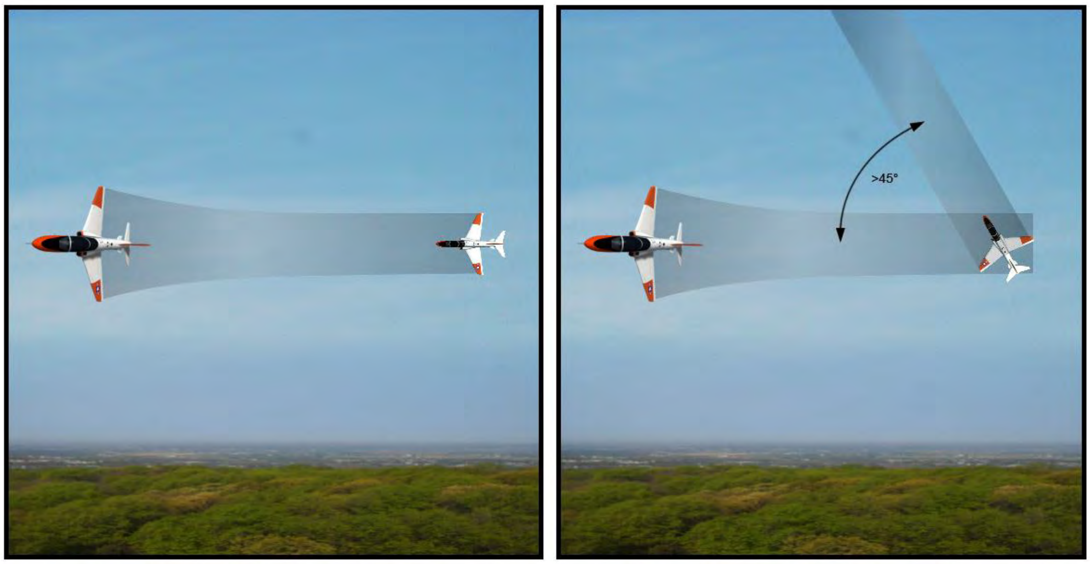

Figure 1-11 In-Plane vs. Out-of-Plane Maneuvering

7. Pursuit Curves

The concept of pursuit geometry between attacker and defender in the BFM environment is basic to every tactical maneuver and is fundamental to the cornerstone maneuvers for the management of the rate-of-closure (RAC) ACM problem. Pursuit curves are technically defined by the orientation of the attacking aircraft's relative velocity vector. If we are In-Plane with our opponent, nose position determines our pursuit curve. If we are Out-of-Plane from our opponent (>45 degree), lift vector placement defines our pursuit curve.

Depending on where your nose/lift vector is pointed, you will fly a distinctive pursuit curve in relation to your opponent (Figure 1-12). The three basic types of pursuit curves are Lead Pursuit, Pure Pursuit, and Lag Pursuit.

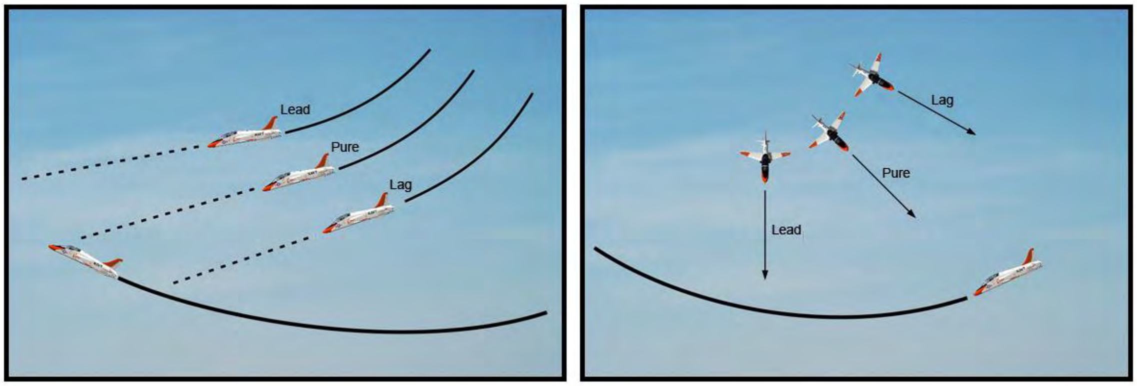

Figure 1-12 In-Plane vs. Out-of-Plane Pursuit Curves

Lead Pursuit occurs when the nose or lift vector is placed in front of the opponent (Figure 1-13, left image). "Lead" is the ICS call and is generally commanded to decrease range and achieve the desired angle for employment of a weapon or to get inside an opponent's bubble. Lead pursuit will:

a. Decrease nose to tail separation (range)

b. Increase AOT

c. Increase closure (V_C)

Pure Pursuit occurs when the nose or lift vector is placed on or at the opponent (Figure 1-13, middle image). Pure pursuit is similar but less extreme than lead; it is most often used to employ a weapon such as a boresight IR missile shot (Fox-2). Assuming the attacker is co-speed and inside the bubble of the defender, pure pursuit will:

a. Decrease nose to tail separation (range)

b. Increase AOT

c. Increase closure (V_C)

Lag Pursuit occurs when the nose or lift vector is pointed behind the opponent (Figure 1-13, right image). Lag is most often used to slow the closure rate or preserve turning room; it may be required due to a failure to properly manage RAC. Lag pursuit will:

a. Increase/maintain range

b. Decrease/maintain AOT

c. Decrease/maintain closure (V_C)

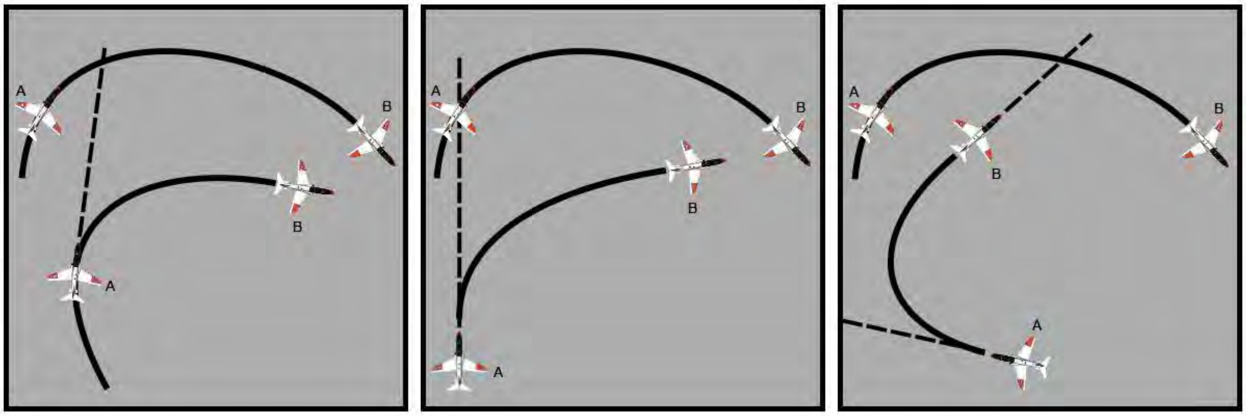

Figure 1-13 Lead Pursuit, Pure Pursuit, and Lag Pursuit

8. Flow

In the BFM arena, there are generally two types of flow: One-Circle and Two-Circle. One of the priorities for training at VT-86 is for the SNFO to quickly recognize the engagement flow and to fight the aircraft accordingly. When proceeding to a high aspect merge, two aircraft can either fly in the same direction or in the opposite direction after the merge. The direction flown relative to each other will determine the flow.

9. One-Circle Flow

After the merge, if both aircraft turn in the same direction, the flow is said to be "One-Circle" because both aircraft are turning around the same relative post to create one circle (Figure 1-14). In a one-circle flow, the two aircraft are fighting nose-to-nose.

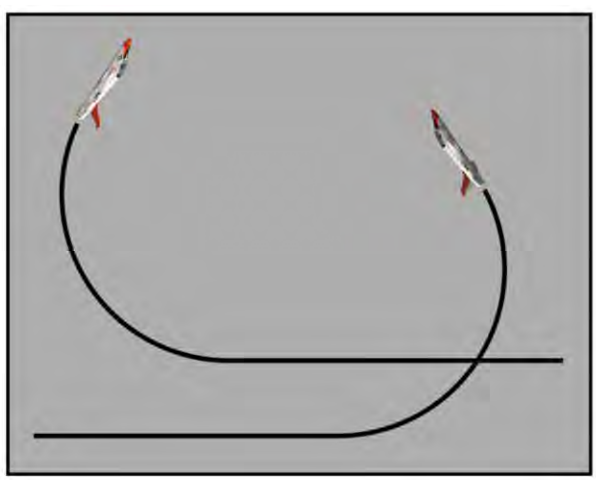

Figure 1-14 One-Circle Flow

In a one-circle fight, the aircraft with the smaller turn radius will develop a positional advantage by turning inside the opponent's turn circle. A one-circle fight is therefore a radius fight, meaning that the aircraft with the smaller turn radius, irrespective of rate, will be nose-on first with the ability to employ a weapon. As discussed earlier in the E-M Diagram section, the smallest turn radius is achieved by "max performing" the aircraft at 19-21 units AOA. If we find ourselves in a one-circle fight, we want to target our radius band of 150 to 300 KIAS.

10. **Two-Circle Flow**

If after a merge both aircraft turn across each other's tail, the flow is said to be "Two-Circle" because each aircraft is turning about different posts, creating two circles (Figure 1-15). In a two-circle engagement, the two aircraft are fighting nose-to-tail.

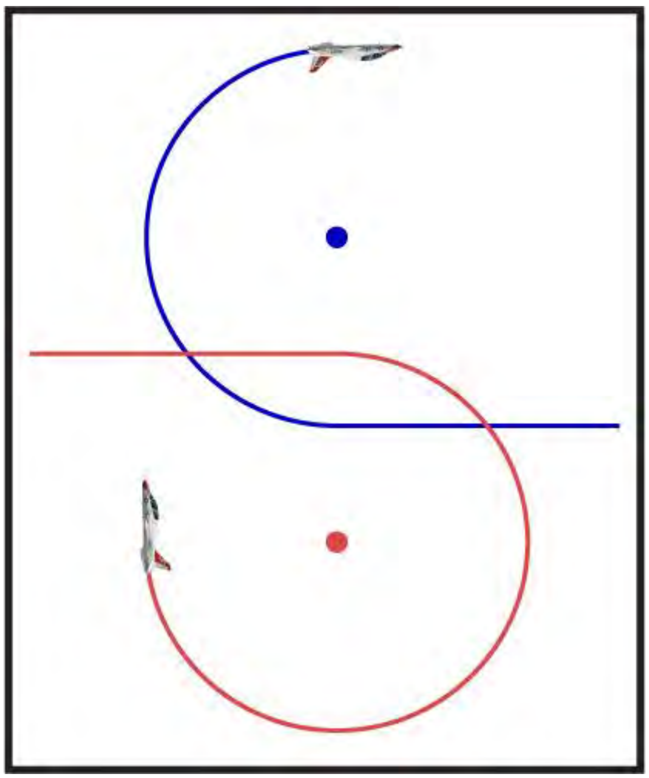

Figure 1-15 Two-Circle Flow

In a two-circle fight, the aircraft with the higher turn rate (degrees per second) will gain the positional advantage. A two-circle fight therefore is a turn rate fight, meaning that the aircraft with the greater turn rate, irrespective of radius, will be nose-on first with the ability to employ a weapon. From the E-M Diagram discussion, we may come to the incorrect conclusion that the best turn rate occurs within our rate band, 300 and 330 KIAS. This is a misnomer. Remember, the greatest achievable turn rate actually occurs at T-45C Corner Airspeed of 410 KIAS. However, it is impossible to max perform at corner while maintaining both altitude and airspeed in a T-45C.

The rate band yields the best sustained turn performance. However, if sustaining energy is not a priority (we need to honor opponent sensor nose or we have altitude to lose), we should max perform the aircraft. For example, in a two-circle fight with altitude to lose, you should perform at 19-21 units, trading altitude for airspeed and turn performance. Continue to max perform (nose-low attitude) until the deck transition. When on the deck, maximum perform until airspeed bleeds to 300 – 330 KIAS. Then, ease the pull to 14 units to maintain the best sustained turn performance on the deck. There are reasons to not trade altitude for turn performance which will be covered later in this chapter.

11. **Out-of-plane Maneuvering and Flow**

Out-of-plane (OOP) maneuvering is defined as any maneuvering in which our plane-of-motion is greater than 45 degrees above or below the horizon. While not generally considered a type of flow in itself, OOP maneuvering is often included in the flow discussion because with proper lift vector placement, it can often force a specific type of flow. For example, by initiating an OOP maneuver and putting the lift vector into lead pursuit, we can change two-circle flow into one-circle flow.

In addition to forcing a desired flow, OOP maneuvering provides the added benefit of buying a delayed reaction from our opponent. If un-countered, OOP also allows the ability to cut across the circle and gain or take away angles from our opponent. As a general rule we would like to initiate OOP maneuvering. If our opponent initiates OOP, we must counter with a more aggressive out-of-plane maneuver.

12. **RAC Management**

As discussed earlier, BFM is an exercise in the management of the range, angles and closure (RAC) between us and the opponent. To manage RAC, we have several tools, some of which will be more effective than others. In the following discussion, we will define tools that have been utilized since the dawn of aerial combat. In today's ACM arena, several of the methods have become outdated with advanced missile technology. However, we will still define those methods, describe why they are no longer desirable or effective, and detail how to exploit those methods as BFM errors. Finally, we will outline the possible consequences of not managing RAC and subsequent maneuvering scenarios.

13. **High Yo-Yo**

A High Yo-Yo is an offensive lag pursuit maneuver originally designed to prevent an overshoot by controlling excessive closure and preserving range. It is an out-of-plane maneuver intended to control excessive down range travel so the fighter does not overshoot the opponent’s flight path. As a fighter sees an overshoot developing, the fighter executes a quarter roll away and raises the nose to slow the closure on the defender’s flight path. The OOP maneuvering will place the nose of the fighter above the plane of attack and exchange airspeed for altitude. The combination of the OOP maneuvering and the slower airspeed will allow the fighter to turn with a smaller radius while aligning fuselages. The fighter’s slower airspeed will also reduce the closure rate allowing him to maintain or increase range. The severity of the pull up and final nose position is dictated by the rate of closure (Figure 1-16).

Although the maneuver will avoid an overshoot and keep the attacker inside of the turn, this is an outdated tactic used before modern missiles; there are significant disadvantages today. The High Yo-Yo has the adverse effect of taking pressure off of the opponent and increasing time-to-kill. In addition, by maneuvering nose-high OOP, we decelerate out of the rate band during a two-circle fight. A better alternative is to maintain rate numbers, accept the flight path overshoot and allow the concept of misaligned turn circles to work for the attacker. This will bring the attacker much more quickly into a rear quarter IR missile WEZ.

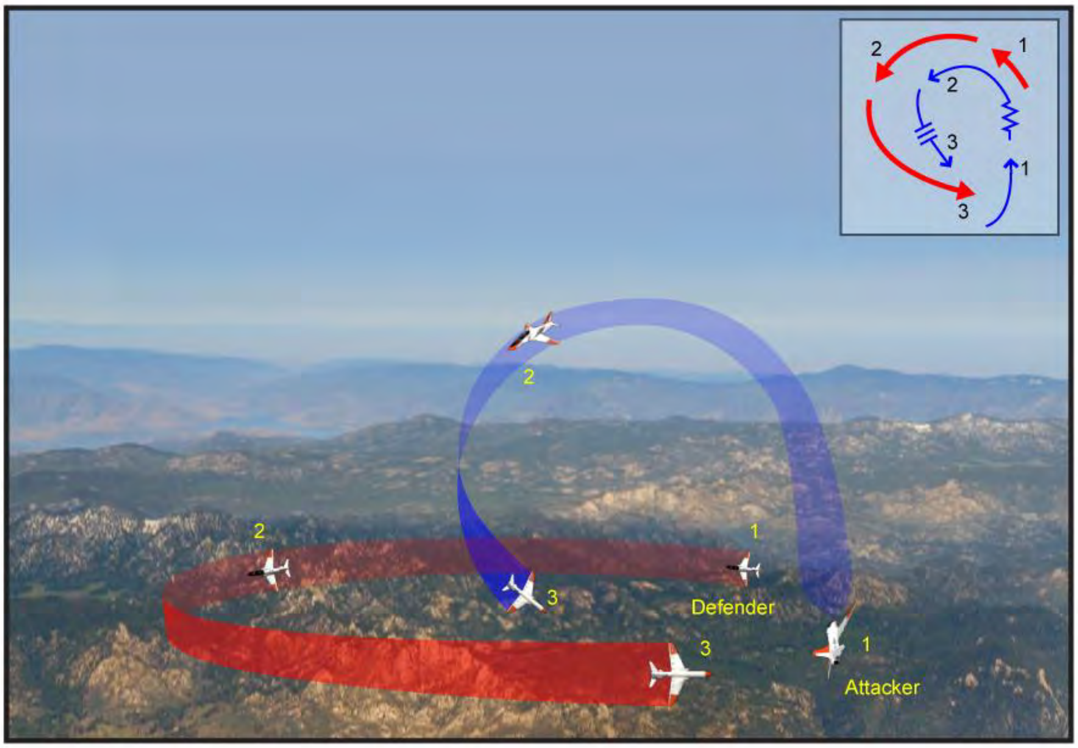

Figure 1-16 High Yo-Yo

As a defender, if the attacker mismanages RAC and executes a High Yo-Yo, we need to recognize the mistake. By taking lift vector off, the opponent has taken sensor nose pressure off and allowed the defender to regain precious energy. The defender will unload and get back as much energy as possible before the attacker puts the pressure back on through the use of the required follow-on Low Yo-Yo.

14. **Low Yo-Yo**

The Low Yo-Yo is a lead pursuit maneuver originally designed to decrease range by increasing closure rate when the attacker is trapped in lag. A Low Yo-Yo is usually employed when the attacker is in a low closure or low angle-off situation as may be found after the execution of a High Yo-Yo. A Low Yo-Yo is accomplished by flying inside the bandit's turn while descending below the bandit's plane of motion (Figure 1-17). As such, depending on the degree of the nose-low maneuver, it is generally characterized as an OOP nose-low maneuver.

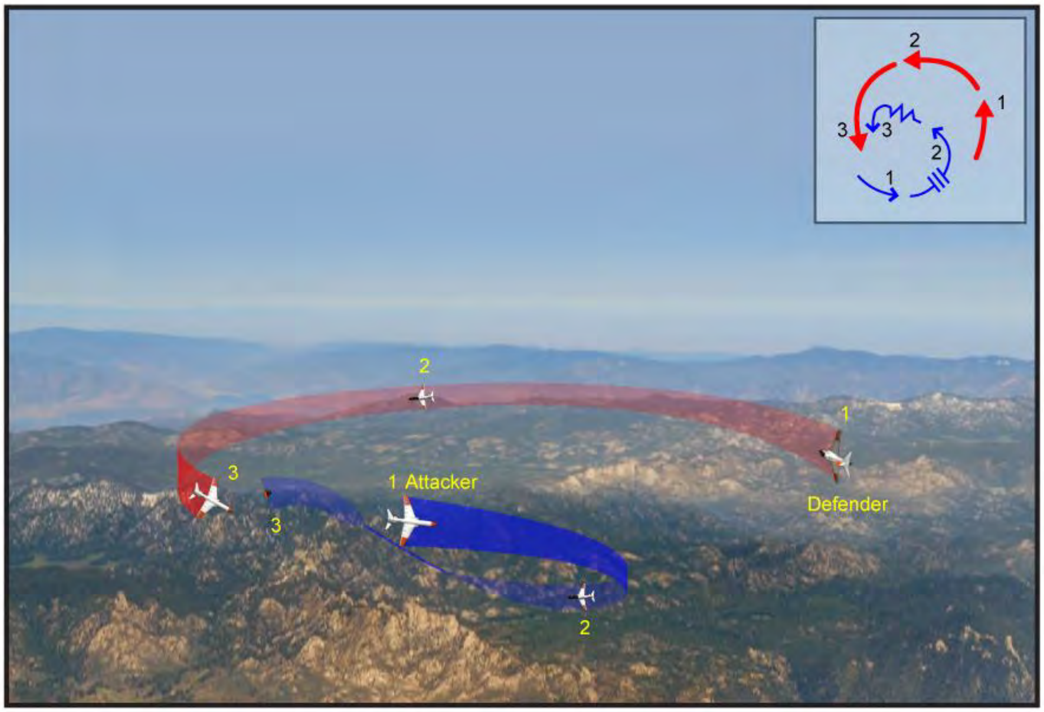

Figure 1-17 Low Yo-Yo

Like the High Yo-Yo, the Low Yo-Yo is an outdated tactic that has little application in the world of modern ACM. One of the attacking aircraft's primary concerns is the preservation of separation (or RAC) between aircraft. Lateral separation is preserved through the use of in-plane, two-circle flow. A nose-low OOP maneuver like the Low Yo-Yo will actually reduce the separation between aircraft in the attempt to align fuselages. Additionally, if the attacker initiates a nose-low maneuver, the defender may do likewise. This will further collapse the fight and take away the separation the attacker wishes to preserve. Separation, in modern ACM, is desirable for weapon employment.

As a defender, if the attacker executes a Low Yo-Yo, we need to recognize the mistake. The defender should match the attacker nose-low and match the pull to generate as much closure as possible to collapse the range between aircraft. Collapsing the fight may seem counterintuitive to a defender, but this tactic is analogous to two boxers, one of which has a significant reach advantage. The smaller boxer would want to stay inside the larger boxer's reach, reducing the likelihood of a knockout punch.

This is not to say that there is never a time for a Low Yo-Yo. If poor Offensive BFM results in the attacker trapped in lag pursuit on the opponent's turn circle and outside of the rate band, the only option may be a Low Yo-Yo. If it is not countered, the Low Yo-Yo may work; but a savvy opponent will counter the maneuver nose-low and make the attacker pay for the mistake. In general, nose position greater than 10 degrees nose-low during a Low Yo-Yo should be avoided.

15. **Displacement Roll**

Like the High Yo-Yo, a displacement roll is a maneuver designed to reduce angle-off, reduce closure rate or displace the aircraft into a "lag pursuit" position. Normally, the displacement roll begins with an attempt to align fuselages on the inside of the defender's turn. The nose is then pulled up and the aircraft is rolled opposite the direction of the defender's turn (Figure 1-18). The roll rate and amount of vertical displacement used will depend on the amount of nose-to-tail separation that is desired.

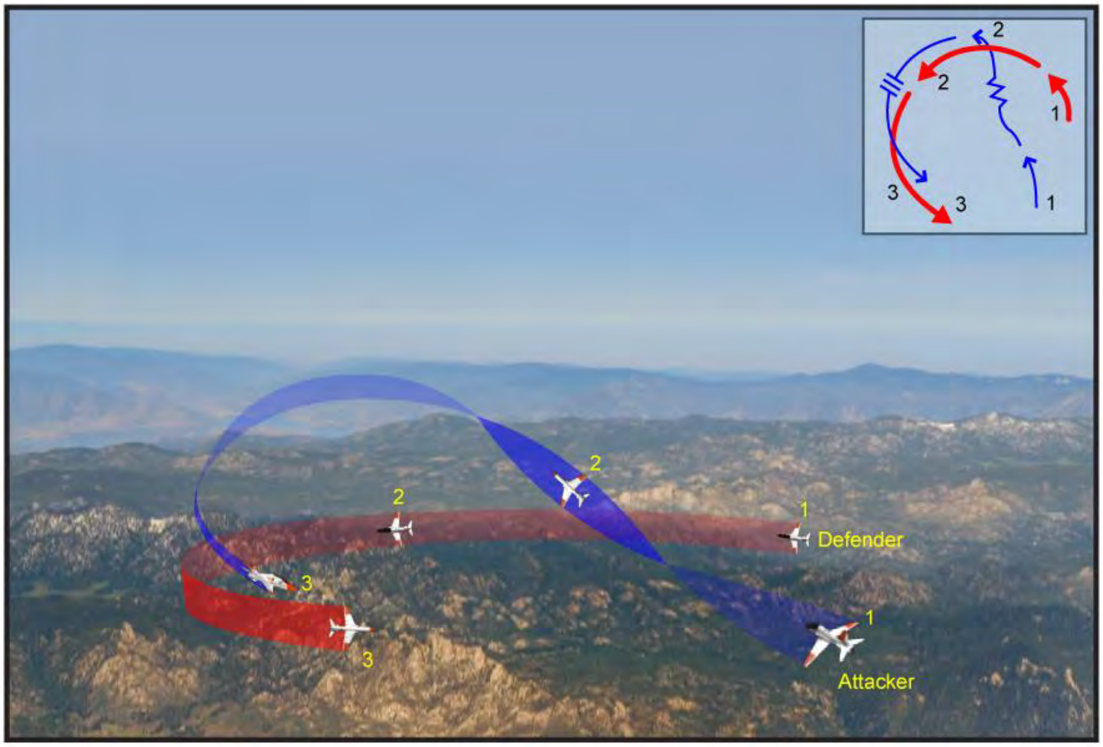

Figure 1-18 Displacement Roll

Like the High Yo-Yo, the Displacement Roll takes the pressure off the defender thus allowing the defender to regain energy. For that reason it is not the preferred method for managing RAC. However, the displacement roll can be useful as a last ditch attempt to avoid an in-close overshoot and possible role-reversal.

16. **Overshoots**

The consequences of poor RAC management are excessive closure, decreasing range and increasing AOT. Each of these can result in an overshoot. The two basic types of overshoots are the 3/9 overshoot and the flight path overshoot. A third overshoot, the in-close overshoot, is actually a severe flight path overshoot.

17. **3/9 Line Overshoot**

The 3/9 line is the line drawn through the wings of an aircraft. A 3/9 line overshoot occurs when an attacker flies from an aft position to a position forward of the defender's 3/9 line. This is called "flying out in front" and results in a role reversal (Figure 1-19).

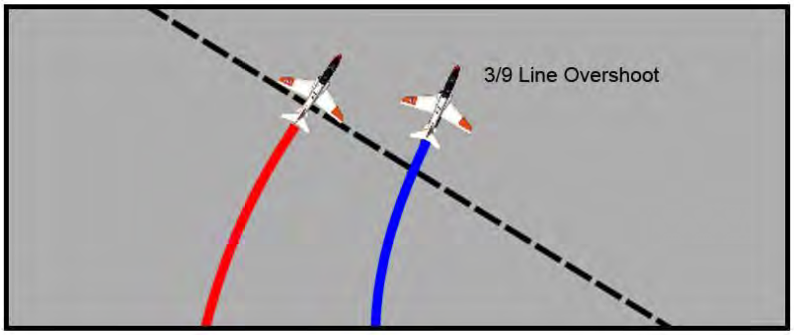

Figure 1-19 3/9 Line Overshoot

18. **Flight Path Overshoot**

A flight path overshoot occurs when the attacker flies through the defender's flight path (the defender's extended 6 o'clock). Figure 1-20 illustrates a flight path overshoot. In this case, a role reversal is not guaranteed and the defender should closely evaluate whether the overshoot meets the three criteria that warrant a reversal:

a. In-Close - inside the control zone (< 2,000')

b. High Angle-off - target aspect > 60 degrees

c. High Track-Crossing Rate/Closure - defender must mentally project whether a reversal will cause a 3/9 overshoot by attacker

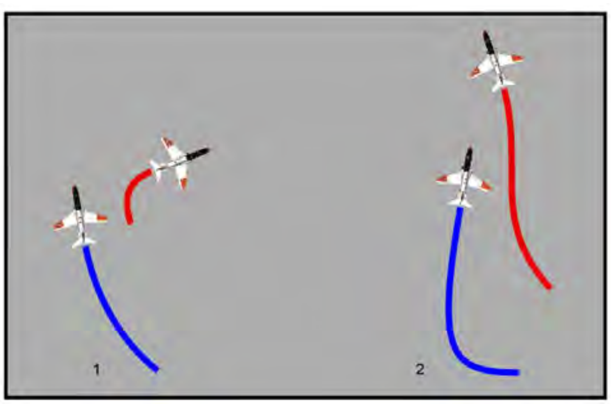

Figure 1-20 Flight Path Overshoot

19. **In-Close Overshoot**

An in-close overshoot occurs when the attacker crosses the defender's flight path inside the defender's control zone. In-close overshoots are significant because an instantaneous reversal by the defender could result in a 3/9 line overshoot and a role reversal (Figure 1-21). However, before reversing, the defender should determine if the in-close overshoot meets the reversal criteria mentioned above.

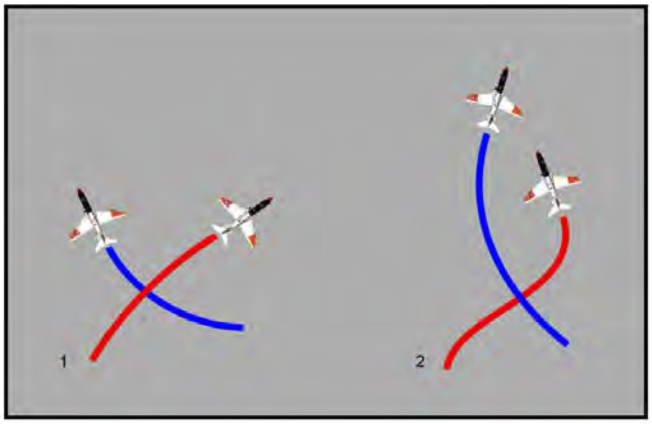

Figure 1-21 In-Close Overshoot, Reverse for Roll Reversal

If any one of three reversal criteria is not met, do not reverse. Instead, continue in the present direction of turn, increase survival time and wait for your Wingman to shoot the bandit. If all three reversal criteria are met, reversal timing is critical. The axiom, "No earlier than lag, no later than line of sight rate" applies. Start the reversal no earlier than when the opponent's nose/lift vector begins falling aft and no later than when the opponent is crossing the extended six o'clock. This is a large window and the exact timing depends on the opponent's track crossing rate. With a low track crossing rate, the reversal is delayed until the opponent crosses our six. With high track crossing rate, the reversal can be executed sooner (Figure 1-22).

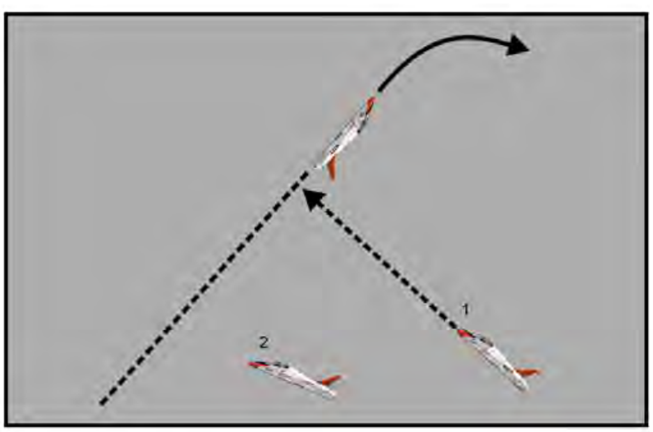

Figure 1-22 Reversal Timing

20. **Scissors Maneuvering**

The consequences of poor RAC management and the subsequent overshoot often result in one of two types of slow-speed maneuvering:

a. Flat Scissors

b. Rolling Scissors

In any scissors maneuvering (Flat or Rolling), the key element to obtaining a positional advantage is to stop down range travel, primarily through the use of lift vector placement in lag.

21. **Flat (Horizontal) Scissors**

The Flat Scissors is a series of nose-to-nose (One-Circle) turns and horizontal overshoots performed by two aircraft in the same maneuver plane. Flat scissors generally result from an overshoot. In a Flat Scissors, each aircraft attempts to get behind the other for positional advantage (Figure 1-23).

While all Flat Scissors are one-circle radius fights, not all one-circle fights are Flat Scissors. The Flat Scissors is a slow speed, high AOA fight in which both fighters are attempting to decrease down range travel more efficiently than the opponent by continuously crossing each other's flight paths in a series of weaves. The aircraft that can reduce its forward velocity component more than the opponent will gain a positional advantage. This can be achieved in several ways:

a. Max performing the aircraft in radius

b. Flying the aircraft slower

c. Out-of-plane maneuvering

d. Lift vector placement in lag of the opponent

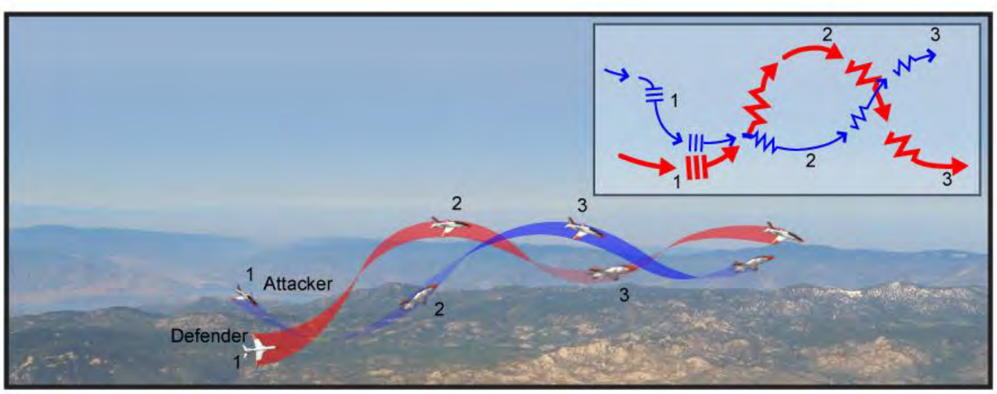

Figure 1-23 Flat Scissors

Disengaging from a Flat Scissors is difficult. Because both aircraft are generally operating at slow speeds in close proximity, the opportunity to achieve valid escape ("Bug Out") criteria is usually nonexistent. A good rule of thumb is to never transition from a slow fight to a fast fight.

22. **Rolling (Vertical) Scissors**

Like the Flat Scissors, the Rolling Scissors is the result of an overshoot. However, while a Flat Scissors is the result of a horizontal overshoot, a Rolling Scissors is generally the result of a vertical overshoot in which one aircraft breaks the other's altitude. A developed Rolling Scissors will consist of a series of horizontal and vertical overshoots (Figure 1-24). Though it appears like the Rolling Scissors is two-circle flow, a neutral Roller is actually one-circle flow. This is better witnessed from a God's-eye view where the aircraft can be observed turning nose to nose with one aircraft nose-high and the other nose-low. Only after one aircraft obtains a slight positional advantage and begins to align fuselages does the Roller become two-circle. Normally, at that time, it has transitioned more to a looping fight rather than a Roller. Like the Flat (Horizontal) Scissors, positional advantage in a roller is achieved by reducing down range travel relative to the bandit. In a roller, this is accomplished by using vertical maneuvering with proper energy and lift vector control.

A key determinant in winning the roller is the ability to get the nose up when at the bottom of a roller before the opponent can get nose down at the top, and vice versa (utilizing the tactical egg to an advantage). Oppose the Nose is the rule to live by in a Rolling Scissors. Any time the opponent is nose-high on the "front" side of the roller and we have not transitioned to nose-low on the "back" side, the opponent is gaining angles and an offensive advantage. Likewise, if we are at the bottom of the Roller and cannot (or do not) transition to nose-high when the opponent has transitioned to nose-low, the opponent is gaining an angular advantage.

The old saying used to be "lag at the bottom and lead over the top." This is misleading because it mostly refers to stick and rudder skills rather than a geometric analysis of how to win a Rolling Scissors. What we are really trying to do, after establishing the highest reasonable nose attitude, is to get the nose down before the bandit gets the nose up (a.k.a. "Lead him/her"). At that point, "Lag" the opponent down the back side to gain turning room and 3/9 advantage. This ensures the opponent travels further down range, resulting in a positional advantage. In essence, try to early turn the bandit over the top and pull down to then place the lift vector towards the opponent's control zone (lag; about 1,500 feet behind opponent).

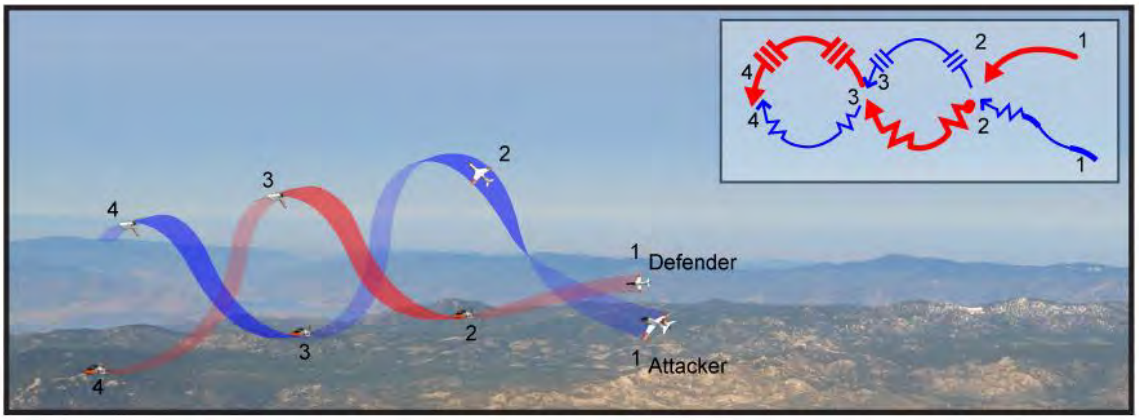

Figure 1-24 Rolling Scissors

Proper lift vector control in a Rolling Scissors generally consists of lag pursuit. Throughout slow speed portions of the Roller, particularly over the top, it is very tempting to pull lead either to align fuselages or pull for a shot. Because each aircraft is typically inside the other's bubble, lead pursuit generally leads to increasing down range travel and flushing out in front. There are generally only two times to pull lead in a Rolling Scissors:

a. Pull lead to get inside the bubble when offensive and outside the opponent's bubble

b. Pull lead when pulling for a shot nose-high

Generally, it is only desirable to pull lead going nose-high because with a nose-high overshoot, the opponent typically cannot reverse and take advantage of it. When nose-low, the lift vector should be kept in lag to counteract the larger turn radius generated by increasing airspeed and decreasing radial G.

In general, each aircraft will feel offensive at the top of a roller and defensive on the bottom. This may be an optical illusion due to the effects of radial G and the tactical egg. If most of the time the opponent is in the forward part of the canopy, the fighter is offensive and vice versa. Because most fighter aircraft do not have a 1:1 thrust-to-weight ratio that can overcome the bleed rates associated with BFM maneuvering, the Rolling Scissors tends to degenerate in altitude. At some point, one of the aircraft will be unable to roll due to proximity of the hard deck. This will result in a level reversal, transitioning the fight into a Flat Scissors. The first aircraft to go flat is generally at a disadvantage and usually ends up defensive. For that reason, proper energy management and lift vector placement are essential to fly an efficient Roller so as not to transition first.

103. WEAPONS EMPLOYMENT

The primary BFM weapons are the IR missile and the gun. Figure 1-25 depicts the CNATRA weapon envelopes for use in employing simulated weapons during BFM training.

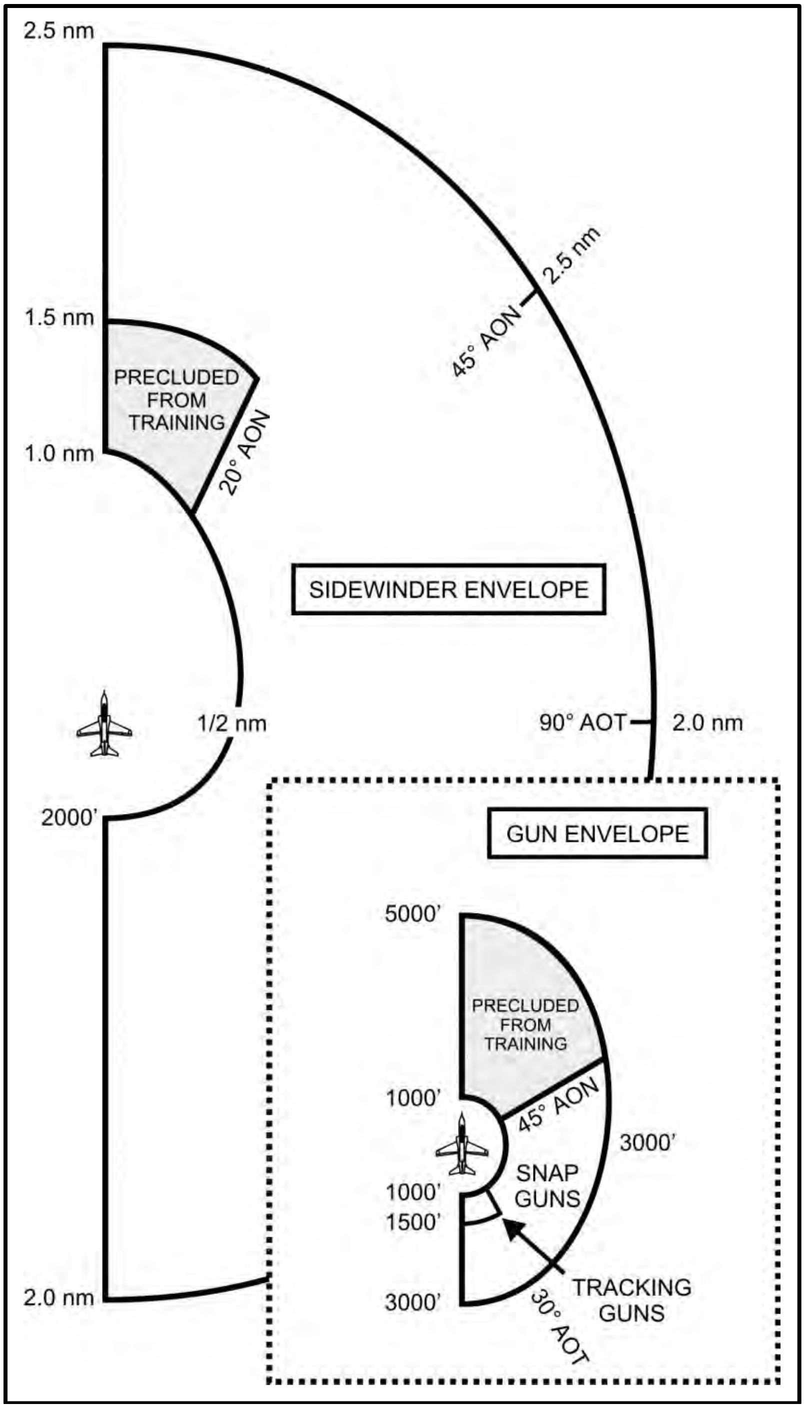

Figure 1-25 CNATRA Weapon Envelopes

1. Valid Shot Requirements

We cannot just pull the trigger and consider the shot to be successful. Certain parameters must be met in order for the missile to track to the target or have bullets actually hit and inflict damage on the enemy aircraft. Listed below are the requirements that must be met to consider it a valid shot.

a. IR Missile:

i. Shooter within CNATRA Sidewinder Envelope

ii. Target in the HUD Field of View (FOV)

iii. Wingman must not be in HUD FOV (shot de-confliction).

iv. ***Pull the trigger (when steps 1, 2, and 3 met)***.

b. Gun Snap Envelope:

i. Shooter within snap gun envelope.

ii Pull trigger early (>1 sec. prior) to establish bullets downrange at target

iii. Target must pass through pipper.

iv. Two valid Snapshots (Snaps) equal a kill.

c. Gun Tracking Envelope:

i. Shooter within tracking gun envelope.

ii. Pull trigger with pipper on target.

iii. One second of cumulative tracking time equals a kill.

Although not required for a valid kill, for training we must call our shots. The called shot must be appropriate for the weapon/envelope being employed after a valid shot has been taken:

d. IR missile shot - "(fighter call sign)…Fox-2."

e. Snap gun - "Trigger down, snap (assessment), (missed high/missed low/looked good)."

f. Tracking gun - "Pipper's on, tracking…pipper's off."

2. **Bug Validation**

If the target is wings level, tail-on (i.e., running away), utilize the rules of 3 to evaluate a valid "bug out":

a. Greater than 250 KTS opening at 0.5 NM separation

b. Greater than 200 KTS opening at 1.0 NM separation

c. Greater than 150 KTS opening at 1.5 NM separation

d. Greater than 100 KTS opening at 2.0 NM separation

3. **Air-to-Air Gun**

Although the gun is a true all-aspect weapon, in the interest of safety, its employment in the training environment is limited by training rules as well as the CNATRA gun envelope depicted in Figure 1-25.

The air-to-air gunnery problem is a difficult one; it involves hitting a moving target from a moving platform with projectiles that follow curved paths at varying speeds. The Probability of Kill (P_k) of the gun is primarily a function of two factors: bullet velocity and bullet density at target range. Bullet velocity at impact is affected by target range and closure; while bullet density is a function of target range (in the form of bullet pattern dispersal), track crossing rate and employment parameters of the shooting aircraft. Because of this, not all quadrants of the Gun Employment Envelope will achieve the same P_k. In fact, the quadrant that provides the highest P_k is actually precluded by training rules and CNATRA: forward quarter gun employment.

The next most lethal sector would be the tracking region from 0 degrees to 30 degrees AOT, within 1,500 feet. This region has very little track crossing rate and requires minimal lead or maneuvering from the shooter, providing a high bullet density. The decreased range provides the bullet with adequate kinetic energy. Snapshots taken from the beam (30 degrees to 150 degrees AOT) are less lethal due to the high track crossing rates. These rates require higher lead requirements, resulting in much lower bullet densities at target range.

4. **Air-to-Air Gun Employment**

To effectively employ the gun against a moving target in the air-to-air arena the shooter must solve for "The Big Three" basic parameters:

a. Plane of Motion (POM) – This is the target's track across the sky relative to the shooting aircraft. The RTGS pipper in the HUD is calculated by T-45C GINA; it shows where a bullet will be after one second TOF. If the pipper track can be lined up with the target's POM track, a successful gun-shot can be made as long as range and lead are also solved.

b. Range – This is the linear distance from the gun to the target. As an aid for solving range, set 31' (T-45C wingspan) into the A/A stores page. This provides a 31 mil diameter pipper in the HUD FOV (1 mil = 1' at 1,000' slant range). If the target is wingtip-to-wingtip inside the reticle, the target is at approximately 1,000 feet in range.

c. Lead – If a target is moving, the Gun Bore Line must be ahead of the target for a bullet to hit it. In air-to-air gunnery, the nose of the attacking aircraft must be in front of the target's flight path (lead pursuit) when firing; otherwise, the bullet will travel down range but behind the target. The lead must be sufficient for the bullet and the target to arrive at the same location, at the same time.

5. **Guns Defense (Guns 'D')**

Defending against a gun attack is an important concept in BFM. As an attacker attempts to solve for POM, Range, and Lead, the defender attempts to disrupt that effort. Pulling harder may increase the lead required, resulting in a miss with bullets late to target range. However, if all three parameters are solved, the Guns Defense is the only option for the defender. The Guns 'D' is designed to defeat POM. For a successful Guns 'D', two distinct actions must be accomplished. The first is to put the wingtip on the attacker which will present as small a target as possible. Once the wingtip is on, a pull out of the attacker's plane-of-motion is required. The Guns 'D' can be performed nose-high, nose-low or with a wings level bunt.

a. Nose-high – There are several reasons why we might want to initiate a "Nose-high" Guns 'D'. Perhaps we are on the deck with no ability to go nose-low, or maybe we do not want to initiate a slow speed, nose-low maneuver that would be extremely easy for an opponent to follow. In addition, if our opponent was coming from high-to-low, a nose-high maneuver would be extremely difficult to follow. However, for the most part, nose-high maneuvers are not difficult to follow and allow the attacker to pull lead pursuit. In addition, the reduction in radial G due to the effects of gravity provide for less displacement away from our original plane-of-motion and our attacker's solution.

b. Nose-low – There are several reasons why we might want to initiate a defense "Nose-low." A nose-low maneuver has the combined effect of increasing radial G and displacement; gravity helps maintain kinetic energy (Figure 1-26). However, a slow-speed, nose-low maneuver will be fairly easy for an attacker to follow. If the attacker is coming from low-to-high, maneuvering opposite the plane-of-motion could be advantageous. However, maintaining sight in a nose-low Guns 'D' is difficult and makes follow-on BFM problematic.

c. Wings Level Bunt – The wings level bunt, either upright or inverted, is another option once the wingtip is on the attacker. The bunt is normally accomplished by reducing positive AOA or establishing negative AOA to displace the aircraft opposite the lift vector. While it is an option, it is not necessarily recommended as it relies mainly on deception. Our performance under negative G is much less effective and therefore provides much less displacement from POM.

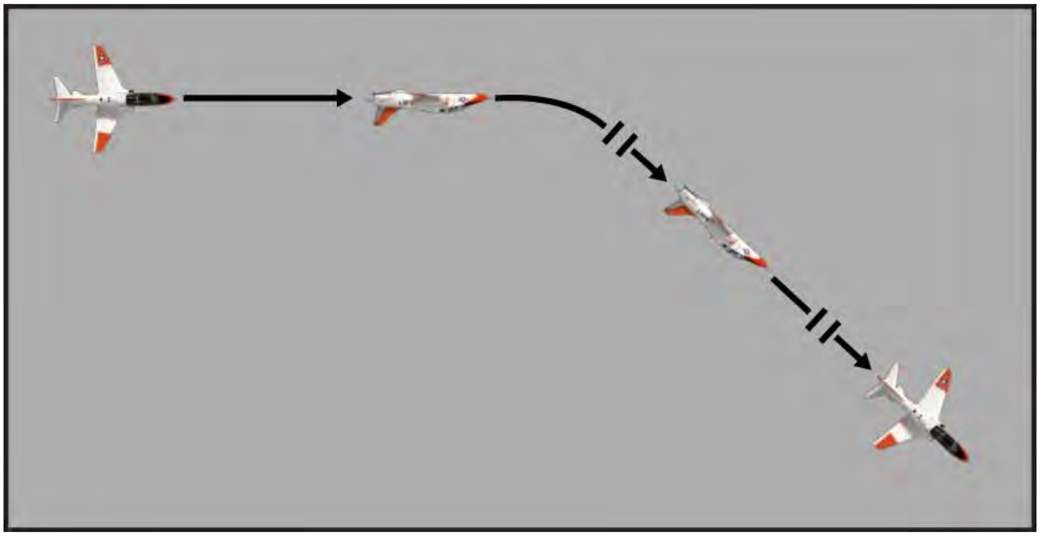

Figure 1-26 Wingtip On, Guns 'D' Low

104. OFFENSIVE/DEFENSIVE BFM

Offensive and defensive BFM principles provide the foundation of air combat maneuvering. Regardless of the degree to which you are offensive or defensive in an engagement, the overarching goals remain the same:

Offensive Goals:

1. Preserve lateral separation/turning room (Control RAC)
2. Pressure the defender
3. Maneuver to arrive in the control zone
4. Employ weapons

Defensive Goals:

1. Deny weapons employment opportunities
2. Collapse the fight, denying angles/turning room
3. Create fuselage misalignment
4. Separate/Neutralize/Kill

Specifically, for defensive BFM, there are four axioms that support the defensive goals:

1. Maneuver to Survive: Recognition of "sensor nose" and responding with break turns or Guns 'D' as appropriate.

2. Attacker outside the Bubble: Pull Attacker as Far Forward as Possible

    a. Sensor nose-on = break turn (19-21 units)

    b. Sensor nose-off = hard turn (17 units)

3. Attacker Inside the Bubble: Decrease in Target Aspect = Increase in pull - and vice versa.

4. Sensor nose-on and Cannot Pull Forward of 3/9 Line = Redefinition/Ditch

1. **Offensive/Defensive Perch BFM**

VT-86 uses a "building block" approach to learning BFM, starting with offensive and defensive perch sets. The perch sets begin with an attacker 40 degrees AOT of a defender. 40 degrees AOT is used because the visual sight cues are exaggerated and bubble entry generally occurs through the use of pure pursuit. The perch sight picture is a great vantage point for SNFOs to see what is happening and react accordingly. The standard perch sets utilized in the VT-86 syllabus are the 9K', 6K' and 3K' sets at 40 degrees AOT. The following discussions will focus on the training objectives from both the offensive and defensive perspectives.

2. **9,000 Feet (9K') Perch Set Offensive**

The attacker begins the 9K' set Outside the Bubble; the offensive objectives are:

a. Bubble entry

b. Attack Window Entry Mechanics (Mech)

c. Rate war/misaligned turn circles

d. Second Bubble entry

3. **Bubble Entry**

The attacker begins outside the defender's bubble. As discussed earlier, the first goal (Offensive Goal #1) of the attacker is to maintain or preserve turning room. As long as the attacker is outside the defender's bubble, the defender can take away angles and turning room. The first priority for the attacker is to penetrate the defender's bubble as quickly as possible (Figure 1-27). Simple geometry tells us that the shortest distance to bubble entry is realized by flying directly to the post. Depending on the quadrant of entry, one of the three pursuit curves will yield the most direct path to the post: lead, pure, lag. For the purposes of a 40 degrees AOT scenario, pure pursuit will generally be towards the post.

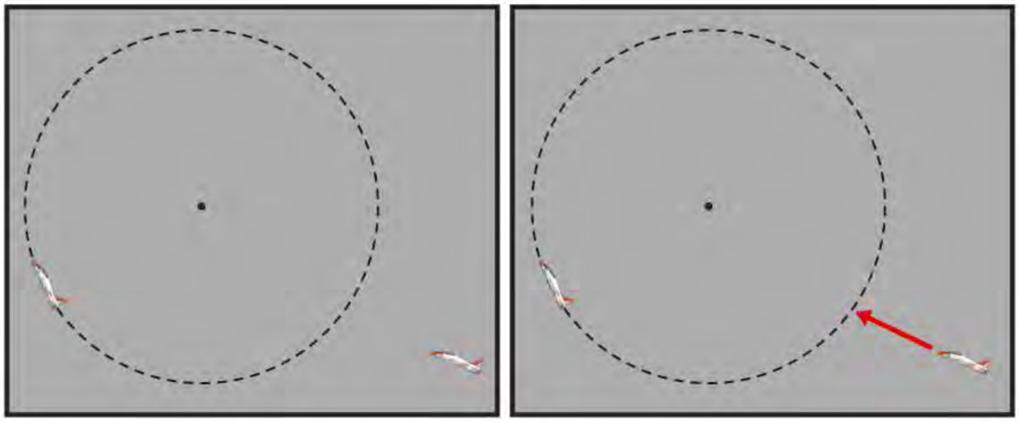

Figure 1-27 9K' Set Outside Bubble/Pure Pursuit for Bubble Entry

4. **Attack-Window-Entry-Mech**

Once we have achieved bubble entry (target aspect change switches to line of sight change), work toward lag until we see our Attack Window Entry cues (line of sight rate starts to explode). At that point we will initiate the Attack Window Entry Mech (Figure 1-28): place the defender one fist above the canopy bow and maintain the pull required to hold them there, up to max perform (19-21 units). Continue to pull as required until we can no longer hold that sight picture without bleeding below the rate band (300 to 330 KIAS).

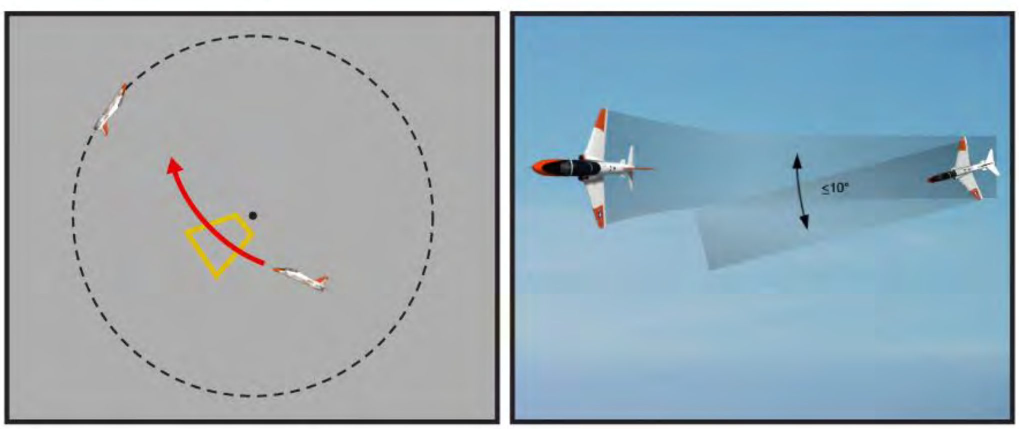

Figure 1-28 9K' Attack Window Entry Mech

5. **Misaligned Turn Circles**

We do not want to lower our nose more than 10 degrees because if our opponent counters nose-low, the fight collapses, violating Offensive Goal #1: preserve turning room. Additionally, we will accept the flight path overshoot as long as it does not meet the criteria of an in-close overshoot. Should we try and execute a High Yo-Yo, we take the pressure off our opponent, violating Offensive Goal #2, and allowing the opponent to get energy back. If we are patient and remain in the rate band, “misaligned turn circles” (Figure 1-29) will work over time, and we will arrive nose-on again in a follow-on missile WEZ and second bubble entry.

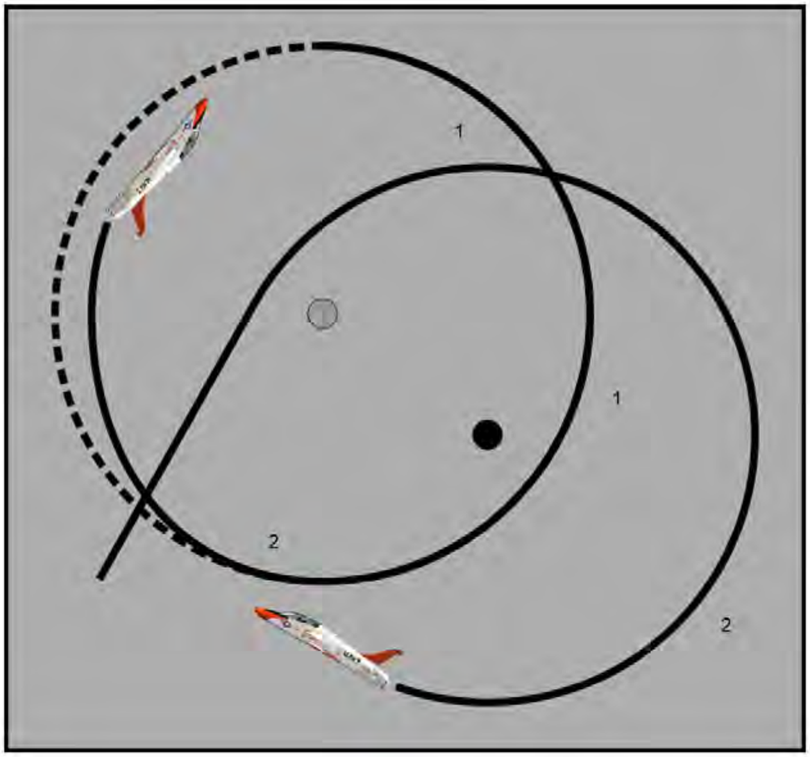

Figure 1-29 9K’ Set Misaligned Turn Circles

6. **9,000 Feet Perch Set Defensive**

From the defensive perspective, aircrews need to remember the defensive goals and follow the four defensive axioms previously listed. The 9K’ set begins with attacker outside the bubble and has the following objectives:

a. Break turn

b. Bubble entry

c. Misaligned turn circles/rate war

d. Bug

e. Second Bubble entry

7. **Break Turn**

At the start of the set, the attacker is nose-on, outside the bubble. The first axiom applies: maneuver to survive. Any time our opponent is sensor nose-on, we execute a level (no more than 10 degree nose-low), break turn at idle with flares to deny the IR missile shot (Figure 1-30). This has the added benefit of taking away angles as long as the opponent is outside the bubble (Axiom #2). We execute the break turn level because an in-plane pull with the attacker outside the bubble denies the greatest amount of angles. Any out-of-plane maneuver we execute with the opponent outside the bubble just preserves turning room for the opponent (violation of Defensive Goal #2).

Figure 1-30 Defensive Break Turn with Flares

8. **Bubble Entry**

Once the attacker has achieved bubble entry, we must evaluate the attacker's intentions. If the attacker remains sensor nose-on, we must continue to defend. If the attacker correctly falls into lag, we will ease the pull to gain back some of the energy lost during the break turn (Figure 1-31). A common mistake at this point is for the defender to lower the nose to regain airspeed. As the defender, we do not want to lower the nose more than 10 degrees below the horizon for two reasons:

a. We need to preserve altitude in the case we meet redefinition/ditch criteria.

b. We are evaluating the BFM prowess of our opponent.

If we can win in a rate war, we would like to do so "level" in order to preserve all of our options. However, if our opponent makes a mistake and drops the nose in an effort to Low Yo-Yo, we will counter nose-low and collapse the fight (reinforcing Defensive Goal #2).

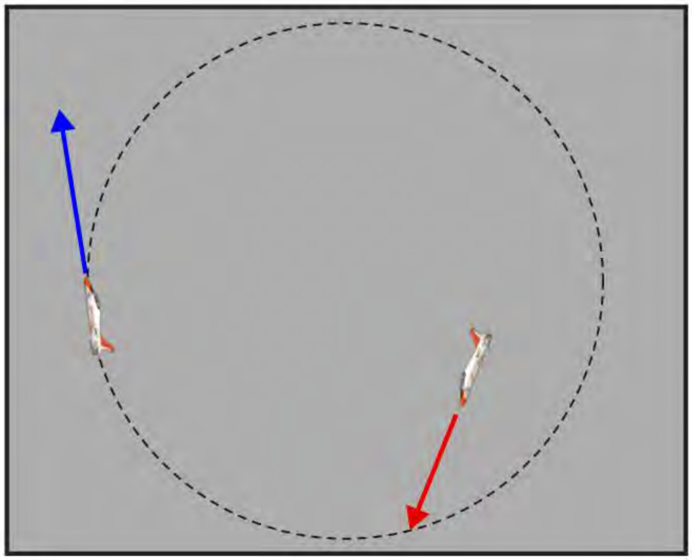

Figure 1-31 Match Attacker's Pull Inside the Bubble

9. **Misaligned Turn Circles**

Once established in the rate war, we will ease our pull when the attacker eases and tighten when the attacker tightens (Axiom #3) (Figure 1-32). In this manner, we are misaligning fuselages and turn circles to the maximum extent possible and setting ourselves up for a high aspect pass. If we can position ourselves across the circle from our opponent, outside his bubble, we have gotten closer to a neutral fight. The potential to bug out at the next merge is a possibility. Alternatively, if the attacker cuts across the circle forcing one-circle flow, we can match nose-low and bug at that merge.

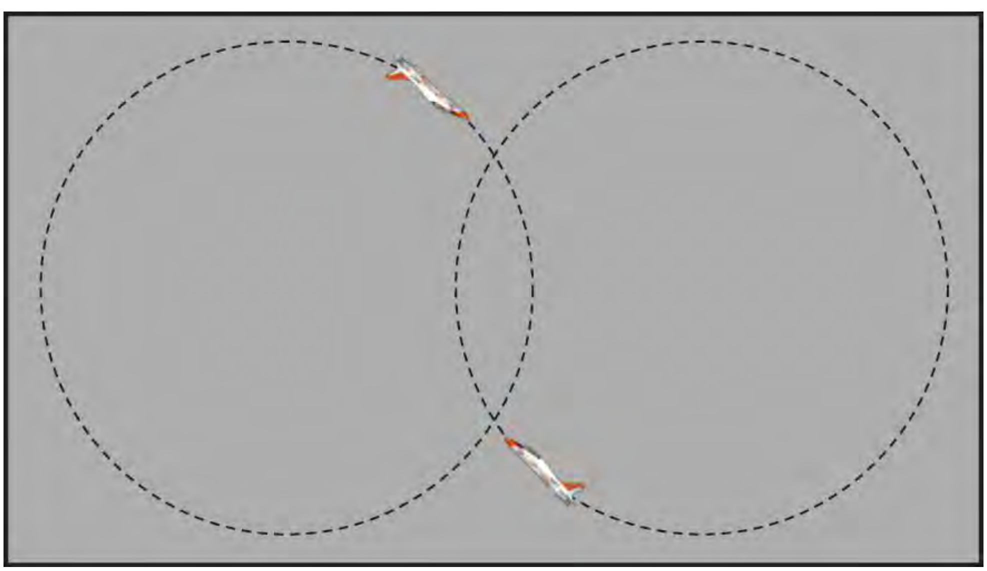

Figure 1-32 Successful Rate Management Back to Neutral Pass

10. **Bug**

To bug we need a 180 degree out close aboard pass, on the deck so that our opponent cannot follow in the vertical. When bugging, execute only one check turn away from the opponent's turn at the merge, then get as low and fast as possible (Figure 1-33).

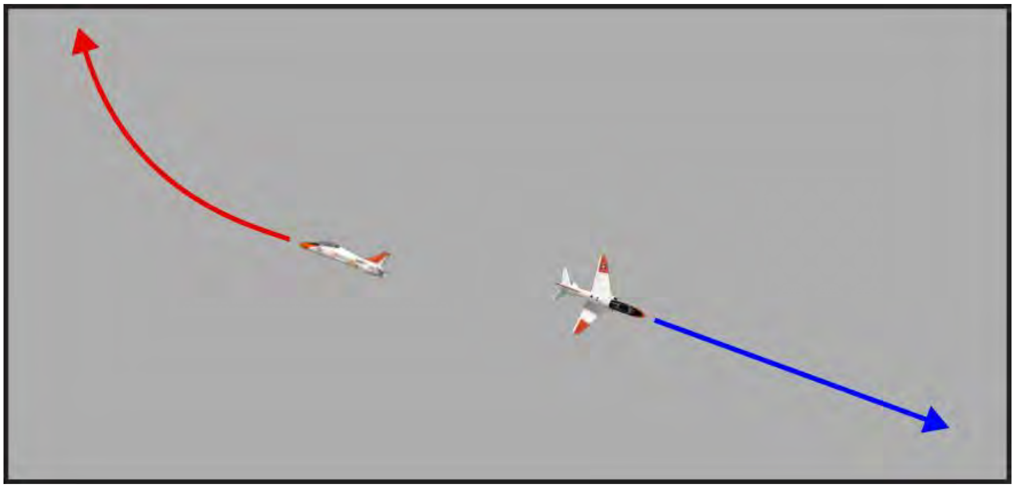

Figure 1-33 Bug if Possible, 180 Degrees Out

11. **Second Bubble Entry**

After the initial flight path overshoot and possible bubble exit, misaligned turn circles will eventually allow the attacker to come back around to achieve sensor nose and bubble entry again. When sensor nose is on, execute the same break turn with flares as before. If at any time the attacker is approaching sensor nose and we cannot pull the opponent forward of the 3/9 line (Axiom #4), we must redefine the fight. This will be discussed in the 6K' Perch set.

12. **6,000 Feet (6K') Perch Set Offensive**

The training objectives for the 6K' set are:

a. Bubble entry

b. Attack Window Entry Mech

c. Ditch follow & timing mechanics

d. Deck transition

13. **Bubble Entry/Attack Window Entry Mech**

The 6K' Perch set begins at bubble entry (Figure 1-34). We will execute the mechanics exactly as we did in the 9K' set although we will be more offensive and the sight cues will occur more quickly. If we execute proper Attack Window entry mechanics, we should find ourselves with a slight flight path overshoot which will quickly resolve itself as misaligned turn circles. We will then quickly bring our sensor nose back on the defender.

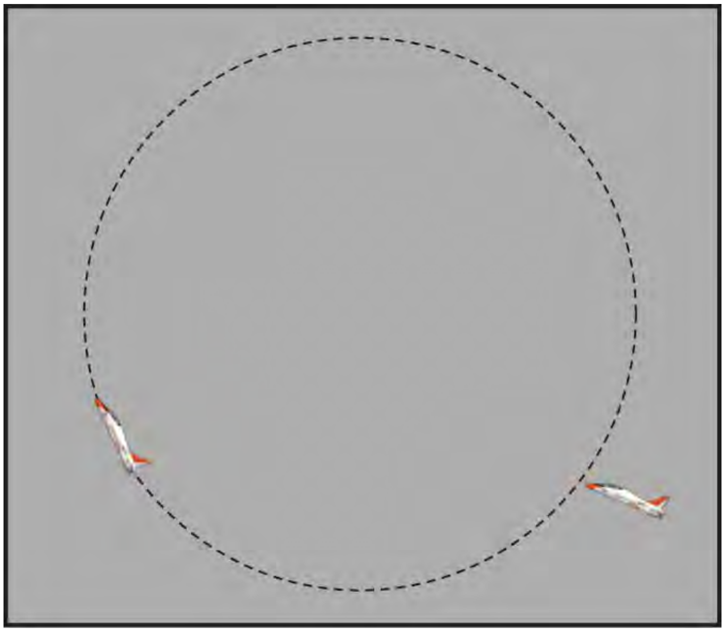

Figure 1-34 6K' Set, Just Outside the Bubble

14. **Ditch Follow**

As misaligned turn circles bring our sensor nose-on for the second time, we should have bled our opponent down to an airspeed below the rate band. With no airspeed to hold our nose-off any longer, the defender will try to redefine in the vertical ('Last Ditch' maneuver), altitude permitting. We can expect a savvy opponent to execute a "Ditch" maneuver. This is a Split 'S' type of nose-low maneuver in which our opponent rotates the lift vector out in front of us to deny us his control zone. It is not a difficult move to follow and the mechanics are identical to the Attack Window Entry Mech we executed previously, albeit now in the vertical.

Our first priority is to pull toward the defender's point of departure. A common mistake is for the attacker to go to the point of departure before following, resulting in a late follow. This is not the case. We will pull toward the point of departure, but the line of sight rate cues of the attack window will signal our ditch follow timing (Figure 1-35). When the defender's line of sight rate takes off in the vertical, we will follow "in-plane" using as much pull as necessary to remain on the defender's turn circle. The opponent was slow when the ditch started, so do not carry too much airspeed into the follow as a 3/9 Line overshoot in the vertical is a possibility. As we arrive sensor nose-on again, the opponent may ditch again, altitude permitting. If not, watch closure and transition to the deck.

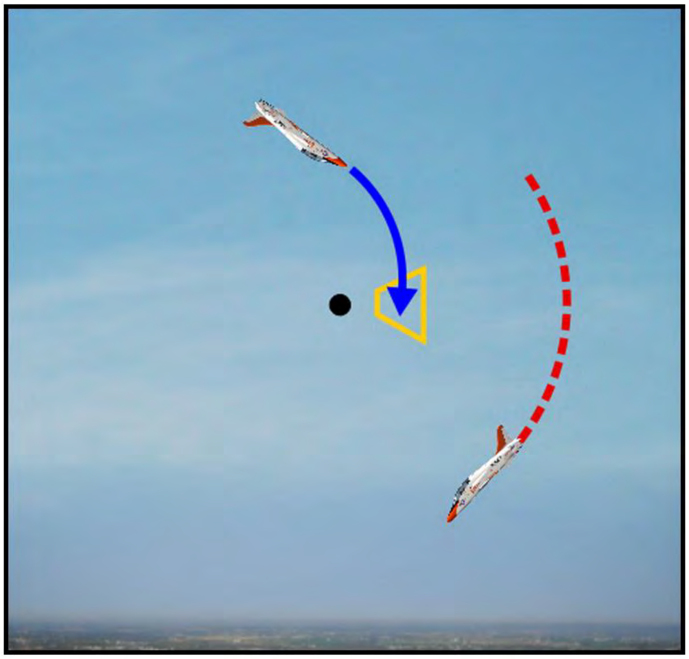

Figure 1-35 First Lag towards Departure Point, then Ditch Follow

15. **Deck Transition**

As we approach the deck we have two options: a pure positional deck transition or an oblique, energy rate deck transition. If at any time we have the altitude to do so, we would like to go pure nose-low to convert that altitude to angles on the deck. We would like to use a compromise pull (17 units AOA) to arrive on the deck in our rate band. If, however, we do not have the altitude to go pure nose-low, we will use an energy rate deck transition utilizing the 10 degree rule (10 degree nose-low for every 1,000' above the deck) to arrive on the deck offensive and in our rate band.

16. **6,000 Feet Perch Set Defensive**

The 6K' defensive training objectives are:

a. Break Turn

b. Bubble entry

c. Ditch, timing/mech

d. Deck transition

17. **Break Turn/Bubble Entry**

As stated during the offensive discussion, the 6K' set begins at bubble entry. We will execute just as we did in the 9K' set, understanding that we will be more defensive and the sight pictures will occur much more rapidly. Utilizing Axiom #3, we will find ourselves pulling more than we did in the 9K' set because we are being pressured far more. After the first break, turn and attack window entry from the attacker, we will quickly find ourselves below our rate band with the attacker approaching sensor nose-on for a second time. When we can no longer pull our opponent forward of the 3/9 line and sensor nose is a factor, we will redefine/Ditch (Axiom #4).

18. **Ditch**

With no other options available and assuming we have the altitude (~6,000' above the deck in the T-45C); we will execute our ditch maneuver. Utilizing coordinated stick and rudder, we will roll/pull into a bullseye nose-low maneuver, rotating our lift vector out in front of our attacker. This has the effect of rotating our control zone away from the opponent (Figure 1-36). Once established nose-low, we will max perform the aircraft to minimize altitude loss, using idle power and speedbrakes if necessary. We will continue rolling our aircraft to keep the lift vector out in front of the attacker. As our opponent follows, sensor nose again becomes a factor. We will ditch again if altitude permits. The hope is to create more fuselage misalignment. However, we probably will not have the altitude to execute a second ditch in the T-45C.

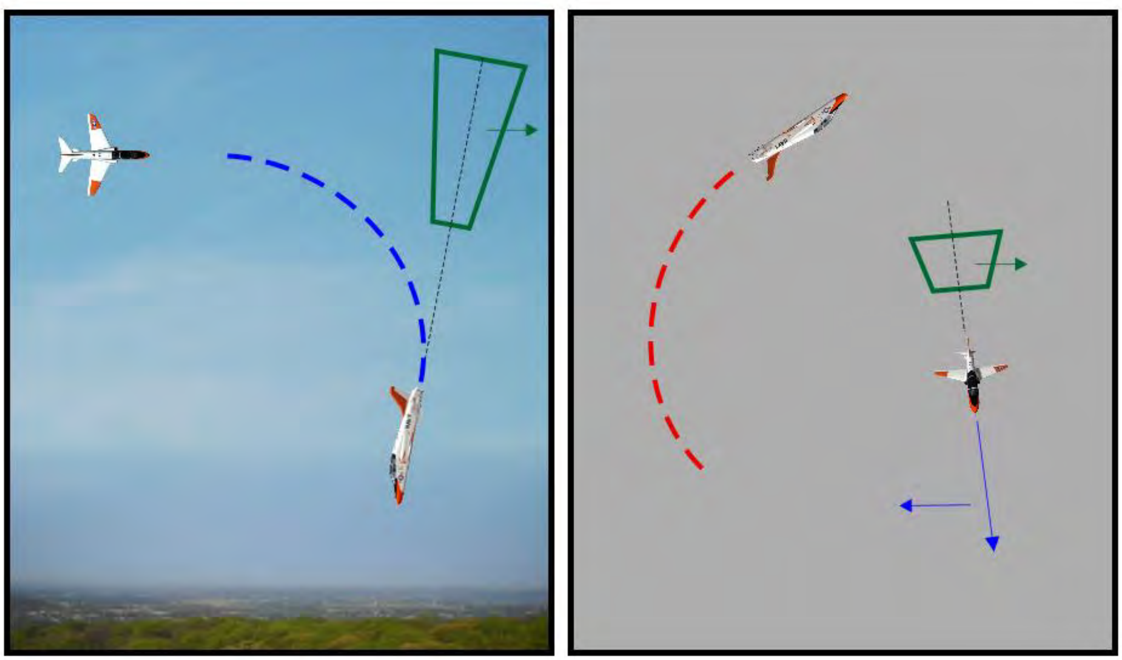

Figure 1-36 Ditch Mechanics, Deny Control Zone

19. **Deck Transition**

Once we find ourselves within 6,000’ of the deck, we must start working a deck transition. As the defender, we have one of two transition options available to us:

a. Positional transition

b. Energy rate transition

If we find ourselves with fuselages still aligned (defensive), we will execute a positional deck transition, max performing our aircraft to take out angles. If we have enough altitude to go pure nose-low (6,000’), it becomes just another ditch. If we do not have the altitude, we will use the 10 degree rule but with the understanding that we are max performing (19-21 units) in the oblique. If we find that fuselages have become misaligned (more neutral), we can afford to do an energy rate deck transition, either pure nose-low or oblique, depending on our altitude. In either energy rate case, we are striving to get back as much airspeed as possible when we arrive on the deck. If we are on the deck, bled down with our opponent coming sensor nose-on, we must again redefine. This time however, we cannot ditch so we will execute the “On Deck Reversal.” Reversal criteria haven’t been met in this case, but there are no other options. We should break turn into the attacker (Axiom #s 1, 2 and 3), but we don’t have the energy. We have met ditch criteria (Axiom #4), but we do not have the altitude to do so. Our only option (other than die) is to reverse and hope that our opponent makes a mistake.

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 in the FTI. With practice and experience you will be able to perform a more aggressive transition, but these recommended wickets provide a good starting point. Note that the max degrees nose-low translates to 10% of the altitude above the deck.

c. 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

20. **3,000 Feet (3K') Perch Set Offensive Training Objectives**

The 3K' set begins with the attacker inside the bubble (Figure 1-37). The offensive objectives are:

a. Attack Window Entry Mech

b. Ditch/Guns 'D' follow, timing/mech

c. Deck transition

d. Finishing

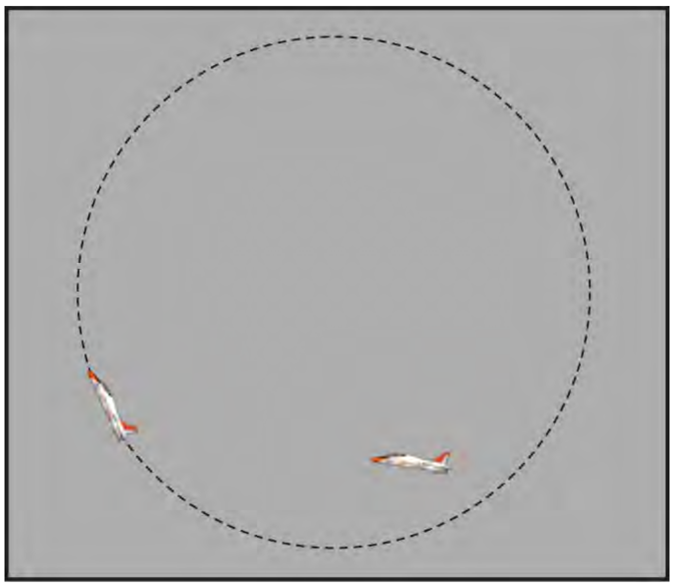

Figure 1-37 3K' Set, Inside the Bubble

21. **Attack Window Entry to Deck Transition**

For the 3K' set, we start inside the defender's bubble. We will execute Attack-Window-Entry-Mech, Ditch Follow and Deck Transitions just as we did in the 6K' set. The difference here is that it will occur even more quickly as we are in a substantially more offensive position. Unless we make a BFM error, we should arrive on the deck in our opponent's control zone. Once on the deck in the control zone, we need to finish the fight.

22. **Finishing**

Finishing is easier said than done. Our opponent will continue to maneuver to deny us a weapons opportunity, cause us to overshoot or scrape us off the deck. We can expect to arrive on the deck in some sort of weave, a cross between a Flat Scissors and a Snapshot drill. Our first priority is to avoid the deck. Our second priority is to preserve an offensive advantage. The defender will try to maximize closure and force an overshoot. We should mainly pull for lag, early turning (lead) only if we have sufficient nose to tail to align fuselages (minimum of 1,000'). This will be the quintessential "knife fight," so max performing our aircraft (19-21 units) is the key to success. Finally, our last priority is weapons employment. Any time our nose is going to pass through the defender, we should employ the gun (Figure 1-38).

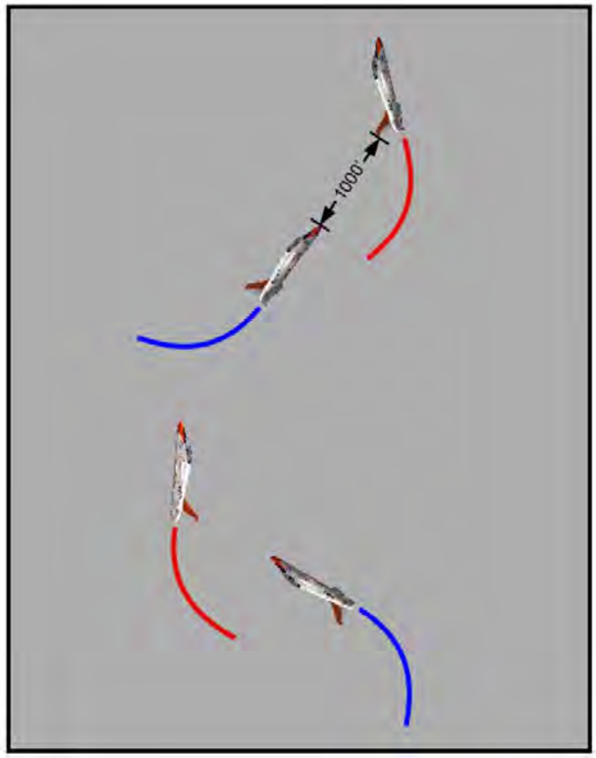

Figure 1-38 Finish the Fight, Maneuver to Weapons Employment

23. **3,000 Feet Perch Set Defensive Training Objectives**

The 3K' set begins with the attacker inside the bubble. The defensive objectives are:

a. Ditch/Guns 'D', timing/mech

b. Deck transition

c. Guns Weave

Since the attacker is already inside the bubble, we will execute our Ditch almost immediately and subsequently execute a deck transition. We will execute these maneuvers just as we did in the 6K set except that our ditch may turn into a Guns 'D', depending on our attacker's intentions. The key is to defend as appropriate (Axiom #1) when threatened. With the attacker starting from such an extremely offensive position, it is likely that we will find ourselves on the deck, out of energy, with the attacker approaching a guns tracking solution.

24. **Guns Weave**

Never give up! As we find ourselves on the deck, out of energy and our opponent pulling lead for a gun solution, we will initiate a reverse (Figure 1-39). As with the offensive discussion, our first priority is to avoid the deck. Target 500' above the deck to give some buffer. In order to employ the gun, our opponent must solve plane of motion, range and lead. If we are on the deck, in-plane and in-phase with our attacker, two of the three are solved. The only variable we can affect is lead.

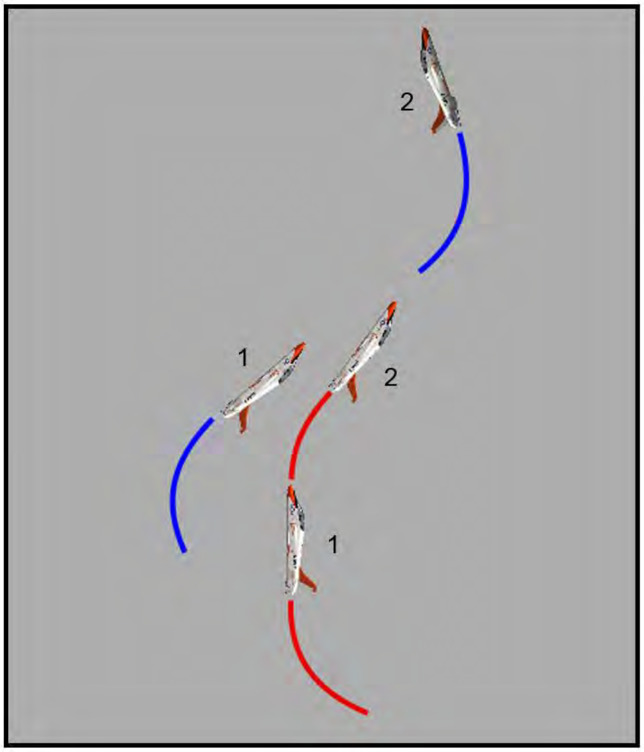

Figure 1-39 On Deck Reversal

Our opponent cannot shoot us nose-on; lead is required. With our attacker in phase and pulling for lead, we will target 150 KTS and max perform (19-21 units) to maximize the closure. Just as the attacker is pulling nose-on, we will reverse, disrupting the lead solution. Once established in the opposite AOB and turn, max perform and look to reacquire sight at our 5 or 7 o'clock position. Repeat this process as the attacker pulls for lead again. As we max perform, we hope the attacker will have to lag to preserve nose-to-tail range. It may take a couple of iterations, but we can hopefully get out of phase with the attacker. The goal is to turn a high percentage guns tracking scenario into a low percentage snapshot scenario. With our opponent out of phase, we continue max performing in an attempt to force an overshoot. Any time our opponent's nose comes to bear in a snapshot, we will go "wingtip on" to reduce our planform, then reverse. We continue maneuvering to survive until we scrape our attacker off on the deck, run the attacker out of fuel/bullets or our wingman comes to save the day.

105. HIGH ASPECT BFM

High Aspect BFM encompasses much more than just one or two-circle flow. It is an opportunity to go from a neutral start with a well-designed game plan and transition to either offensive or defensive BFM as the scenario plays out. To be successful at BFM, a firm understanding of game plan development, execution and the offensive/defensive transition is required.

1. Game plan Development

The concept of "game plan" is often misunderstood and misused in BFM. "My game plan is to go up" may be heard as someone's game plan, but this is not a real game plan. It may be an initial move or part of a game plan. A game plan is a comprehensive concept that revolves around three components: threat, mindset and flow.

2. Threat

The focus of our game plan is the threat. We must look at the performance characteristics of our aircraft versus the characteristics of our opponent by comparing E-M diagrams. From that comparison, we find the strengths and weaknesses of both platforms and design a game plan that maximizes the strengths of our aircraft while minimizing the strengths and exploiting the weaknesses of the opponent's. The other threat consideration is weapons capability. As with performance characteristics, we develop a game plan that minimizes the strengths of our opponent's weapons and maximizes the strengths of our own. The comprehensive analysis of these factors is the basis for our game plan.

3. Mindset

The mindset discussion is comprised of two aspects: energy and weapons separation.

We must consider how much energy we are willing to sacrifice for the sake of performance. If we have an inferior performing aircraft compared to our opponent, we may be willing to expend energy to gain or deny angles on our opponent. However, if we have an equal or superior performing aircraft, we may be unwilling to expend energy, relying on the performance of our aircraft to gain or deny those angles.

We must also consider the amount of weapons separation we are willing to allow. If we have a forward quarter weapons advantage over our opponent, we would prefer a lot of separation between aircraft to take advantage of our superior weapon capabilities. However, if our opponent also has a forward quarter weapon, we may be unwilling to allow much separation between aircraft. It does no good to have separation for both aircraft to employ a weapon, resulting in both aircraft dying at the merge. The separation component of mindset leads into flow.

4. **Flow**

The final component of our game plan development is flow. As discussed earlier, there are two types of flow: one-circle and two-circle. Additionally, we must consider out-of-plane (OOP) maneuvering in our flow discussion.

Overall, the amount of separation our mindset will allow dictates the type of flow we choose. Two-circle in-plane flow provides the most separation between aircraft. One-circle in-plane flow provides the least amount of separation. OOP maneuvering falls in between one-circle and two-circle.

Based on the above discussion, a sample game plan may sound something like: "*We will look to execute an energy conserving, in-plane, two-circle flow to maximize the capability of our forward quarter weapons suite and take advantage of our opponent's rear quarter IR only capability.*" Once we decide on a game plan, we will strive to execute it throughout the entire engagement. We will not change our game plan in the middle of an engagement just because the fight is not going our way (i.e., switch from two-circle to one-circle flow). Doing so would play into our opponent's game plan. If our game plan is not working for us, perhaps the best course of action is to disengage prior to becoming defensive and live to fight another day. That is not to say that we force flow at all costs when we are not in a position to execute our desired flow. If our opponent forces a particular flow, we may need to fight that flow until the next merge. Then we will try again to execute our game plan.

5. **Execution**

Once in a BFM engagement, we will execute our game plan utilizing the mechanics and concepts previously discussed. However, prior to formulating a first move, we must consider several factors unique to high aspect BFM.

6. **Exclusive Use Turning Room**

Generally, turning room between aircraft belongs to the first aircraft to take advantage of it. However, there are several scenarios in which only one aircraft will be able to take advantage of the available turning room. We call that turning room "Exclusive Use Turning Room" (Figure 1-40).

An example of exclusive use turning room is a merge in which turning room exists and the altitude of the merge is within one turn diameter of the deck. In this situation, the low aircraft can use that turning room, airspeed permitting, but the high aircraft cannot use it without hitting the deck. Another situation that would create exclusive use turning room occurs at the top of a slow speed merge. Vertical separation between aircraft exists, but neither aircraft has enough airspeed to go up again. Because the low aircraft does not have enough airspeed to go up, only the high aircraft can take advantage with a nose-low maneuvering of the turning room, thus making it exclusive use. Whenever possible, we want to capitalize on exclusive use turning room.

A final example of exclusive use turning room that requires special consideration is the vertical merge.

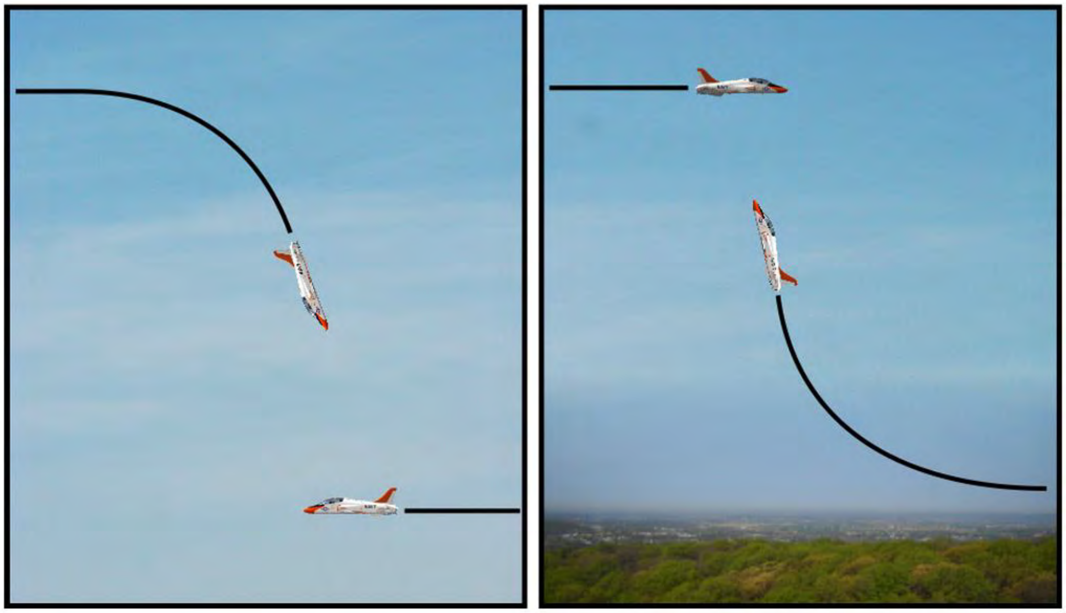

Figure 1-40 Exclusive Use Turning Room

7. **Vertical Merge**

The vertical merge (Figure 1-41) is a unique instance of exclusive use turning room. As one aircraft merges nose-high, its turn radius and turn rate will benefit from the additional force of gravity. Conversely, the nose-low aircraft is hampered by increased turn radius and slower rate due to gravity. The resulting disparity in aircraft performance effectively provides the nose-high aircraft with an exclusive use turning room scenario. As the nose-high aircraft, we have the opportunity to gain a significant offensive advantage, but the execution depends on the reaction of our opponent. If our opponent tries to extend out of this merge, we will execute an early turn to gain as many angles as we can prior to the merge. Our timing and execution will look very similar to the Attack Window Entry Mech that we discussed under the Offensive Perch BFM discussion. We will put the opponent on the canopy bow and pull to keep them there. If our opponent chooses to max perform and stop the vertical overshoot, we will extend in the vertical to try and maintain separation (exclusive use in the vertical).

On the other hand, if we are the nose-low aircraft, the first priority should be to avoid this type of merge. If our opponent is coming up at us, we need to oppose the nose and come down to meet him. However, we will strive to work up and behind the opponent, attempting to flatten out the merge and make it less vertical. With a merge in the oblique, we now have the option to force two-circle flow and can either accelerate into our rate band or disengage. If we cannot flatten out the merge and we hit a vertical merge nose-low, treat it as if we are defensive and react according to the Axioms of Defensive BFM, specifically Axiom #3. If our opponent tries to early turn, we match by max performing to minimize our altitude loss (Decrease in TA = Increase in Pull). If our opponent tries to extend through the merge to gain altitude, we will extend as well in an effort to exit our opponent's bubble where we will be able to pitch back in and deny the opponent angles.

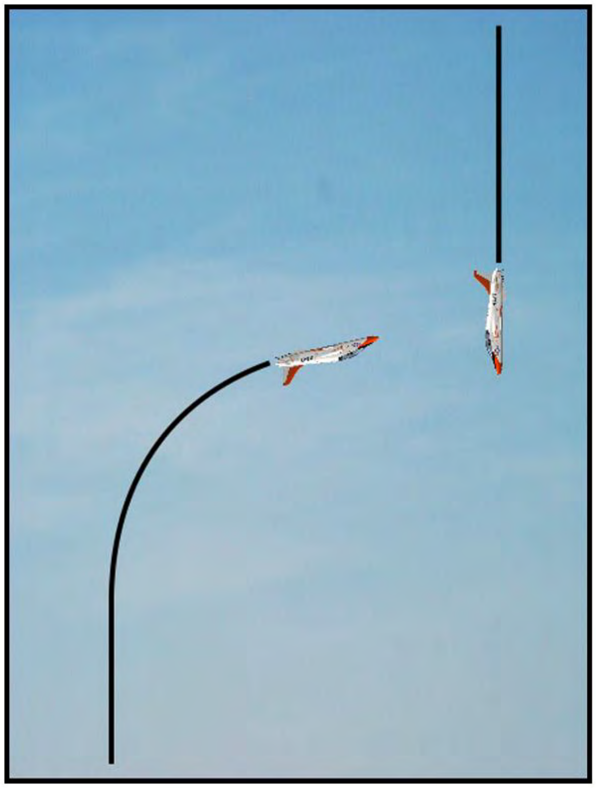

Figure 1-41 Vertical Merge

8. **Slow Speed Merge**

If both aircraft maneuver nose-high and arrive at a high, slow merge (Figure 1-42), angles can be gained or lost if not executed properly. With both aircraft slow, we do not want to reverse to force one-circle flow, even if that was part of our game plan. Doing so provides exclusive use turning room for our opponent and puts us immediately down range in a radius fight. Instead, we will cross our opponent's tail and look to initiate an OOP maneuver nose-low (cut across the circle). However, we have to be careful not to go down too soon. Turn radius at those slow speeds, coupled with the added effect of gravity, will result in our opponent's ability to roll in right on top of us. We need to wait until the opponent exits our bubble, before we initiate our nose-low maneuver. If our opponent initiates first and we are inside his bubble, we will use the offensive sight picture to time our follow. If the opponent initiates OOP nose-low first and we are outside the bubble, we will follow immediately and match the opponent nose-low. If our maneuver is un-countered, we will arrive at the bottom with an angular advantage. If our opponent counters, we will look to arrive at the bottom in our rate band for follow-on options.

9. **Nose-High Counter**

Another unique scenario is a merge on the deck in which going up appears to be the only option. If our opponent decides to go up, we could go up immediately but be unable to gain any angles. This is because both aircraft would be going up on each other's bubble (we cannot gain angles on or inside our opponent's bubble). However, if we cross our opponent's tail and wait for bubble exit (Figure 1-42), there exists an opportunity to gain angles. We learned the sight cues for entering the bubble in Offensive BFM. In the nose-high counter we will look for those sight cues in reverse; when our opponent's track crossing rate slows down and transitions to aspect change, the opponent is exiting our bubble. At that point, we initiate our nose-high maneuver and pull lead in the vertical. If our opponent does not honor our nose and come back down, we gain un-countered angles. If the opponent honors our nose, we set up the vertical merge and take advantage as the nose-high aircraft.

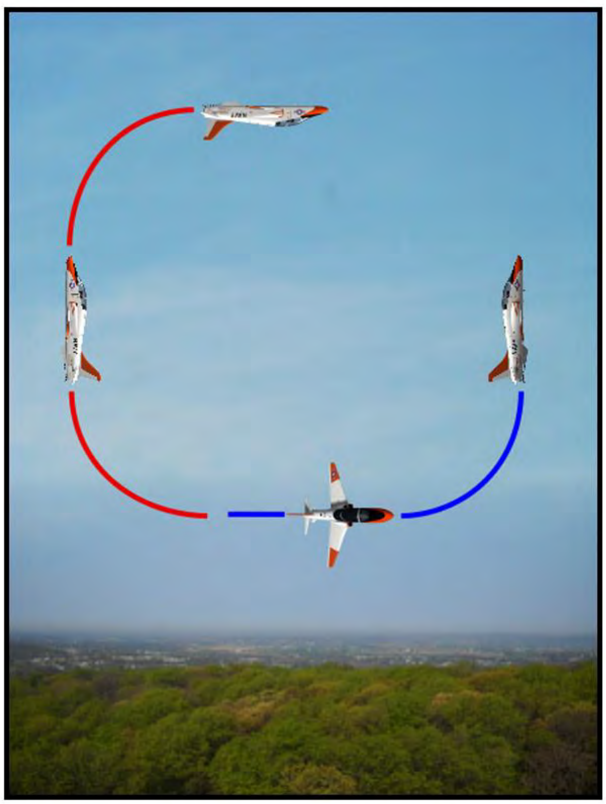

Figure 1-42 Nose-high Counter

This scenario can also be used if our opponent goes up and we do not have the energy to follow. In this case, as we cross our opponent's tail, we need to ease our pull to regain as much energy as possible so that we can go up prior to our opponent coming back down. Of course, if we initiate a nose-high maneuver and our opponent executes a nose-high counter against us, we need to work up and aft of our opponent to try and shallow out the follow-on vertical merge.

10. **First Move Options**

Based on the above discussion of unique merges, we can now evaluate our First Move Options at the initial merge. While "Go up" is not a game plan in itself, it may be a First Move Option that is part of our game plan. At the merge, we want to initiate our desired mindset and flow. In general, there are three possible options:

a. Level turn

b. OOP Nose-High

c. OOP Nose-Low

11. **Level**

A "level turn" is one that is executed within 45 degrees of the horizon. In High Aspect BFM, we often turn level across the horizon to evaluate the intentions of our opponent (Figure 1-43). That is not to say that we are executing a "reactionary" game plan; rather, we have our game plan in place, but are evaluating our opponent's first move in an effort to force the desired mindset and flow. For instance, if we wanted to force one-circle flow and arbitrarily chose to go nose-high at the merge, our opponent could go nose-low and affect two-circle flow; not the flow we want. By going level initially, we can evaluate our opponent's first move, and reorient our lift vector so as to force the flow we want. By no means do we want to continue level if our opponent initiates out-of-plane maneuvering. Doing so would eventually result in our opponent gaining a positional advantage. Rather, we evaluate our opponent's flow and counter when the proper sight picture develops.

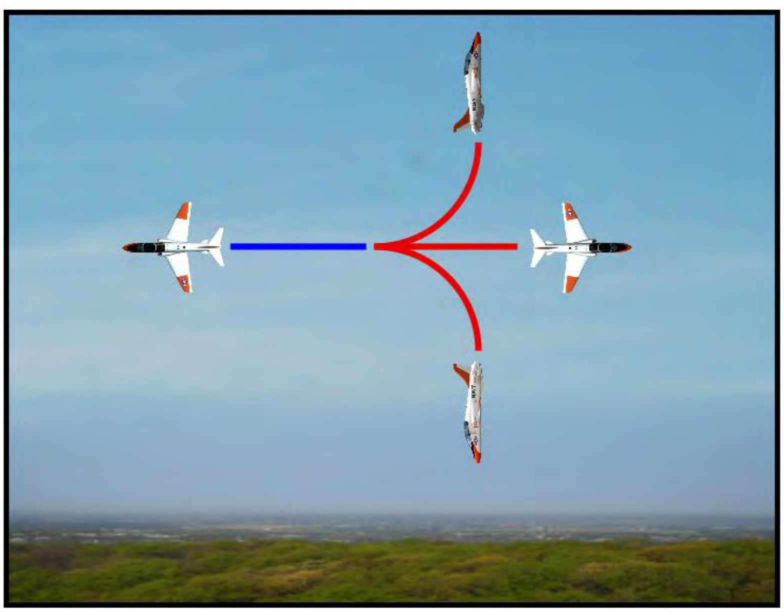

Figure 1-43 First Move Option, Level

12. **Out-of-Plane Maneuvering**

Again, we define Out-of-Plane maneuvering as any maneuvering in which our plane-of-motion exceeds 45 degrees above or below the horizon. In general, we initiate OOP maneuvering to correspond with the mindset portion of our game plan. The two options are nose-high and nose-low OOP.

We initiate OOP nose-high maneuver as part of a mindset in which we are willing to sacrifice energy for positional advantage (Figure 1-44). Generally the nose-high OOP maneuver is used in conjunction with one-circle flow. If our opponent matches us nose-high, we have the one-circle flow we desire. If our opponent goes nose-low OOP, we must be careful because we are now in two-circle flow and potentially setting ourselves up for the defensive High-Low Vertical Merge. If our opponent turns level and does not counter nose-high, with proper lift vector placement we can execute bubble-post mechanics to arrive in an offensive position in the control zone. If the opponent does counter, we have the possibility of arriving at a vertical merge.

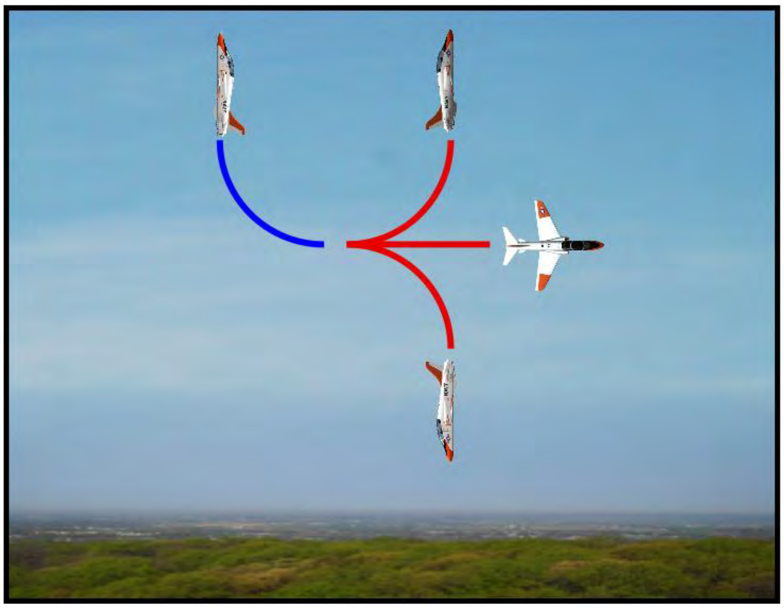

Figure 1-44 First Move Option, Nose-high

We initiate OOP nose-low maneuver as part of an energy conserving mindset that may be either one-circle or two-circle (Figure 1-45). If our opponent goes nose-high and we go nose-low, the flow will probably be two-circle. The radial G will be higher for the opponent going nose-high over the top, so sensor nose must be honored. The potential also exists for us to execute the nose-high counter and create a low-high vertical merge. On the other hand, if our opponent goes nose-low, we may end up with either one or two-circle flow depending on how nose-low the opponent goes. With either flow, if we are more nose-low than our opponent, we will gain an advantage of less downrange travel (one-circle) or angular position (two-circle). If both aircraft end up pure nose-low, the fight transitions to one-circle in the vertical.

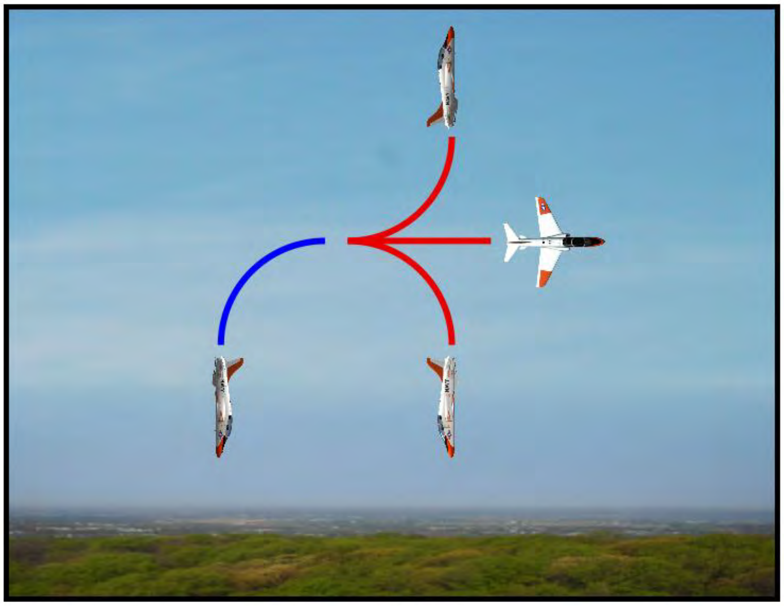

Figure 1-45 First Move Option, Nose-low

While max performing to achieve a smaller turn radius downhill is tempting, it can be a mistake. As we approach the deck, the vertical separation we potentially generate is unusable because of the deck; it becomes exclusive use turning room for our opponent. Additionally, if we bleed below Tactical Vertical Airspeed in an attempt to minimize turn radius, we may put ourselves at an energy deficit and not be able to match nose-high if required. If our opponent goes level, we will utilize bubble-post mechanics to arrive in the control zone with a positional advantage.

13. **Transition to Offensive/Defensive BFM**

Arguably the hardest part of BFM is recognizing the sight cues and transitioning to either offensive or defensive BFM. Almost immediately after the first merge, roles will be established even though the advantage may be as little as 20 degrees. The aircraft to recognize that advantage, or disadvantage, and make the transition first is usually the one that prevails. The key to understanding the transition process is to realize that the same sight cues we learned in perch BFM still apply in high aspect BFM, albeit more subtle and fleeting. For example, let us take the scenario that two aircraft are approaching the second merge and one of them has a 30 degree bite (Figure 1-46). We will examine the transition phase from both their perspectives.

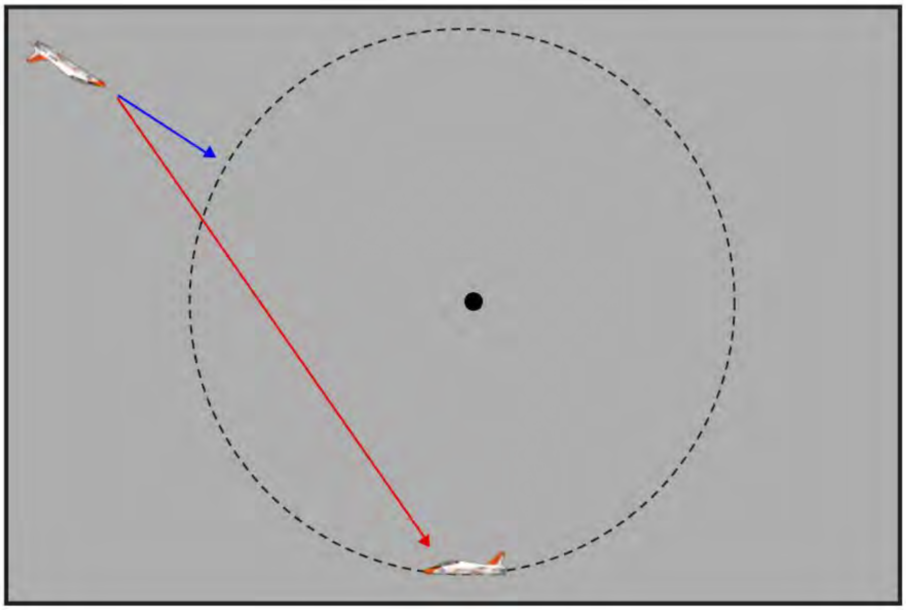

Figure 1-46 Offensive/Defensive BFM Transition

14. **Offensive with 30 Degree Bite**

From the offensive perspective, the first priority is to preserve lateral separation. Remember from perch BFM that any time we are outside the defender's bubble, angles can be taken from us. Because of this, we strive for bubble entry as quickly as possible. In perch BFM, at 40 degrees AOT, we did this roughly through pure pursuit, which is almost coincident with the post. However, in the forward quarter (Figure 1-47) pure pursuit will keep us out of the bubble longer and allow the defender to take out more angles. The quickest way to enter another aircraft's bubble is to point at the post. Considering the closure rates associated with an impending merge, taking a cut away from the defender is not a recommended option; a slight lag or ease of pull toward the post may be all that is required. As in perch BFM, once we see the line of sight rates associated with the Attack Window, we will execute our in-plane Attack Window Entry Mech to arrive in the control zone. In this scenario, the cues for bubble entry and attack window will happen almost simultaneously. Quick recognition is crucial. These procedures allow us to preserve lateral separation.

15. **Defensive with 30 Degree Disadvantage**

From the defensive perspective, once we recognize the slightest advantage by our opponent, we must transition to the four defensive axioms. At this moment, the most important of these is to take away as many angles as possible before the attacker enters our bubble (Axiom #2). Put lift vector on and pull to collapse the lateral separation. Attempt to create a close aboard, 180 degrees neutral pass if possible. Whether we wish to redefine the fight with a reversal or bug, we cannot afford to give our opponent an angular advantage. Regardless of the angular advantage of our opponent, whether it is 10 degrees or 90 degrees, the four axioms of defensive BFM always apply.

16. **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.

Defensive BFM is extremely difficult and sometimes frustrating. A solid understanding of the aircraft performance capabilities and BFM concepts will, however, give you the tools you need to survive. This section has described many techniques in an effort to capitalize on the mistakes the bandit may make. You need to keep one thing in mind whenever you are defensive: never give up. You may be able to turn the tables and kill the bandit, stay alive long enough for a wingman to help you, or perhaps disengage and live to fight another day.

CHAPTER TWO
BASIC FIGHTER MANEUVERING (BFM) WEAPONS

200. INTRODUCTION

As with most industries, technological innovation played a critical role in the design and production of today's air-to-air weapons. These weapons are extremely lethal, and a solid understanding of their capabilities and limitations is essential to survival in the air-to-air arena.

In the fleet, a large variety of weapons are available to aircrews, including high off-boresight Radar and IR missiles as well as the gun. For the purposes of demonstrating the building blocks of BFM, VT-86 will concentrate on the basic rear quarter IR missile, forward quarter IR missile and the gun.

201. IR MISSILES

The heat signature of an aircraft in flight, especially that of a jet aircraft, provides a very strong infrared (IR) signature if viewed from the correct aspect using the right equipment. IR seeker heads capitalize on this phenomenon, and provide relatively cheap and uncomplicated, yet effective, "fire and forget" guidance systems.

The first operational IR-guided missile ("heat seeker") was the AIM-9 Sidewinder. The AIM-9 will be covered in more detail in later chapters. For the purposes of BFM training, IR missile employment will focus on a generic simulation of a short range IR missile.

The rear-quarter IR missile is the most basic of air-to-air missiles, utilizing heat from the target's engine exhaust to guide the weapon to impact. IR missiles are fairly maneuverable but are limited in employment range, making them capable "within visual range" (WVR) ACM weapons. Figure 2-1 depicts the IR missile envelope specific to the Short Range Missile (SRM) simulation in the T-45 OFT and T-45C/VMTS aircraft.

NOTE

> Figure 2-1 depicts the envelope for SRM simulation that will be used later during all-weather intercept training. For BFM employment utilize the CNATRA weapons envelope depicted in Figure 1-25.

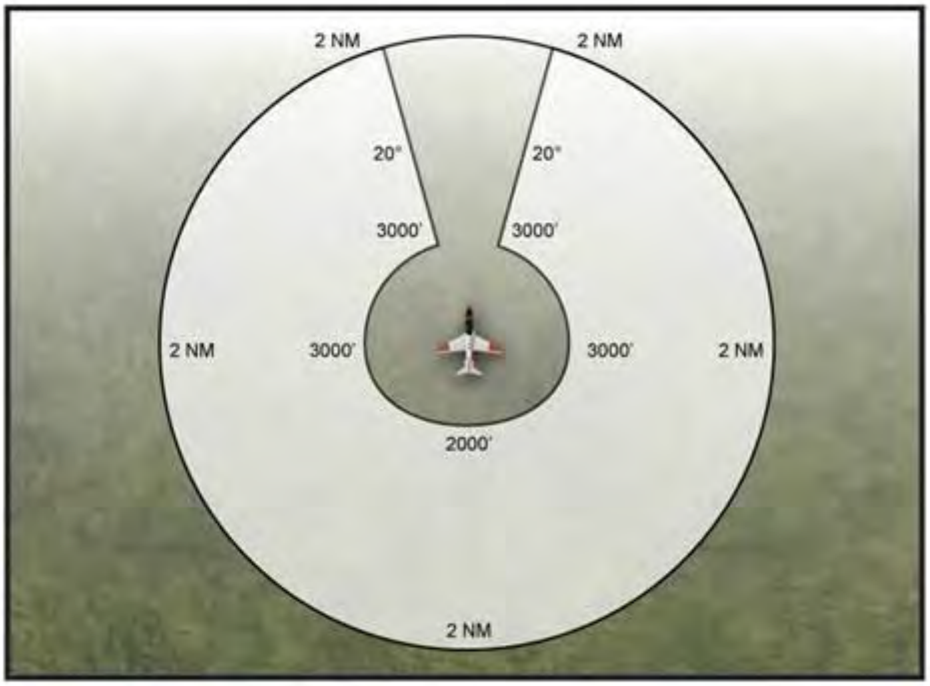

Figure 2-1 T-45 OFT/VMTS SRM (IR) Missile Envelope

202. SRM EMPLOYMENT

The short range missile (SRM) simulation (Figure 2-2) provides for limited all aspect capability.

Figure 2-2 T-45 with Short Range Missiles

Due to the lack of a cueing system in the T-45, VT-86 training will focus on acquisition technology that ties the seeker head of the SRM to the radar line-of-sight. Three methods of employment will be utilized:

- Rear quarter without a radar lock
- Rear quarter with a radar lock
- Forward quarter with a radar lock

1. **Rear Quarter with Radar Lock**

The primary employment method will be in the rear quarter with a radar lock (Figure 2-3), whereby the seeker of the SRM is directed by the radar. This simulates AIM-9 employment modes. In the OFT, an audible tone is used to simulate the acquisition tone of an AIM-9 that is tracking a target. Additionally, an IN LAR indication will be displayed.

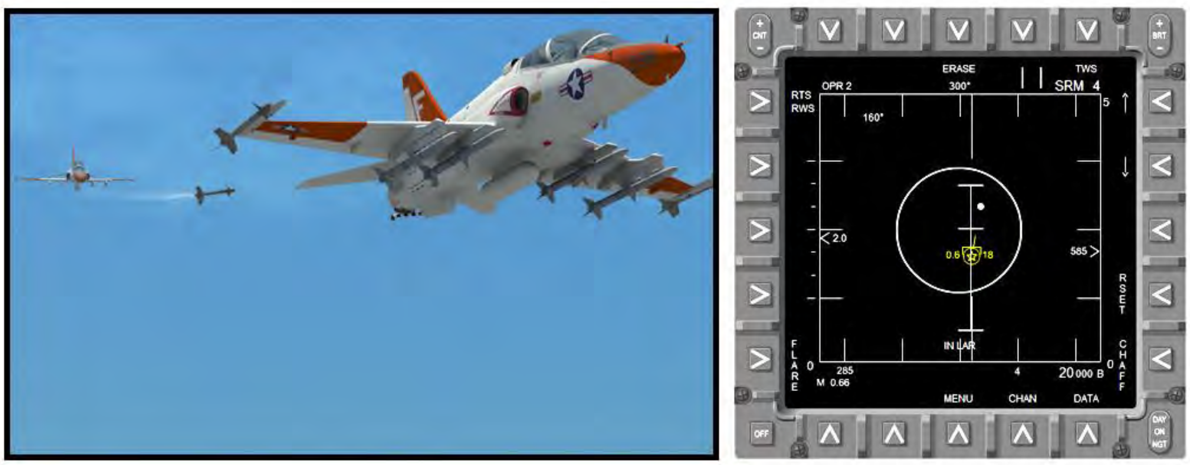

Figure 2-3 Rear Quarter SRM Employment with Radar Lock

In the aircraft, radar indications of IN LAR are displayed. However there is no audible tone. Any shot taken with an IN LAR cue is considered to be a valid shot. SNFOs should use the displayed LAR with a radar lock. Although this employment method will not be used until later in the syllabus, it may be demonstrated in BFM.

2. **Rear Quarter without Radar Lock**

The primary employment method in BFM will be in the rear quarter without a radar lock. Training will emphasize visual recognition of the RQ LAR based solely on sight picture.

a. Target on the HUD waterline, between the airspeed and altitude boxes

b. Target AOT less than 90 degrees

c. Range between 0.5 NM and 2.0 NM

d. If target is wings level, tail-on (i.e., running away), utilize the rules of 3:

i. < 250 KTS opening at 0.5 NM

ii. < 200 KTS opening at 1.0 NM

iii. < 150 KTS opening at 1.5 NM

iv. < 100 KTS opening at 2.0 NM

These parameters should be committed to memory prior to the first BFM brief.

3. **Forward Quarter with Radar Lock**

SRM forward quarter shots with a radar lock simulate AIM-9 acquisition and employment modes. The SRM seeker is directed by the radar, and an IN LAR or SHOOT cue is displayed as appropriate. This LAR is dynamic in both the OFT and the VMTS. A thorough discussion of this LAR is covered in later chapters. During BFM, it is only important for the SNFO to know that this employment capability exists. Additionally, the ranges depicted in Figure 2-4 should be committed to memory as part of the forward quarter IR missile envelope.

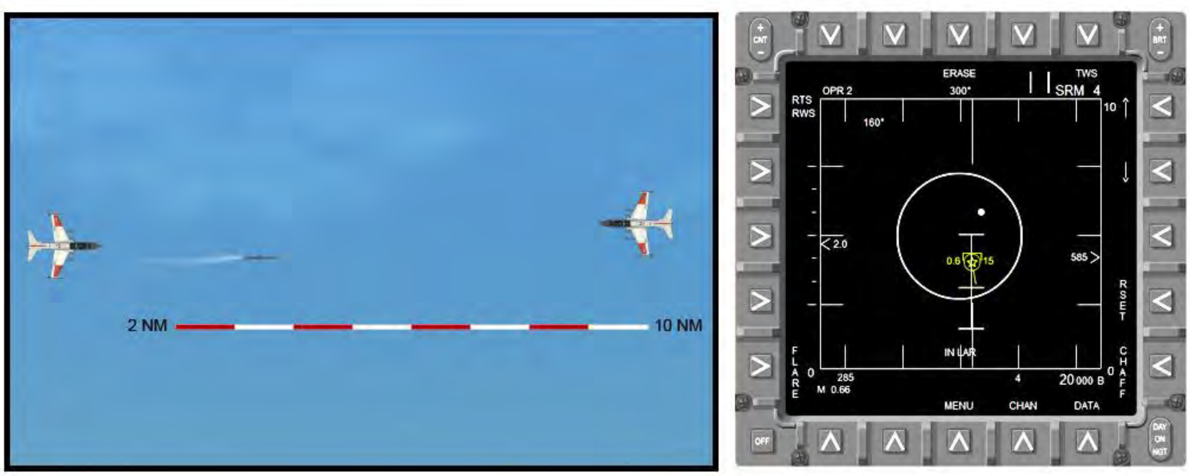

Figure 2-4 Forward Quarter SRM Employment with Radar Lock

203. AIR-TO-AIR GUN

The gun is by far the simplest and most widely used air-to-air weapon ever devised. It is also the most misunderstood with regard to employment. The gun is an all-aspect weapon with no minimum range.

1. **History**

The first instance of air-to-air gunnery in combat occurred when one pilot shot at another pilot with a pistol. While rudimentary, it was effective if for no other reason than to distract the other pilot. Over time, air-to-air guns have evolved into fixed and turret mounted systems capable of shooting down other aircraft.

A post-WWII assessment of air-to-air engagements concluded that the .50 caliber round was too small and the gun systems offered insufficient rates of fire. Additionally, multiple gun barrels in a single wing (Figure 2-5) negatively impacted aircraft balance if a gun became jammed.

Figure 2-5 F4U Corsair with Wing Cannons

Air cannons and the associated ammunition have undergone many changes, improvements and innovations over the last half century, and nearly every ammunition size has been tried. While small calibers lack the destructive power of the higher calibers, the higher calibers incur a penalty of both weight and capacity. Modern aircraft cannons fire a variety of calibers, but the most common fall in the 20 mm to 30 mm range (Figure 2-6). Additionally, these modern cannons fire a wide range of explosive shells at extremely high rates of fire with very small dispersions. These small dispersion areas result in either the complete destruction of the target or a total miss.

Weapon	Caliber	Number of Barrels	Rate of Fire Rounds/Min	Ammunition Capacity	Aircraft Equipped
M61A1/2	20 mm	6	4000-6000	500-700	F-14, F-15, F-16, F/A-18
GSh-23-2	23 mm	2	3200	300	MiG-21
GSh-6-23	23 mm	6	10,000	500	Su-24
BK-27	27 mm	1 (Revolver)	1700	350	Tornado (2)
GSh-30-1	30 mm	1	1500	100-150	MiG-29, Su-27
DEFA	30 mm	1 per Gun, 2 Guns per System	1200-1800	150	Mirage Series (2)

Figure 2-6 Modern Aircraft Cannons

2. **M-61A1/2 20 mm Cannon**

In 1946, Project Vulcan M61 assessed the feasibility of a multi-barreled, Gatling-style gun mounted on aircraft centerline. The end product was the M61, a six-barreled 20 mm gun. First fielded in 1956 on the F-104 Starfighter (Figure 2-7), the M61 has become the standard gun for western fighters.

Figure 2-7 F-104 Starfighter

3. **M61 Components**

The M61 (Figure 2-8) is an externally powered six-barrel 20 mm cannon that arms a variety of air, land, and sea platforms. The F-18 Hornet is armed with the M61A1, and the Super Hornet is armed with the improved M61A2. The M61A2 shares the same features of the M61A1, but is 20 percent (52 pounds) lighter. The weight reduction is a major improvement that is achieved through the use of a smaller barrel contour.

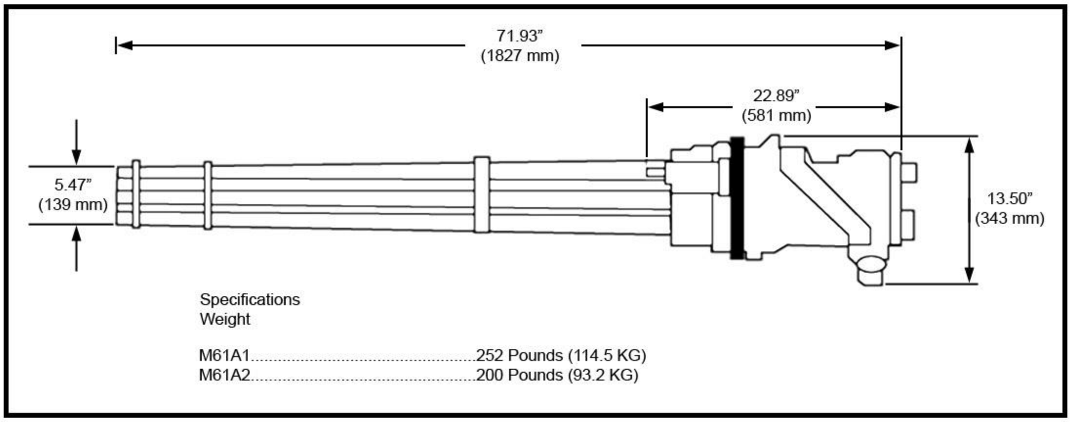

Figure 2-8 M61 Cannon Dimensions

The M61 (Figure 2-9) is electrically controlled, hydraulically powered and air cooled. In the Super Hornet, it has two selectable firing rates of 4,000 and 6,000 rounds per minute. Ammunition movement is conducted by a linkless, continuous transport system which keeps all spent cases onboard the aircraft. For the Super Hornet, the barrels are aimed 2 degrees above the waterline, optimizing the gun for air-to-air engagements.

Figure 2-9 M61 Cannon

204. T-45 AIR-TO-AIR GUN EMPLOYMENT

In BFM, the gun is the weapon of choice. A solid understanding of the T-45 gun symbology, modes and data entry methods used in the HUD and MFCD is essential.

1. **Air-to-Air Data Entry**

Air-to-air (A/A) data entry is similar to the A/G target data entry. However, the only A/A data to be entered is the bandit's wingspan in feet. The DEU uses this information to adjust the size of the reticle so the bandit fits inside the reticle at a range of 1,000 feet. Once the interactive BIT is run, A/A data can be entered.

To enter the A/A data from the MFCD:

a. Select MENU

b. Select STRS

c. Select A/A

d. Select WSPN (Figure 2-10)

- The previously entered wingspan stored in memory is displayed in the scratchpad

e. Press ENT to accept the displayed wingspan

f. Enter the desired bandit wingspan using the number keys on the DEP

i. Valid wingspans range from 0 to 120 feet

ii. The reticle size will change when ENT is pressed

Alternatively, MODE can be selected on the DEP, followed by MENU and STRS on the MFCD. WSPN can then be selected on the A/A Stores display, and the wingspan can be entered as described above.

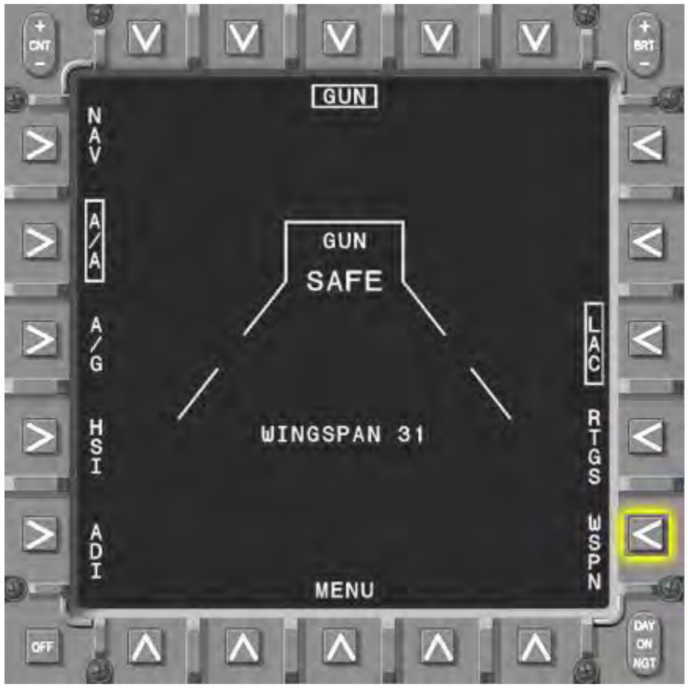

Figure 2-10 STRS Display on MFCD

2. **Gun Sub-Modes**

The A/A gun is selected by pressing the MODE button on the HUD data entry panel (DEP), or alternatively via the HOTAS. The A/A gun mode has two aiming sub-modes:

a. Lead-angle computing (LAC)

b. Real-time gun sight (RTGS)

The sub-mode is displayed above the weapon identifier (GUN) on the right side of the HUD. LAC is the default aiming sub-mode when GUN is selected.

LAC and RTGS sub-modes have the following symbols:

a. GUN (Mode identifier)

b. A/A aiming reticle (pipper)

i. indicates the computed impact point

ii. reflects the wingspan of the bandit at a range of 1,000 feet

iii. the default size is 31 feet (T-45 wingspan)

iv. flashes as it approaches the edge of the HUD FOV

The primary difference between LAC and RTGS relates to the reticle. In LAC, the reticle position compensates for the flight time of the bullets. In RTGS, the reticle shows the impact point of bullets at 1,000 feet after 1/3 second time of flight (TOF).

With gun mode selected, in either LAC or RTGS, the following items are removed from the HUD:

a. Bank Scale

b. Bank Pointer

c. Groundspeed

Once gun mode is selected, air-to-air LAC is displayed on the HUD. To select RTGS:

a. Select MENU on the MFCD

b. Select STRS

c. Select RTGS

3. **LAC Employment**

LAC should only be used when the bandit is performing limited or mild maneuvers, or when the RTGS mode is degraded. Because the impact point is computed, the pipper should be placed over the bandit and held steady in a tracking solution for at least one second prior to firing. The pipper indicates the bandit wingspan at 1,000 feet, so if the range to the bandit is more or less than that, the impact computation will not be accurate.

4. **RTGS Employment**

RTGS in the T-45C (Figure 2-11) is similar to the Lead Computed Optical Sights (LCOS) found in most U.S. fighter aircraft when they are denied target information via the radar. In determining a valid gun solution, the RTGS/LCOS receives information from the INS (own-aircraft speed, G, roll rate, AOB, etc.) and makes assumptions about target parameters (target range/closure/track-crossing-rate/Plane-of-Motion). RTGS assumes a target range of 1,000 feet with the target maneuvering in the same phase, load factor and plane-of-motion as the shooting aircraft. If any of those assumptions are untrue, the solution is invalid.

Figure 2-11 RTGS Gun Sub-Mode

RTGS should be used against maneuvering targets. The pipper represents the impact point of bullets after 1/3 second TOF. The piper should be placed 1/3 of a second ahead of the target along its projected flight path. Because the firing solution is always valid in RTGS, you should call the shot anytime the bandit is within range and you are leading him by 1/3 of a second. The RTGS sub-mode works well for both tracking and raking gun shots, so long as the 1/3 second of lead is applied.

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CHAPTER THREE
BASIC FIGHTER MANEUVERING (BFM) PROCEDURES

300. INTRODUCTION

With a solid grasp of BFM theory, the tactics and procedures utilized during the BFM syllabus flights may now be introduced. A "building block" approach is used to progress from T-45C aircraft performance to offensive/defensive engagements to high aspect 1v1 BFM neutral engagements.

This chapter chronologically presents the maneuvers and procedures performed in the BFM syllabus. It is more procedural than tutorial. When studying this chapter, referencing the BFM Theory chapter will aid in understanding the procedures.

The five syllabus flights will be flown in section to a local working area. Thorough knowledge of the working area procedures is required. Basic section procedures are utilized and Lead responsibilities are normally shared on alternating flights between paired students. Sound Contact procedures such as checklists, fuel management, and navigation are expected. Flight preparation is paramount to success in BFM; SNFOs should read the FTI prior to the brief and use the brief as a time to clarify concepts and answer questions. The flights are an opportunity to demonstrate sight pictures and practice concepts learned during pre-flight study.

301. WEAPONS ENVELOPES

For the purposes of demonstrating the building blocks of BFM, VT-86 will utilize the CNATRA Weapon Envelopes depicted in figure 1-25. These envelopes will be briefed before every flight. SNFOs are required to have these envelopes illustrated on briefing boards.

1. IR Missile Employment

SNFOs are encouraged to recognize offensive employment opportunities and should call “pull for the shot” over ICS when appropriate. In addition to the IR missile discussion in the previous chapters, a large emphasis is placed on sensor nose recognition during the flights. Knowing the envelope parameters and airborne recognition of being inside or outside those parameters are two completely different things.

2. Air-to-Air Gun Employment

Emphasis on gun employment during the syllabus flights lies heavily on solving for Plane of Motion, Range and Lead as described in Section 103.6. Solving for these parameters is required for successful air-to-air gun employment. POM, range, and lead are required for every successful gun employment. Aggressiveness is rewarded in BFM; SNFOs are encouraged to seek shot opportunities. One single snapshot may be the only shot opportunity throughout an eight-merge engagement; recognizing and capitalizing on that opportunity is crucial.

3. **SNFO Responsibilities**

Although SNFOs are expected to be aggressive in calling "pull for the shot" when an offensive IR or gun shot is available, the larger focus at VT-86 is defensive recognition. Sensor nose recognition is a recurrent theme across all flights, as is recognition of when an attacker solves for POM, range and lead. Making a timely, appropriate "Break L/R Flares" and/or "Guns 'D'" call is one of the major training goals for the syllabus. Being able to make these calls demonstrates a broader understanding of BFM sight pictures and principles.

302. TRAINING RULES

The following Training Rules apply to all BFM and SEM training. They shall be strictly observed. These rules include those found in OPNAVINST 3710.7U and should be read prior to your BFM training. It is a requirement to brief training rules prior to each flight. Do not let this repetition lead to complacency. It is important to note that these rules were developed over a long period of time and each is based not only on common sense, but also on situations where pilots were guilty of making serious and even tragic mistakes.

1. **Administrative**

   a. Departure/spin and Compressor Stall/EGT/RPM. As the student you are responsible to brief OCF and engine stall EPs.

   b. Scheduled face-to-face brief. Each experience in Air Combat Maneuvering (ACM) is unique, requiring all aspects of BFM and SEM flights to be briefed and debriefed thoroughly.

   c. ACM authorized by cognizant commander.

   d. Designated ACM area.

2. **Currency**. All in flight have flown:

   a. < 750 hrs FPT in type/class:

      i. Once within previous 6 days.

      ii. Twice within previous 14 days (1 dynamic in T/M).

   b. > or = 750 hrs FPT in type/class or INFO/SNFO:

      i. Once within previous 14 days.

      ii. Twice within previous 30 days (1 dynamic in T/M).

3. **Weather, Decks and Blocks**

a. Weather

i. Daylight (from 30 minutes past sunrise until 30 minutes prior to sunset), VMC, 5 miles visibility and a defined horizon.

ii. Cloud separation – 2,000 feet vertically and 1 mile horizontally.

b. Decks (brief MSL altitudes for working area)

i. Hard Deck

- Minimum 10,000 feet AGL (or 5,000 feet above an undercast). The undercast shall be no higher than 7,000 feet AGL solo/8,000 feet AGL dual.

ii. Soft Deck

(a). Minimum 5,000 feet above the hard deck.

(b). No slow-speed or high AOA maneuvering below the soft deck (less than 120 KIAS or more than 24 units AOA sustained for more than 3 seconds).

c. Blocks

i. Established in assigned block by 10 nm without required SA on opposing force. Comm Requirements

ii. Transmit/Receive/Monitor Guard/ICS (multi-place aircraft).

4. **Configuration changes other than speedbrakes are prohibited.**

- You may not drop your flaps or gear.

5. **Pre-commencement of ACM**

a. Perform g-warm maneuver.

b. Confirm:

i. Weather

ii. Announce local altimeter setting and any decks/blocks changes

6. **Commencement of ACM**

Collision Avoidance

a. ***500 feet separation between all aircraft at all times***. This safety rule applies for training, both in the training command and in the fleet. In the real world, though, you must consider your adversary. For instance, if you maintain 500 ft on a head-on pass with a bandit who has forward-quarter weapons, you may be putting yourself directly into his weapons envelope. In the real world, know your adversary's capabilities.

b. ***Always assume the other aircraft does not see you.*** You are personally responsible for collision avoidance at all times.

c. Head-on pass:

- Maintain the established trend; if no trend established, give way to the right to create left-to-left pass.

d. Broadcast your own intentions.

e. Converging flight paths:

i. Nose-high goes high.

ii. Nose-low has collision avoidance responsibility. Nose-low aircraft will ensure safe separation and must make way if the nose-high aircraft departs controlled flight, or somehow can't stay nose-high (ballistic).

f. Never intentionally maneuver to lose sight (blind lead turn). ***Do not make blind lead turns.*** A blind lead turn is when your nose is in front of the bandit's flight path, and you cannot see the bandit.

g. Up-sun aircraft has the responsibility for collision avoidance. If down-sun aircraft lost sight, transmit "(call sign) blind sun" and turn away from predicted collision bearing. If up-sun aircraft still has sight of the down-sun aircraft and safe separation can be maintained, the up-sun aircraft shall immediately broadcast "(call sign) continue," otherwise knock-it-off. If you are in the sun, you are using a tremendously powerful tactic because it blinds the bandit. But because he is blind, it is your responsibility to maintain the safe separation. Also, if the weather is hazy, the sun creates a halo when you are looking down with the sun at your back. If the bandit is in the halo area, he cannot see you.

h. If lost sight, transmit "(call sign) blind" and turn away from predicted collision bearing. Other aircraft shall transmit "(call sign) continue" or "(call sign) blind (altitude)." If two aircraft have lost sight the first aircraft to transmit blind shall deconflict via altitude.

7. **Knock-it-off anytime deconfliction is not assured.**

a. BFM Events Only: Knock-it-off if both aircraft have lost sight.

b. SEM Events Only: If lost sight of bandit use the term "no joy" vice "blind." Without a tally/visual on all fighters/bandits, aircraft shall conduct belly checks at a minimum of every 90 degrees of turn. Be sure to differentiate between "blind" and "no joy." "Blind" means you cannot see your wingman anywhere. It is a call made strictly to maintain safety. "No joy" means you can't see a threat aircraft described by your wingman.

c. Call "ballistic" (for slow-speed [<100 KIAS] reduced maneuverability).

d. Brief CNATRA Weapons Envelopes:

i. No head-on missile attacks inside 9,000 feet (1.5 nm) and 20 degrees of the target's nose.

ii. No forward-quarter gun attacks (45 degrees of the target's nose).

iii. Break off all gun attacks at 1,000 feet.

8. **Terrain Avoidance**

a. No guns defense below the soft deck (aggressive nose-low, greater than 45° out-of-plane).

b. Offensive aircraft will monitor the defensive aircraft's altitude, attitude, and airspeed and will break off the attack prior to pushing the defensive aircraft through the hard deck. Typically a "watch the deck" call is sufficient to warn the other aircraft; this is for safety and to continue the fight.

9. **Termination of ACM**

a. ACM shall cease when:

i. Any training rule is violated.

ii. "Knock-it-off" is called by anyone, all players echo, or an aircraft is rocking its wings.

b. Knock-it-off for:

i. Interloper.

ii. Departure/spin. NATOPS calls for throttle to idle below 85 KIAS above 15,000 ft.

iii. G-LOC (mandatory RTB).

iv. Min altitude broken.

v. Nordo/ICS failure.

vi. Overstress.

vii. Bingo fuel. Don’t forget about your fuel. You must keep your scan moving.

viii. Inadvertent IFR.

ix. Loss of situational awareness/any unsafe condition develops.

c. 85 KIAS and decelerating for T-45.

i. Training objectives attained. This is usually determined by the trunk IP (lead if Solo).

ii. In a BFM engagement, both aircraft lose sight approaching training area boundary.

10. **Post Termination of ACM**

- Aircraft shall maneuver to maintain safety of flight and be aware of the high midair collision potential following the “knock-it-off” call.

303. COMMON T-45 BFM EMERGENCIES

Due to the high load put on the T-45 during these engagements, there are times when certain aircraft systems will fail or underperform due to the stress. Here are some common emergencies:

1. **OIL PRESS Warning**

This occurs typically following an overly aggressive unload to gain energy prior to an attack window entry. The negative G’s experienced followed by a positive G onset will cause a momentary OIL PRESS Warning according to NATOPS. Knock-off the fight and go through your emergency procedures. It is acceptable to continue training after both fighters reset following a momentary illumination of the light after this kind of maneuver.

2. **Compressor Stall**

The majority of compressor stalls in the T-45 happen during this stage of training. They are easy to prevent as long as you are careful not to maneuver at high angles of attack, and/or maneuver above heavy buffet, when the engine is accelerating from low power settings, or when the engine is at high power settings. Typical characteristics of a stall are loud audible bangs, chugs, or knocks from the engine. Execute your emergency procedures. The flight will RTB if either aircraft experiences this emergency.

3. **CABIN ALT Warning**

Do not confuse the CABIN ALT warning light with an engine flameout or compressor stall. This is typically experienced under high AOA when engaged in the flats. You will hear the cockpit get quiet from the loss of cockpit ECS airflow, and there will be an audible warning tone and CABIN ALT warning light, with an associated loss of cabin pressure; RPM and EGT will however remain normal. Simply turning the ECS switch off for 1-2 seconds, then back on, typically clears the warning light and repressurizes the cockpit.

304. FLIGHT CONDUCT

1. **Brief**

At the scheduled briefing time, SNFOs will have a briefing board prepared in accordance with the Student Briefing Guide. Administrative flight data will be displayed to include a drawing of the scheduled operating area and applicable weapons envelopes. SNFOs should expect to spend approximately 30 minutes briefing their required items, whereupon the Lead IP will take the remaining 30 minutes to brief BFM concepts more in-depth. The SNFO portion of the brief should include the following:

a. Mission Training Objectives - (~1 Minute)

b. Admin - (~5 Minutes)

c. Tac Admin - (~4 Minutes)

d. Flight Conduct - (~5 Minutes)

    i. Walk/Preflight

    ii. Taxi/Takeoff

    iii. Enroute

    iv. RTB

    v. Recovery

e. Emergencies/Safety - (~5 Minutes)

f. Tactical Conduct - (~10 Minutes)

i. Position, Altitude, Distance, Speed (PADS)

ii. Comm Sequence

iii. Safety Considerations

iv. SNFO Responsibilities

Special emphasis during the briefing will be placed on the SNFO's thorough understanding and verbatim recitation of the Out-of-Control Flight (OCF) recovery procedures. During the coordination briefing, training rules and OCF Procedures will be covered with all aircrew present. SNFOs will have the training rules available and be prepared to read them.

2. **Launch/Enroute**

BFM flights will be flown as a section to and from the working area. A "Section Go" or "Interval Go" will be briefed and executed as conditions dictate. Should the weather preclude operating as a section (WX < Circling Mins), a plan to launch as singles and rendezvous in the working area will be briefed as a contingency. SNFOs will manage the flight so as to arrive at the entry point of the working area fenced in and ready for maneuvering flight.

3. **BFM Working Areas**

The primary operating area for BFM is W155A (Figure 3-1). The Pensacola MOA serves as the secondary operating area and is used when W155A is unavailable or is unworkable due to weather. The flight schedule will assign a working area for the section (i.e., NPA-13 for W155A or NPA-8 for the PNSS MOA).

4. **W-155A Procedures**

If W-155A is scheduled, a mission number may be assigned and annotated on the flight schedule. If assigned, SNFOs will have this mission number available for in-flight reference. Sequence 2 in the T-45C waypoint database is permanently allocated for the W-155 Alpha areas and the PNSS MOA Hawk 4. Sequence 2 will be used for all BFM flights in these areas. Figure 3-1 depicts W-155A.

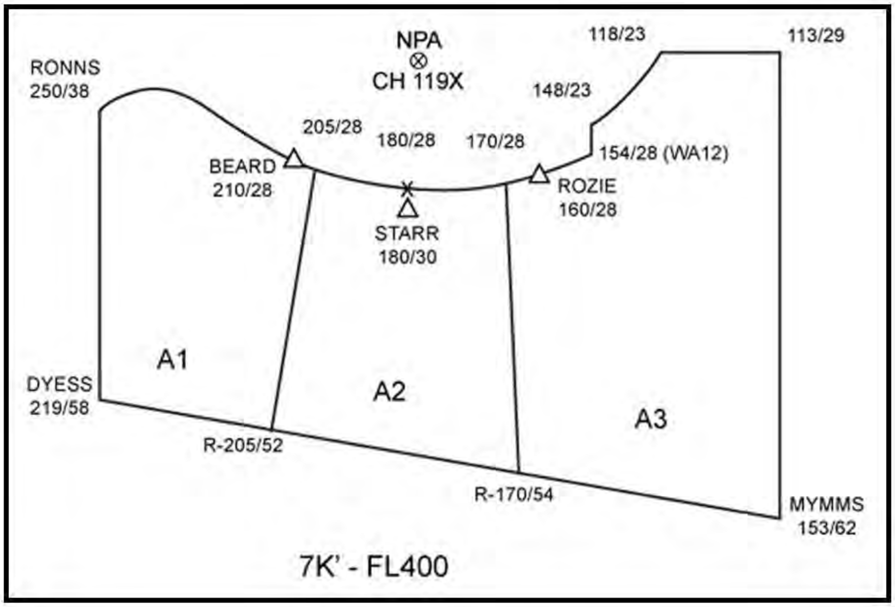

Figure 3-1 W-155A

5. **W-155 Check In**

The Lead SNFO will be responsible for all navigation and UHF communication while transiting to and from the operating area. Shortly after departure, the controller will direct the flight to contact SEABREEZE (the controlling agency for W155). Lead SNFO will acknowledge the frequency change and then over AUX, direct the flight to "Fence-in."

The Lead SNFO will request the frequency change if it has not been received by 20 DME. On initial contact with SEABREEZE, the Lead SNFO will request one, two, or all three of the W155A operating areas, depending on the following:

a. Previous de-confliction with other sections scheduled at the same time

b. Transit corridor requirements for other aircraft to transit to W-155B

If unable to comply with the flight's request (i.e., the requested areas are occupied), SEABREEZE will assign the available working area(s). Since multiple sections can be scheduled into the W155 area simultaneously, SNFOs are responsible for de-confliction of both area and comms prior to the brief. This will enable expeditious coordination with SEABREEZE for area entry and exit.

Upon receiving clearance to a working area, the Lead SNFO will navigate the section to the applicable entry point for the assigned area. During this transit, SEABREEZE should provide clearance into W-155A. Clearance to proceed **to** a working area and clearance **into** a working area are two distinct clearances and should not be confused. If SEABREEZE delays the clearance, or is very slow in providing it, the SNFO is expected to be proactive and assertive to expedite the coordination without undue delay.

As the flight approaches the entry point, SEABREEZE will assign a separate squawk for the Wingman and assign a discrete frequency. Both will be required before SEABREEZE will authorize aircraft to maneuver within the confines of W-155. SNFOs will ensure that all requirements have been met prior to the Entry Point so the tactical portion of the flight may immediately commence. Upon the switch to discrete, Lead SNFO will initiate a check-in on the discrete/Safety-of-Flight (SOF) frequency. The following is an example of the normal comm after the Lead SNFO has acknowledged ATC's switch to SEABREEZE (BTN 15):

Lead SNFO (Aux) - "*Viper, fence in.*"

Wing SNFO (Aux) - "*Two*"

Lead SNFO (Pri, 15) - "*SEABREEZE, ROKT 403, flight of two, request Alpha one and two, discrete*"

SEABREEZE (Pri, 15) - "*ROKT 403, cleared Alpha one and two, 7,000 to FL 300, switch discrete 275.6, have Wingman squawk 4020*"

Lead SNFO (Pri, 15) - "*ROKT 403, cleared Alpha one and two, 7 to 300, switch 275.6, Wingman squawk 4020*"

Lead SNFO (Aux) - *"Viper check Pri"*

Lead SNFO (Pri, 275.6) - *"Viper-11"*

Wing SNFO (Pri, 275.6) - *"Viper-12"*

Lead SNFO (Pri, 275.6) - "*SEABREEZE, ROKT 403 on 275.6*"

SEABREEZE (Pri, 275.6) - "*ROKT 403, loud and clear, radar services terminated, contact me 10 minutes prior to RTB with intentions*"

After both aircraft have checked-in on discrete/SOF, all tactical comms will be made on the SOF frequency. SNFO fuel checks will continue to be made on AUX.

6. **W-155 10 Minute Prior Call/RTB**

Approximately 10 minutes prior to RTB, the Lead SNFO will inform the Wingman that he/she will be off PRI for 1 minute. Lead will switch PRI to BTN 15 and inform SEABREEZE that the flight will RTB in ten minutes with approach intentions (Course rules, PAR, etc.). SEABREEZE will read back the weather, altimeter, and duty runway for NPA. Upon return to the discrete frequency, the Lead SNFO will report back up and pass the applicable weather and runway information to Wing.

The quick transition from a dynamic BFM engagement back to section navigation for the RTB is very challenging. After the Knock-it-off (KIO), the Lead SNFO will direct the Lead IP to descend to 7,000 feet (W155A exit altitude) and provide an initial heading towards the applicable exit point (BEARD, STARR, or ROZIE for Area 1, 2, or 3, respectively). If an altitude higher than 7,000 feet was assigned upon check-in as the bottom of the area, descend to that altitude until cleared lower by SEABREEZE. If the KIO occurs near the northern boundary of the area, execute a descending 360 degree turn to stay in the area until cleared. If for any reason the flight is approaching the exit point without exit clearance, the Lead SNFO will direct the IP to orbit until clearance is obtained.

During the descent while navigating to the exit point, the Lead SNFO will switch the section to SEABREEZE (BTN 15) on PRI and direct the fence out. The Lead SNFO will then coordinate the area exit and subsequent switch to approach. After the KIO call, the comms are as follows:

Lead SNFO (Aux) - "*Viper, switch button 15, fence out*"

Wing SNFO (Aux) - "*Two*"

Lead SNFO (Pri, 15) - "*SEABREEZE, ROKT 403, flight of two, complete Area [1, 2 or 3], RTB course rules*"

SEABREEZE (Pri, 15) - "*ROKT 403, descend and maintain 7,000, have Wingman stop squawk, cleared to Navy Pensacola via STARR, direct, contact approach 270.8*"

Lead SNFO (Pri, 15) - "*ROKT 403, descend to 7,000, cleared NPA via STARR, direct, switching approach BTN 6*"

Lead SNFO (Pri, 6) - "*Approach, ROKT 403, flight of two 7000, atis information <Lima>, course rules*"

7. **Pensacola South MOA Procedures**

The PNSS MOA (Figure 3-2) will be utilized if scheduling conflicts or weather precludes the use of W-155A. The confines and procedures for PNSS MOA use are detailed in the T-45C Student In-flight Guide. The Pensacola South MOA confines are Lo block 10,500 – 16,500 feet, Hi block 17,000 – 23,000 feet (both blocks required for BFM). These altitudes will require adjustment of the "hard deck" and the PADS as necessary, which shall all be pre-briefed or verbalized real time.

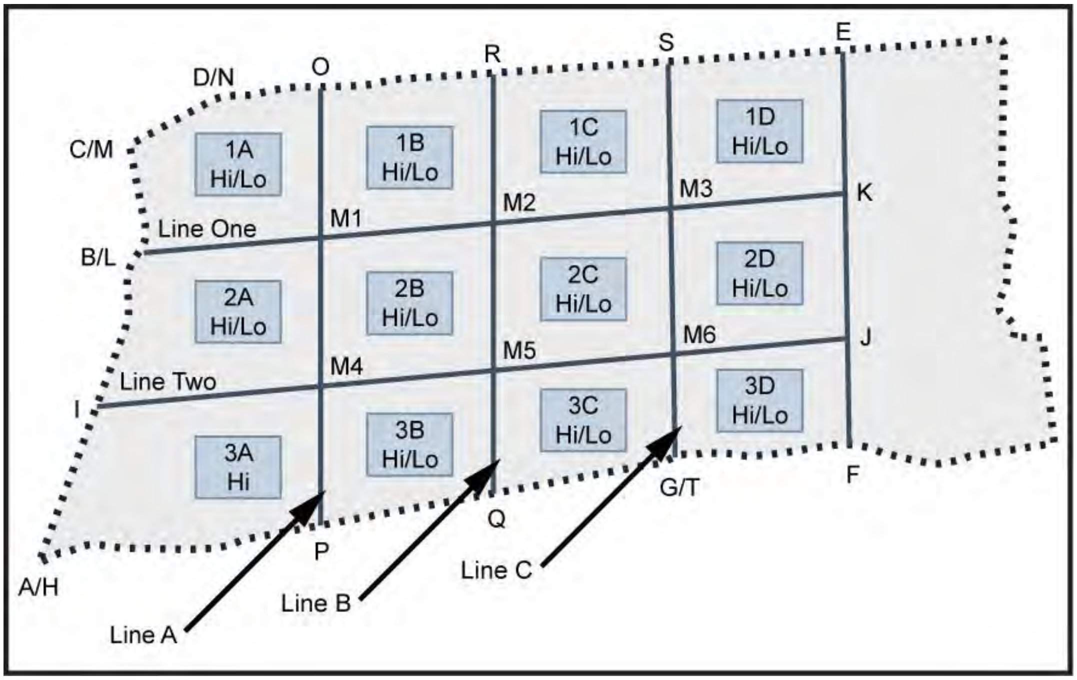

Figure 3-2 PNSS MOA

Because it is a general use area, there are several procedural differences as compared to operating in the Warning Area. For T-45C use, the "HAWK" 1-4 areas can be scheduled. The HAWK 4 (Figure 3-3) is the most common area used at VT-86 and is part of the Sequence 2 standard waypoint load.

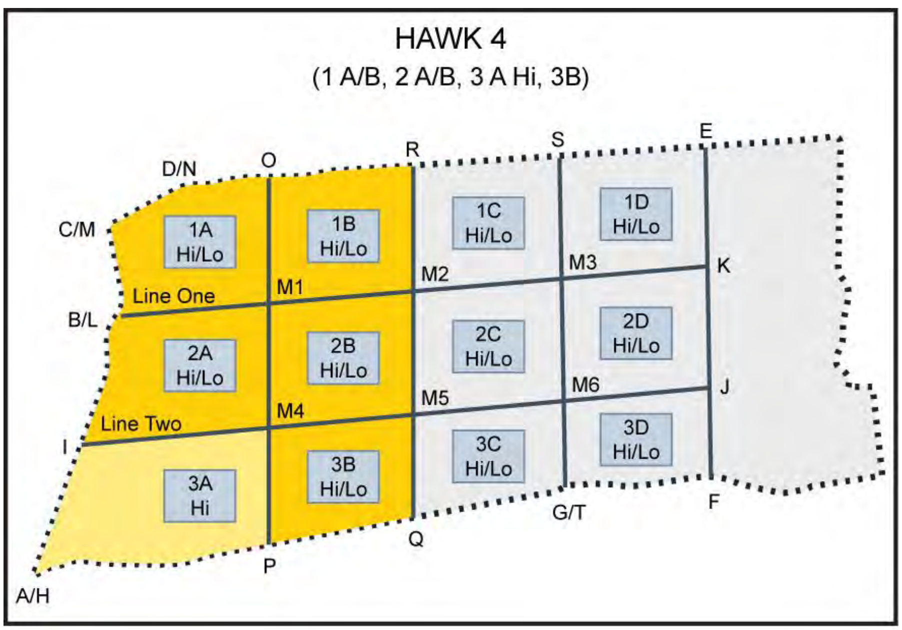

Figure 3-3 HAWK 4 Working Area

Lead SNFO is responsible for all navigation and comms. Lead will switch the flight to BTN 18 and direct the fence-in over AUX. Since the MOA frequency is a common use/SOF frequency, the section will execute a positive check-in on PRI, BTN 18. However, all subsequent tactical and admin comm will be over Tac Freq. For the RTB, the flight will fence-out, execute a descending orbit down to 11,000, get ATIS, and then switch to approach for exit clearance.

8. **Rendezvous**

During any rendezvous, the number one priority for all aircrew involved is the safe and expeditious joining of aircraft. Other tasks should only be accomplished on a "not-to-interfere" basis with our primary responsibility. Rendezvous flow should occur as follows:

a. Rendezvous

b. Fence Out

c. Report Fenced out

d. Battle Damage Checks

e. Wingman in Cruise Formation

f. Pre-Descent Checks

9. **Recovery**

BFM Flights will execute section recovery procedures in accordance with standard section flight procedures. SNFOs should always be prepared to execute weather contingencies (Section Approaches, Individual Approaches, etc.). The flight is not over after the "*Knock-it-Off*."

10. **Emergencies**

Standard section emergencies apply. However, the following specific situations apply to BFM:

a. If an aircraft goes Lost Comm during an engagement, call KIO in the blind and rock the wings. The NORDO aircraft will establish the nearest “safe” altitude (Lead-Odd, Wing-Even) and establish a 30 degrees AOB left turn if no other problems exist. Wait for the other aircraft to join and RTB via NORDO procedures.

b. If an aircraft goes OCF during an engagement, *KIO* is called and the OCF aircrew will execute the OCF procedures to recover the aircraft. Wingman are reminded to consider making an “*Eject*” call over UHF if the OCF aircraft is below the 10,000’ NATOPS ejection altitude and still has not recovered.

11. **Debriefing**

The Debriefing is the most important part of any flight. The majority of learning is accomplished here. For BFM debriefing to be effective, it is broken up into three distinct phases: recall, reconstruction and analysis.

12. **Recall**

The first phase of the debriefing revolves around the ability to remember what actually happened during particular engagements. To that end, there are several means to aid in remembering the details.

a. Notes – The primary and most effective means of recalling the details of a particular engagement. Taking effective notes is an acquired skill that is perishable and requires diligence and practice to maintain. Notes should be prompts to jog the memory. The important things to record are initial start headings and formation (260 degrees, left), passes and headings at merges (R/R, 350 degrees), flow out of merges (2C left), headings of shots, headings going into and out of ditches and knock-it-off headings. With adequate notes and sound reconstruction techniques, SNFOs will begin to be able to recall most engagements. It is recommended for SNFOs to compare notes prior to the debriefing.

b. HUD Tapes – The HUD cannot be relied on as the only source for BFM debriefings. It can be used to verify shots and add detail to certain engagements. HUD tapes merely augment the notes and recall from aircrews.

13. **Reconstruction**

Before an engagement can be analyzed and learning points taken away, an accurate reconstruction of the engagement must occur. There are several methods to reconstruct an engagement during a debriefing. Selection of a debrief method generally revolves around the experience level of the audience.

a. Whiteboard Debriefing – Though time consuming, the whiteboard debriefing is by far the most effective reconstruction tool in regards to debriefing BFM. It is the method of choice for debriefing aircrew with little BFM experience. Providing a God's-eye view of the engagement, it provides the most representative picture of what happened during an engagement. Scale is of the utmost importance: if one marker-length represents one mile at the start of the engagement, that scale must be maintained throughout the reconstruction. Additionally, the length of arrows must be representative of the relative velocity of the aircraft being depicted (i.e., faster aircraft are represented by longer arrows). Figure 3-4 represents the symbology typically used in a whiteboard debriefing.

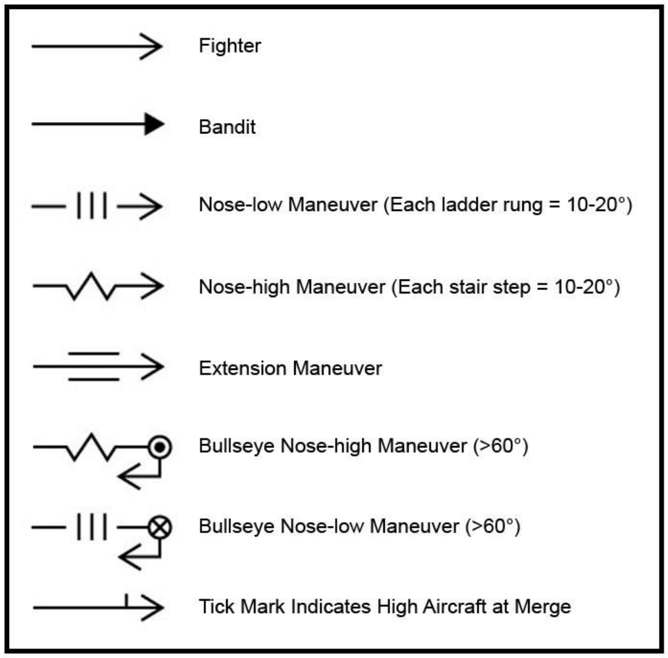

Figure 3-4 Whiteboard Debriefing

b. Model Debriefing – The most important concept to remember when using models is to avoid distractions. Anything that takes attention away from the speaker is a distraction. Common mistakes often found with models are:

i. Using them as pointers

ii. Idle playing with them while talking

iii. Gesturing with them (as they become extensions of your hands)

iv. "Flying the models"

- Flying the models is impractical due to the scale involved. The proper motion of the aircraft through the sky cannot accurately be demonstrated. Most BFM models are 1:72 scale, meaning that 1" on the model corresponds to 72" in real life. At that scale, a 1 NM abeam distance would have to be represented by holding the models 83 feet apart! Even a snapshot of 1,000' would require the models 12' apart. Because it is unrealistic to move the models in a representative fashion, they are used to represent visual sight pictures or general spatial relationships between aircraft via snapshots in time. Movement of the models should be limited to no more than 30-45 degrees of turn, merely for general reference. Finally, if the demonstration is complete, the models should be laid back down until required to demonstrate another sight picture.

c. Chalk-Talk Debriefing – The Chalk-Talk is a debriefing tool commonly used when time or facilities prevent the use of one of the other debriefing tools. It can also be used to quickly debrief simple concepts that do not need to be demonstrated in great visual detail. It is a debriefing tool primarily limited to experienced aircrew with a solid BFM background, who can mentally visualize the BFM arena and BFM concepts. Aircrew with limited experience profit little from the chalk-talk as they do not have the baseline experience often needed to visualize dynamic BFM concepts.

d. Tape Debriefing – Many aircrews are tempted to rely on the HUD tape as a method of reconstruction. While it can provide some useful information in regards to aircraft performance, it does nothing to show the spatial relationships between aircraft during an engagement. For that reason, it should be used more as an analysis tool than a reconstruction tool.

14. **Analysis**

The analysis phase of the debriefing is the portion in which most of the learning is accomplished. A common mistake that occurs during debriefing is to begin analysis of an engagement before an accurate reconstruction has occurred. If a reconstruction is not accurate, especially if there is disagreement as to the conduct of an engagement, any analysis is premature. If all members of the flight do not agree as to what happened, it is unlikely that they will buy-in to the analysis. Likewise, if it is inaccurate, the subsequent analysis may be flawed. The analysis is not started until the reconstruction is complete and all parties agree (to the extent that they can) on the reconstruction's accuracy. Only then can significant learning points be identified. At a minimum, the training objectives should be identified (ditch timing/mechanics, for example). Additionally, any shots taken should be analyzed to determine the validity as well as the reasons for their opportunity.

The HUD tape is referenced to analyze pilot performance technique and parameters during maneuvers. It is also referenced for shot validation. In VT-86 the following Shot Validation criteria will apply:

15. **IR Missile Valid Shot Criteria**

a. At trigger squeeze:

i. HUD in A/A Mode, Witness X in HUD

ii. Target on the waterline, between the airspeed and altitude boxes

iii. Target AOT less than 90 degrees

iv. Range assessed between 0.5 NM and 2.0 NM through the use of yardstick

NOTE

If all parameters met, shot is Valid at Trigger Squeeze, otherwise Invalid

b. For Time-of-Flight (6 sec/NM after Witness X, play tape for TOF):

i. No flares call during TOF

ii. If target is wings level, tail-on (i.e., bugging), utilize the rules of 3:

(a). < 250 KTS opening at 0.5 NM

(b). < 200 KTS opening at 1.0 NM

(c). < 150 KTS opening at 1.5 NM

(d). < 100 KTS opening at 2.0 NM

NOTE

If above parameters met, shot is Valid for TOF, otherwise Defeated by TOF

16. **Gun Tracking Shot**

a. At trigger squeeze

i. HUD in A/A Mode, RTGS Gunsight, Master Arm-On, Witness X in HUD

ii. Target in-phase, in-plane, stabilized under pipper for 1 sec prior to Trigger Squeeze

iii. Target range at 1,000' (wingtip-to-wingtip inside reticle)

iv. Pipper on Target at trigger squeeze

NOTE

If all parameters met, shot is Valid at Trigger Squeeze, otherwise Invalid

b. For Time-of-Flight (play tape for 1 sec after Witness X):

i. No Guns 'D' within TOF (otherwise Defeated at TOF)

ii. Pipper remains over target for TOF (otherwise Invalid for TOF)

17. **Gun Snapshot**

a. At trigger squeeze

i. HUD in A/A Mode, RTGS Gunsight, Master Arm-On, Witness X in HUD

ii. Target in same POM as pipper

iii. Target range at 1,000 feet (wingtip-to-wingtip inside reticle)

iv. Trigger down 1 sec prior to Target flying through pipper

NOTE

If all parameters are met, shot is Valid at Trigger Squeeze, otherwise Invalid

b. For Time-of-Flight (play tape for 1 sec after Witness X):

i. No Guns 'D' within TOF (otherwise Defeated at TOF)

ii. Pipper remains stabilized in same POM as target for TOF (otherwise Invalid for TOF)

iii. Pipper passes over target between TOF and 1 sec after release of trigger (otherwise Invalid for TOF)

305. BFM TAC ADMIN

There are tactical administrative procedures and maneuvers that will be conducted on each of the five BFM flights. The kneeboard card is designed to assist the SNFOs in conducting Tac Admin correctly. The card has a space to recored the environmentals: sun angle, wind and decks. There is also a space for the standard A/A TACAN setting (example: ROKT 403 flight, 3X and 66X). For each of the BFM drills, an ‘H’ is on the card so the start heading can be noted. There are also two aircraft depicted; SNFOs should circle the aircraft that corresponds to the side on which they started the engagement.

Make sure a fuel check is done between every BFM drill or engagement. SNFOs should make the fuel check after the KIO, when both aircraft are established on the flow heading with a visual. Fuel checks are also done with Lead changes. Especially in BFM, monitor the Joker fuel state and pass that fuel state over UHF when reached.

1. **Fence In/Fence Out Checks**

a. Fencing In - Prior to entering the working areas and commencing maneuvers, the Lead shall direct the flight to fence-in over Tac Freq. This call is made to transition the flight from an administrative mindset to a tactical mindset. SNFOs will complete the A/A combat checklist and the Pre-Stall and Aero checklist (both found in the T-45C In-flight Guide as well as in the NATOPS Pocket Checklist). SNFOs should endeavor to complete these checks, except for the G-Warm, before crossing the border of the area in order to maximize the limited time and fuel in the area.

Lead SNFO (Aux) - "*TURBO, switch button 18, Fence In*"

Wing SNFO (Aux) - "*Two*"

Each SNFO will be responsible for completing the A/A combat checks:

i. A/A TACAN - Set/Receiving/TACAN Boxed

ii. HUD A/A Mode - Select (MENU/STRS/ A/A)

iii. A/A Gun Mode - Select RTGS

iv. Wingspan - Verify 31 feet

v. Master Arm - As Briefed (direct IP to arm up)

vi. Tapes - VCR Check ON (direct IP/verify BIT page)

vii. IFF - As assigned

The Lead SNFO will initiate the fenced report, with alibis, over the Tac Freq after completion of the G-Warm.

Lead SNFO (Aux) - "*TURBO 11, Fenced In, 2.5*"

Wing SNFO (Aux) - "*TURBO 12, Fenced In, 2.4, negative yardstick*."

b. Fencing Out

Upon completion of the BFM conduct and safe join up, the Lead SNFO will direct the flight to fence out. In the interest of efficiency, the Lead SNFO should initiate Fencing Out in conjunction with the frequency change to SEABREEZE (W-155A)/Approach (PNSS MOA):

Lead SNFO (Aux) - "*TURBO, switch button 15 Pri, fence out*"

Wing SNFO (Aux) - "*Two*"

Each SNFO will be responsible for setting up the aircraft for the admin RTB:

i. TACAN - A/A Deselected/Set/Receiving

ii. HUD Mode - NAV Mode

iii. IFF - Wingman Standby

iv. Master Arm - Safe (direct IP to safe up)

v. Tapes - VCR Check Off (direct IP/verify BIT page)

vi. Fuel - BINGO Setting set to "Divert" setting

Once both aircraft are fenced out and safely rendezvoused, the Lead SNFO will initiate the "Fenced Out" report.

Lead SNFO (Aux) - "*TURBO 11, fenced out, 1.0*"

Wing SNFO (Aux) - "*TURBO 12, fenced out, .9*"

After reporting completion of the fence out checks, Lead IP will initiate Battle Damage Checks (BDC). It is very important to confirm "fenced out" and all switches safe prior to maneuvering under each other's aircraft.

2. **Weather/Decks/Altimeter**

OPNAVINST 3710.7U requires that the Flight Lead confirm the airspace, weather, type war, hard deck and local altimeter before the commencement of ACM. After fencing in and before executing the first set, the Flight Lead will report those items in the following format:

"*VIPER, welcome to your training event, we have the airspace from 7,000 to FL 400; we have a low scattered layer at 5,000, visibility good in all quadrants; VIPER 11 confirms: all altitudes, clear of clouds, hard deck as briefed, altimeter 29.92.*"

Wing IP confirms by repeating the local altimeter: "*VIPER 12, 29.92.*"

The following are the standardized TOP GUN type war recommendations appropriate for VT-86:

a. "*All altitudes*"

b. "*All altitudes, clear of clouds*"

c. "*High war above XXXX', hard deck XXXXX', clear of clouds*"

d. "*Low war below XXXX', clear of clouds*"

e. "*War between the layers, XXXX' to XXXXX', hard deck XXXXX', clear of clouds*"

3. **Engaging Turns**

Throughout the tactical portion of the flight, whenever the section conducts an engaging turn (Tac or In-place), the SNFOs are responsible for reporting "six clear" and "visual" in the standard manner for section maneuvering. For the purposes of reinforcing those concepts, the following calls are summarized:

a. "Six Clear" - Reported by the either SNFO when his/her aircraft is turning into his Wingman. Made after 90 degree of turn.

b. "Visual" - Reported by the Wing SNFO when reacquiring his/her Lead anytime he turns away from the Lead in an In-Place Turn.

4. **COMM Brevity**

To further enhance section communication, the fighter community has carefully defined tactical in-flight terminology. Utilizing the correct word or phrase will greatly increase situational awareness during an engagement. The following is a list of standardized terminology:

a. Bandit - Known enemy aircraft; does not necessarily give us authorization to employ weapons.

b. Hostile - A BANDIT whose engagement ROE has been met, allowing us to employ weapons.

c. Bogey - A radar/visual contact whose identity is unknown.

d. Tally - Sighting of a target/bandit/bogey; opposite of "NO JOY"

e. Visual - Sighting of a friendly aircraft; opposite of "BLIND" (typically used during 1v1 BFM as our opponent is actually still our Wingman)

f. No joy - No visual contact with target/bandit/bogey; opposite of "TALLY"

g. Blind - No visual contact with friendly aircraft; opposite of "VISUAL" (typically used during 1v1 BFM as our opponent is actually still our Wingman)

h. Knock-It-Off - Term used to stop an entire multi-plane engagement/exercise. In the context of 1v1, used to end a specific engagement/exercise (i.e., Snapshot Drill)

i. Terminate - Term used to stop an isolated engagement without knocking off the overall exercise.

j. Skip it - Typically used during a Snapshot Drill (SSD); equivalent to "TERMINATE"

5. **"PADS"**

While conducting BFM training, numerous formation and tactical setups will be used. The "PADS" acronym is a quick method for referencing the aircraft's setup parameters. Each letter in "PADS" stands for a specific flight parameter and has a specific tolerance:

P – Position
A – Altitude (+/- 100 ft)
D – Distance (+/- 0.1 nm)
S – Speed (+/- 10 KTS)

The specific PADS for each of the maneuvers will be detailed later; the PADS are also depicted for each set on the VT-86 BFM kneeboard cards.

6. **Perch Setups**

Figure 3-5 illustrates the procedural format used for all Perch setups to include:

a. Tail Chase Exercise

b. Offensive/Defensive Maneuvers

c. Intro-to-Ds

d. Uncalled Ds

e. Offensive/Defensive Perch Sets.

Aircraft will start abeam, co-altitude (15K' or 18K', drill dependent), at a half a mile farther than the desired perch distance. When established on the Perch Set PADS, IPs will call "*speed and angels left/right*." The lead IP will then check the flight into the defensive aircraft 50 degrees. The offensive aircraft will pull nose-on and call for the defender to reverse the turn. The offensive aircraft will call out ranges in thousands of feet until the desired range where "*Fox-2*" (with a valid shot) or "*clear to maneuver*" is called. At the "*Fox-2*," the fight is on and the SNFOs will initiate their comm sequence.

Should any unsafe condition develop, a KIO will be called. The defender will roll wings level and maintain altitude while the attacker clears the defender's altitude by 1,000'. Once safely established on a flow heading, the PADS will be reset and the sequence will commence after another "*Speed and Angels*" call.

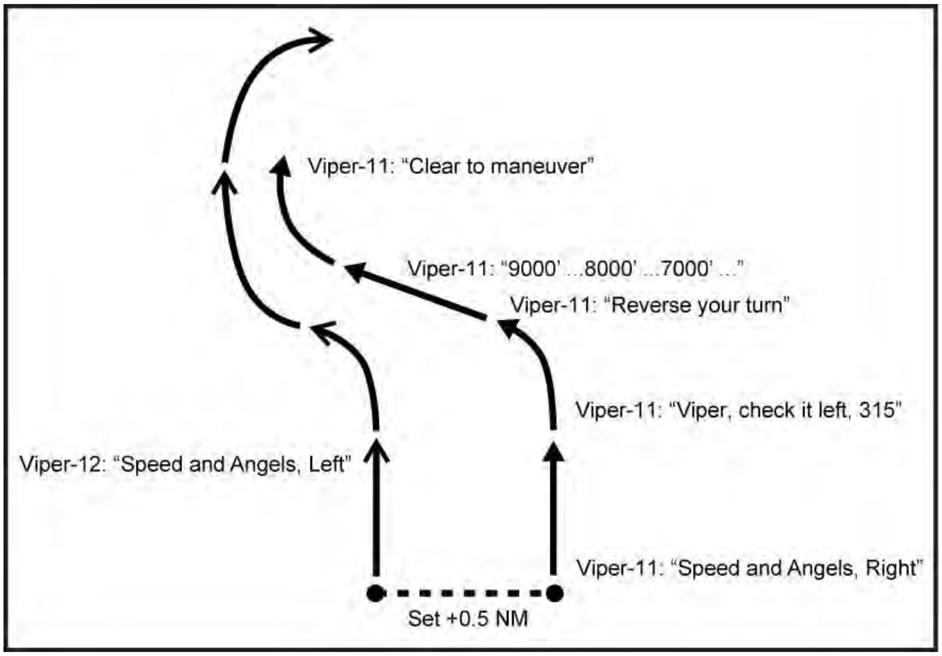

Figure 3-5 Perch Setup

7. **High Aspect Sets**

All High Aspect sets will utilize Butterfly Sets (Figure 3-6) to ensure a neutral sight picture at the merge. The IPs will transmit all high aspect direction-of-pass calls over PRI to ensure safety of flight. Pass calls will be made to "maintain the established trend" as per training rules; do not cross flight paths to force a particular merge.

The PADS for the high aspect sets are: 18K', 300 KTS, 1.5 NM. Lead IP initiates "Speed and Angels," echoed by Wing IP. Lead IP initiates a 30 degree cut away for both aircraft to establish roughly 2.5 NM separation. Prior to 2.5 NM or no later than either aircraft losing sight, either IP can call "turning in, visual" to be echoed by other aircraft. Lead IP at the controls will initiate the pass call, echoed by remaining IP at the controls. Each aircraft will arrive at the merge no closer than 500', 180 degrees out, wings level. Lead IP will call "*Fight's On*" at 3/9 passage, echoed by the Wing IP.

SNFOs will brief safety and de-confliction considerations for high aspect sets in the brief. For example: should an aircraft lose sight approaching the merge, level the wings and transmit "*Blind*." If visual, the other aircraft will maneuver to make a neutral merge happen, trying to talk the blind aircraft on prior to the merge. Should the blind aircraft fail to regain sight prior to the merge, a "*knock-it-off*" will be called, followed by a flow heading for the purposes of regaining sight. If both aircraft lose sight, or there is flight path conflict approaching the merge, either aircraft can call "*knock-it-off*," in which case, the Wing aircraft owns 18K' and the Lead vacates that altitude by at least 500'. Once yardstick shows increasing separation, Lead will call a flow heading for the purposes of regaining sight. With both aircraft visual and back on their PADS, Lead will again initiate the set.

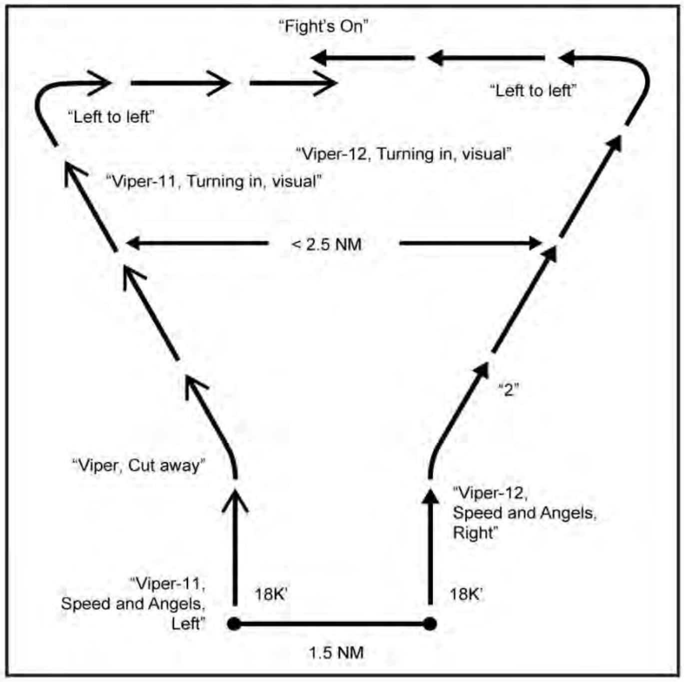

Figure 3-6 High Aspect Set

8. **Knock-it-Off**

The highest potential for a midair collision in the BFM arena exists after the knock-it-off. This is because both aircraft are in close proximity at potentially low energy states and no predictable flow exists. For those reasons, communication and standardization after the "*Knock-it-Off*" call are crucial. During this critical phase of flight, there should be no question as to what is expected and who is to speak next. TOPGUN delineates a clear set of priorities and responsibilities following the knock-it-off:

a. Following initial "*Knock-it-off*" call, all aircraft (including Lead, even if Lead initiated the KIO) establish a "roll call," in order, to acknowledge the KIO.

b. Lead IP provides a flow heading for aircraft de-confliction and to facilitate each aircraft regaining sight

c. Lead IP (directed by Lead SNFO) initiates turns to facilitate area management

d. Lead SNFO initiates a fuel check

e. Flight establishes climb to next PADS parameters as defined by Lead IP

f. Lead IP checks flight to ensure that Wingman is in proper position for the next set

g. Lead IP initiates "*Speed and Angels*"

KIO comm, and follow-on comm sequence, should sound as follows:

Any flight aircrew (Pri) - "*Knock it off, deck*"

Lead IP (Pri) - "*Viper-11, Knock it off*"

Wing IP (Pri) - "*Viper-12, Knock it off*"

Lead IP (Pri) - "*Viper flow 180, Viper-11 is at your left seven o'clock*"

Wing IP (Pri) - "*Viper-12, Visual*"

Lead IP (Pri) - "*Viper, in-place left, 360*"

Wing IP (Pri) - "*Two*"

Lead SNFO (Aux) - "*Viper-11, 2.0*"

Wing SNFO (Aux) - "*Viper-12, 1.9*"

Lead IP (Pri) - "*Viper, climb 18K', 300 Knots, 1.5 miles abeam for the next butterfly set*"

Wing IP (Pri) - "*Two*"

Lead IP (Pri) - "*Viper-11, speed and angels left*"

Wing IP (Pri) - "*Viper- 12, speed and angels right*"

9. SNFO Tactical Responsibilities

SNFOs in the VT-86 BFM syllabus will be expected to show proficiency in the following areas:

a. Solid Admin/Tac Admin

b. Fuel Management

c. Area Management

d. Lookout Doctrine

e. Sensor Nose Recognition

f. Deck Awareness

g. Crew Coordination/BAR

In addition to these overall focus areas, specific drills delineate SNFO responsibilities with regard to a particular objective. For high aspect sets, SNFOs are expected to execute a soundly developed game plan that is based on aircraft weapons capabilities and aircraft maneuvering characteristics. The amount of IP input provide during the execution phase is determined by the "type" engagement (Figure 3-7).

ENGAGEMENT TYPE	ENGAGEMENT CONDUCT
DEMO fight	IP demonstrates concepts and sight pictures.
MAX input fight	SNFO directs maneuvering with maximum IP coaching input.
MIN input fight	SNFO directs maneuvering with minimum IP coaching input.
AUTO fight	SNFO directs maneuvering with no IP coaching input. IP still provides direct, real-time feedback to facilitate learning and prevent negative training.
CREW fight	SNFO and IP work together as a tactical team. SNFO will concentrate on lookout, sensor nose recognition, deck transitions and BAR.

Figure 3-7 Engagement Type

306. BFM SYLLABUS

The BFM syllabus consists of five flights. Each flight is designed to maximize fuel efficiency and therefore optimize training. It is imperative that SNFOs arrive to the brief well prepared with solid procedural knowledge. The items to be covered during each flight are listed below, and SNFOs are required to be familiar all items for the respective event. Each flight in the series builds upon the previous flights.

1. **BFM 4001**

   a. Eyeball Calibration Exercise (DEMO) - 15K'/300 KIAS/1.0 NM

   b. Snapshot Drill (DEMO) - 15K'/300 KIAS/1.0 NM

   c. Intro-to-Ds (6 total) (MAX) - 15K'/300 KIAS/1.5 NM

   d. Flat Scissors Drill (DEMO) - 15K'/300 KIAS/1.5 NM

   e. Rolling Scissors Drill (DEMO) - 15K'/300 KIAS/1.5 NM

   f. High Aspect Flow Demo (DEMO) - 18K'/300 KIAS/1.5 NM

g. Performance Characteristics (DEMO)

h. Accelerated Stall

i. High AOA/Deep Stall Investigation

j. 70 Degrees Nose-High Departure

k. Level vs. Unloaded Accelerations

l. Hard Turns vs. Energy Sustaining Turns

m. G-Available Exercise

n. TACAN Rendezvous

2. **BFM 4002 (Offensive/Defensive Perch)**

a. Snapshot Drill (MAX) - 15K'/300 KIAS/1.0 NM

b. Uncalled Ds (4 total) (MIN) - 15K'/300 KIAS/1.5 NM

c. 9K' Perch (DEMO) - 18K'/350 KIAS/2.0 NM

d. 6K' Perch (MAX) - 18K'/350 KIAS/1.5 NM

e. 3K' Perch (MIN) - 18K'/250 KIAS/1.0 NM

f. Repeat (as necessary/fuel permitting)

3. **BFM 4003 (Offensive/Defensive Perch)**

a. Snapshot Drill (MAX) - 15K'/300 KIAS/1.0 NM

b. Uncalled Ds (4 total) (MIN) - 15K'/300 KIAS/1.5 NM

c. 9K' Perch (DEMO) - 18K'/350 KIAS/2.0 NM

d. 6K' Perch (MAX) - 18K'/350 KIAS/1.5 NM

e. 3K' Perch (MIN) - 18K'/250 KIAS/1.0 NM

f. Repeat (as necessary/fuel permitting)

4. **BFM 4004 (High Aspect BFM/Game Plan Development)**

   a. Snapshot Drill (MIN) - 15K'/300 KIAS/1.0NM

   b. Uncalled Ds (4 total) (AUTO) - 15K'/300 KIAS/1.5 NM

   c. High Aspect Sets (x4) - 18K'/300 KIAS/1.5 NM

   d. MAX, MIN, AUTO, CREW Fights

5. **BFM 4190 (High Aspect BFM/Game Plan Development Check Flight)**

   a. Snapshot Drill (MIN) - 15K'/300 KIAS/1.0 NM

   b. Uncalled Ds (4 total) (AUTO) - 15K'/300 KIAS/1.5 NM

   c. High Aspect Sets (x4) - 18K'/300 KIAS/1.5 NM

   d. MAX, MIN, AUTO, CREW Fights

307. BFM EXERCISES/DRILLS

Prior to executing high aspect 1v1 BFM, the SNFO will be introduced to various sight pictures and scenarios. The most efficient manner in which to introduce these items is through a series of drills and exercises that emphasize specific learning points. These drills/exercises will be introduced on the early stage flights.

1. **Eyeball Calibration Exercise**

   - **PADS**: 15K'/300 KIAS/1.0 NM Abeam

The dynamic nature of the BFM arena is fast-paced and requires aircrews to be “heads out” the majority of the time during an engagement. In addition, closure rates generated between two aircraft often exceed the computing capabilities of our aircraft systems (yardstick in the T-45, specifically). For that reason, it is vitally important to be able to discern an opposing aircraft’s range using eyeball and relative size comparisons to HUD symbology (stadiametric ranging). The BFM syllabus will incorporate an Eyeball Calibration Exercise to cage the SNFO’s eyeball to the sight picture of a T-45 at known distances and aspects. An Eyeball Calibration Exercise will be performed for each SNFO from each perspective, with a Lead change in-between.

Aircraft will start from an abeam position at 15,000 feet, 300 KIAS and 1.0 NM. The Wing aircraft will be given the Formation Lead for the purposes of the exercise and will maintain airspeed and altitude while observing the exercise. At one nautical mile, the Lead aircraft will roll left and right to show the Wing SNFO both the top and bottom of the aircraft at a mile. At one nautical mile, the SNFO should be able to break out the canopy from the rest of the aircraft.

The Lead will then take a cut away to establish his aircraft at 1.5 NM, again showing the Wing SNFO the top and bottom of the aircraft. At 1.5 NM the SNFO should not be able to discern the canopy against the top of the aircraft.

Lead will then direct the Wing to take a 45 degree cut away, pulling nose-on and calling for Wing to reverse his turn. The Wing will establish a 30 degree AOB turn into the Lead, maintaining 15,000 feet and 300 KIAS. Lead will close the distance, nose-on, calling out slant ranges. During this rendezvous, Lead will point out significant milestones with “sensor nose on,” to include the limits of the IR missile envelope, the beginning of the gun envelope and the 1,000’ min range directed by training rules. Passing 1,000 feet, Lead will direct the Wing to roll wings level, whereupon he will cross under and show the SNFO a 500’ position on the opposite side (to demonstrate the limits of the 500’ safety bubble). Once stabilized 500’ abeam, Wing will pass the Formation Lead back to Lead. Figure 3-8 illustrates the Eyeball Calibration Exercise.

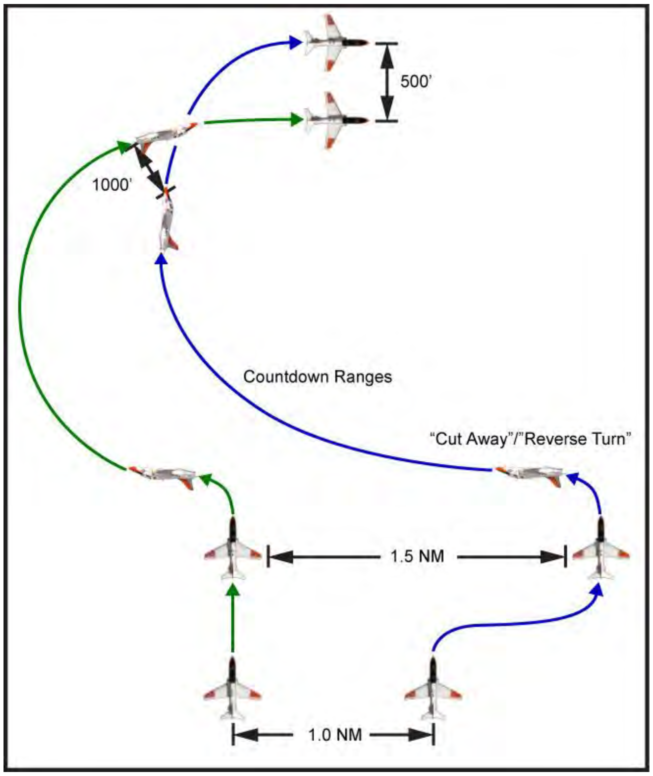

Figure 3-8 Eyeball Calibration Exercise

2. **Snapshot Drill**

a. PADS: 15K'/300 KIAS/1.0 NM Abeam

The Snapshot Drill (SSD) is a cooperative maneuver designed to teach employment of the gun at high angle-off (Figure 3-11). More importantly, the SSD is an eyeball calibration exercise that will be executed prior to every BFM flight, both in the training command and after. The SSD provides an ideal environment to capture the sight picture, both offensively and defensively, of an attacking aircraft at a range of 1,000 feet, which is the ideal range for a "trigger down" call.

The SSD will be set up with the shooter and target aircraft 1.0 NM abeam at 300 KIAS and 15,000 feet. As with all BFM setups, the drill will begin with "*Speed and Angels*" calls initiated by the Lead IP, and echoed by Wing, once the PADS parameters are achieved. The Lead IP will always initiate the comm, calling "in" with his role as either shooter or target. The comm sequence will be as follows:

Lead IP - "*Turbo 11, Speed and Angels left/right.*"

Wing IP - "*Turbo 12, Speed and Angels right/left.*"

Lead IP - "*Turbo 11, In shooter.*"

Wing IP - "*Turbo 12, In target.*"

The two aircraft will turn in towards each other with the "target" placing and holding the shooter at the 10 or 2 o'clock position and the "shooter" solving for the three basic parameters: Lead, range and POM. The shooter will call "*Trigger Down*" when all three are solved and call "*snap*" with an assessment (good, high, low, un-assessable, etc.) when the bullets have reached target range at time-of-flight.

Generally, three Snapshots will be flown for each student as illustrated in Figure 3-9. On the last Snapshot, the Lead IP will call, "*Turbo 11, In target/shooter, maneuver.*" As the shooter approaches the Snapshot envelope, the target student will call for a "*Guns 'D'*." At this command, the target IP will put a wingtip on the attacker and maneuver out of plane (up or down) to defeat the Snapshot. Upon completion of the first maneuvering run, the aircraft will swap rolls but Lead will maintain the comm Lead, calling in with his role as Target.

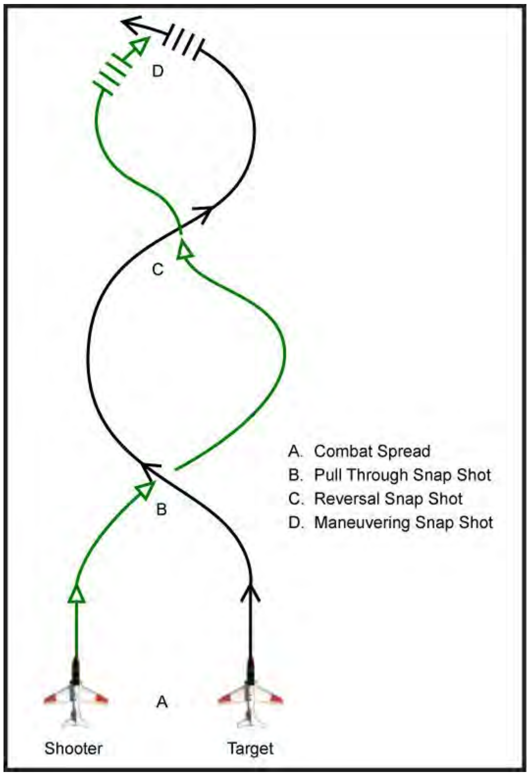

Figure 3-9 Snapshot Drill

b. Safety

If an unsafe situation develops, any member of the flight can call "*Skip it*," "*Terminate*" or "*Knock-it-Off*." If either of these calls is made, the shooter will break off the attack and all aircraft will recover to level flight. If there are any flight-path deconfliction issues at the merge, the target owns the outside of the turn and up, the shooter owns the inside of the turn and down. Lead IP will call for a flow heading and each aircraft will maneuver to achieve that flow heading, 1 NM abeam, co-altitude at 300 KIAS. Once stabilized, Lead IP will again call "*in*" with his role, repeating the "skipped" run. In the event of a "*Knock-it-Off*," maneuvering flight will not be continued until PADS are reset and "*Speed and Angels*" is called/echoed.

c. SNFO Responsibilities

In addition to striving to achieve a solid eyeball calibration, SNFOs will be responsible for calling "*Trigger Down*" when offensive and "*Guns 'D'*" when defensive over the ICS. SNFOs will use real-time feedback from the IP and the other aircraft to adjust timing throughout the exercise.

3. **Performance Characteristics Exercise**

The purpose of the performance characteristics exercise is to demonstrate the performance capabilities of the aircraft as it relates to the E-M Diagram (Figure 3-10). The exercise will demonstrate timed accelerations and timed turns, as well as instantaneous "G" available at different airspeeds.

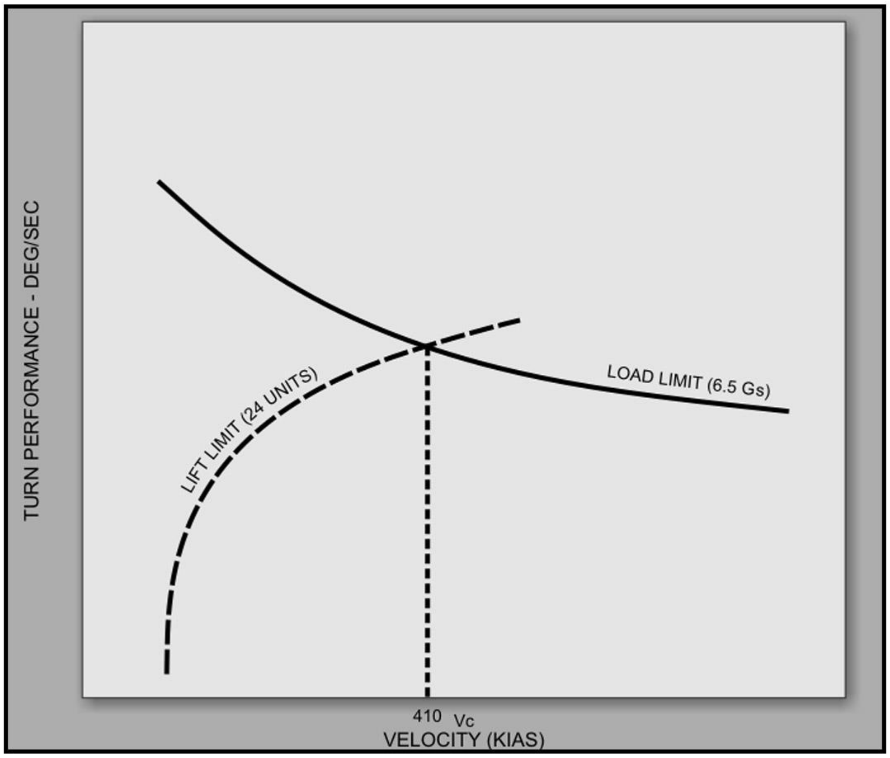

Figure 3-10 E-M Diagram

The maneuvers will be demonstrated independent of the other aircraft. To initiate the exercise, the section will divide the working area and take flight separation. At 15,000 feet MSL, the following performance exercises will be demonstrated:

a. Timed acceleration from 250 to 300 KTS straight and level at MRT.

b. Timed acceleration from 250 to 300 KTS unloaded at "zero G." The timed accelerations will demonstrate the advantage of unloading the aircraft for rapid energy addition.

c. Timed turn at 14 units AOA for 180º of turn maintaining 300 KIAS.

d. Timed turn at 17 units AOA for 180º of turn maintaining 300 KIAS. The timed turns will demonstrate the higher turn rate available at 17 units AOA versus 14 units AOA. During the 17 unit AOA turn however, a loss of airspeed will be expected as a performance tradeoff for the increased turn rate performance.

e. Instantaneous "G" available at 250 KTS.

f. Instantaneous "G" available at 350 KTS.

4. **Stalls and Departures**

Numerous stalls and departures will be flown to demonstrate the edge of the aircraft's envelope. During a BFM engagement, maximum performance from the aircraft will be demanded. The stalls and departures will demonstrate aircraft performance and handling characteristics at the "edge of the envelope." The tactical crew must be able to fly the aircraft to the limits of the envelope in order to take full advantage of its capabilities. Thus, it is likely that the limits will occasionally be exceeded and the crew may suddenly be in uncontrolled flight. Although sometimes spectacular, it is a phase of flight that should not be feared; it is a natural consequence of flying the aircraft to its limits. Every tactical aviator must be prepared to handle uncontrolled flight by:

a. Knowing the Aircraft. Study the NATOPS Flight Manual, particularly the "flight characteristics" sections of NATOPS. Know the associated AOA's cold (i.e., expect rudder shakers at 21.5 units AOA etc.).

b. Knowing the Procedures**.** The recovery procedures must become second nature. The stall recovery and out-of-control flight recovery procedures must be emphasized during flight preparation. In VT-86, the T-45C OCF procedure will be reviewed prior to every flight and shall be briefed VERBATIM.

c. Being Patient! Hasty direction of control application can aggravate the recovery.

d. Checking the Altimeter. When the aircraft is out of control, the altitude becomes time. NATOPS will dictate altitude limits for out-of-control flight. Knowledge of such NATOPS limitations is crucial.

Out of control flight is simply another phase of flight with which every tactical aviator must be familiar. By knowing the procedures and maintaining a cool head, the aircraft control should quickly be regained.

5. **Departure/Spin Recovery Procedures**

Forcefully centering the rudder pedals and neutralizing the control stick usually recovers the aircraft from a departure. The rudder is forcefully centered to stabilize the control surfaces in a fixed position and prevent any surface blow outs. If the rudder blows out due to sideslip forces, a spin is possible and recovery will be delayed. Extended speed brakes are destabilizing and may aggravate the departure and delay recovery. They must be retracted to provide as much smooth airflow as possible across the aircraft. Engine anomalies should be expected following any departure. Retarding the throttle to idle will minimize engine problems but will not eliminate the potential for a flameout or locked-in surge.

You should check the altitude, AOA, airspeed, and turn needle to monitor your recovery progress or to determine if you are in a spin. Altitude will tell you if time is available to attempt recovery or if you are at your minimum altitude limit. With altitude underneath you, you can verify the AOA and confirm if you are in a spin or not. If AOA is pegged at 0 units, airspeed is oscillating between 50 and 160 KIAS, and the turn needle is pegged, then the aircraft is in an inverted spin. Although a stabilized upright spin is unlikely, it would be indicated by AOA above 28 units with similar airspeed and turn needle indications.

Patient and deliberate assessment of these parameters will enable you to direct and verify the correct anti-spin controls. Do not rush through these steps. While timely control inputs are very important, the correct inputs are essential and take precedence over the speed of their application.

6. **Departure Checklist**

The Departure Checklist must be completed prior to the first departure.

a. Stall/aero checklist – complete

b. Lap belts – tighten

c. Helmet visor – tighten down

d. Rudder pedals – adjust aft for full throw

e. Shoulder harness – locked

f. Landing gear and flaps/slats – up; speed brakes – retracted

g. BATT switches – on

h. CONTR AUG – SBI

i. Turn needle, airspeed, AOA – check operation

j. ICS – hot mic

k. Throttle friction – set

After the IP returns the aircraft to wings level following the maneuvers, check that the oil pressure warning light is out before adding power. It is possible that, during gyrations, the oil may cavitate out of the pump, and oil pressure may drop to zero. If all engine instruments are indicating normally, the IP will add power. When the IP recovers from the last departure, you and your IP will complete the post-departure checklist.

7. **High AOA/Deep Stall Investigation/Rudder-Induced Departure**

This maneuver will begin with an exploration of the fully stalled characteristics of the T-45C. Previously practiced stalls focused on recognition and recovery from the onset of the stall. This maneuver will demonstrate the flight characteristics much farther into the stall, up to approximately 30 units AOA.

Before entering a high AOA/deep stall condition, you should know what indications to expect. You will not necessarily experience all of the following indications of deep stall, nor will you experience them in any particular sequence:

a. Increasingly heavier buffeting as stall deepens

b. Yaw rate

c. Increasing sink rate

d. Wing drop

e. Reduced lateral control

The maneuver begins above 20,000 feet with landing gear, flaps/slats, and speed brakes retracted. The IP will reduce power to IDLE rpm and raise the nose 10 degrees to trade altitude for airspeed as the aircraft slows to 20 units AOA. The IP will not trim past 150 KIAS. You should notice that the rudder and aileron effectiveness will be adequate at 20 units.
As the IP increases AOA, you will get the rudder shakers and stall tone at 21.5 units. At 23 units, buffet onset occurs with very little warning. As you slowly increase the AOA to 24-26 units, you will experience light to moderate buffet and wing rock that is controllable with rudder. At 25-26 units AOA, the aircraft will be in light to moderate buffet, and you may encounter mild porpoising. Notice that the rudder and aileron effectiveness are reduced. Notice the adverse yaw generated by aileron deflection.

The IP will increase the AOA to 28-30 units by smoothly but firmly applying full back stick. You will experience heavy buffet, wing drop, stall noise, and a large sink rate. Airspeed will be approximately 110-120 KIAS. In this condition, the aircraft is fully stalled, and aileron effectiveness is marginal. The IP will attempt to maintain wings level with rudder only; aileron will not be used to counter any roll tendencies. If the aircraft rolls into an angle of bank of 90 degrees or more, the IP will recover. If the IP is able to hold wings level with rudder, he will induce a departure using rudder only by maintaining full back stick and input half rudder in one direction to achieve greater than 30 degrees AOB. He will then attempt to return to level flight by inputting full rudder in the opposite direction. The aircraft should start to roll in the direction of the last rudder input, then quickly roll back into the initial direction and depart.

Anytime maneuvering is attempted below 120 KIAS, SNFOs should question whether the IP has control of the aircraft by asking "*Do you have control?*" If the IP responds with "*NO*" or if the aircraft departs, the SNFO will recite/direct the OCF procedures. The aircraft will quickly recover, and airspeed will begin to build. The IP will recover to the nearest horizon at 150 KIAS minimum with AOA between 5 and 20 units by rolling wings level and commencing an optimum AOA pullout (17 units). The IP should avoid pulling into an accelerated stall during recovery. After recovery and before adding power, check OIL PRESS light out so the IP can set power for next maneuver.

8. **Accelerated Stall**

The accelerated stall and recovery demonstrates the characteristics of and recovery techniques for a high-speed stall. It illustrates that excessive AOA, regardless of the cause, will result in a stall. In this stall, however, higher G forces cause the stall to occur at a higher airspeed.

Review the stall and aerobatic checklist. Once established at 280 KIAS, the IP will set the power to maintain airspeed. You will roll into a 70 to 80 degree AOB turn and apply back stick pressure through the onset of buffet and into a stall. Because the stall buffet is very clear, it provides good warning of the stall. Stall characteristics may include a wing drop, pitch oscillations, or the control stick reaching the full aft position. With all these parameters met, you can expect the aircraft to stall within the first 90 degrees of the turn.

To recover, the IP will simultaneously release back stick pressure, advance the power to MRT, and roll wings level. The maneuver is complete when the wings are level and the aircraft is in a level flight attitude. Recovery is immediate when back stick pressure is relaxed.

9. **70 Degree Nose-High Departure**

The objective of this low airspeed departure is to demonstrate the effects of inertia and loss of aerodynamic forces. At zero airspeed, the only forces acting on the aircraft are gravity and the inertia generated before reaching zero airspeed. If the IP holds the controls neutral, the effect of gravity will cause the aircraft to seek the relative wind. As the aircraft accelerates, flight controls will become effective before the AOA is reduced below stall. Consequently, any lateral control input (stick or rudder) will introduce a yaw rate. Coupled with a stalled AOA, this is a pro-spin input.

Low airspeed departures can occur anytime airspeed is so low that aerodynamic forces are negligible, and the aircraft is functionally ballistic. This can occur above 0 KIAS and in any nose-high attitude (not necessarily vertical). The IP will not initiate any low airspeed departures within 20 degrees of pure vertical.

To enter the 70 degree nose-high departure, start at 300 KIAS minimum and no lower than 16,000 feet AGL. The IP will initiate a smooth 15-17 unit pull to 70 degrees nose-high and reduce power to idle as the aircraft decelerates below 150 KIAS. The IP will apply aft stick as necessary to maintain 70 degrees nose up (referencing the ADI) while decelerating. The IP should not use trim in this maneuver. The departure is indicated by airspeed decreasing to 0 KIAS (actually 50 KIAS is the minimum on the airspeed indicator) and the nose falling. The IP will neutralize flight controls as they become ineffective and will not try to counter any oscillations as the nose falls through. At near-zero airspeed, there will not be enough control authority to prevent oscillations. Any deviations from neutral may aggravate the situation as airspeed increases. If performed correctly, you should notice that the inertia of the aircraft will carry the nose through 90 degrees nose-low during recovery until the aerodynamic forces increase and allow the aircraft to seek the relative wind. As airspeed increases through 160 KIAS (the OCF minimum recovery airspeed), the SNFO shall direct the IP to recover to the nearest horizon as was done in the high AOA/deep stall departure.

The student should notice the imminent departure from controlled flight. As the airspeed decreases below 120 KIAS, the SNFO shall ask the IP “Do you have control”? If the answer is “NO,” then the SNFO should start verbalizing the OCF procedures, verify their input, and assess whether the aircraft is in a spin and react accordingly.

10. **Post Stall/Post Departure Scan**

After returning the aircraft to level flight following each of the above maneuvers, check that the oil pressure is normal before adding power. This is accomplished by looking at the OIL Warning light and verifying it is NOT illuminated. It is possible that during the gyrations, the oil may cavitate out of the pump, and oil pressure may drop to zero. Perform a thorough scan of all your instruments and standby indicators for correct indications. Upon completion of the last maneuver, the STBY ADI will most likely have to be realigned and erected.

A careful post-flight inspection of the aircraft will be made upon returning from flights during which departures have been conducted. Look for popped rivets, loose or missing screws and fasteners, and wrinkled or cracked skin. Emphasis should be placed on the empennage area during this inspection.

11. **TACAN Rendezvous**

A TACAN rendezvous is a procedure commonly used to rejoin flights that have been separated, either intentionally or following a lost-sight scenario.

The section Lead will commence his rendezvous turn at any pre-briefed TACAN fix, altitude, direction of turn, and airspeed (usually 250 KIAS). Upon reaching the fix, the section leader will call "*Call Sign - Point 1*" and commence a 30 degrees angle-of-bank turn (Figure 3-18, left side). The Lead will call the four points of the circle as they are overflown. The Wingman will maintain an altitude separation of 1,000 feet below the Lead's pre-briefed altitude until each aircraft has the other in sight. At this time, the Wingman should affect a co-altitude rendezvous on the inside of the Lead's radius of turn (Figure 3-11, right side).

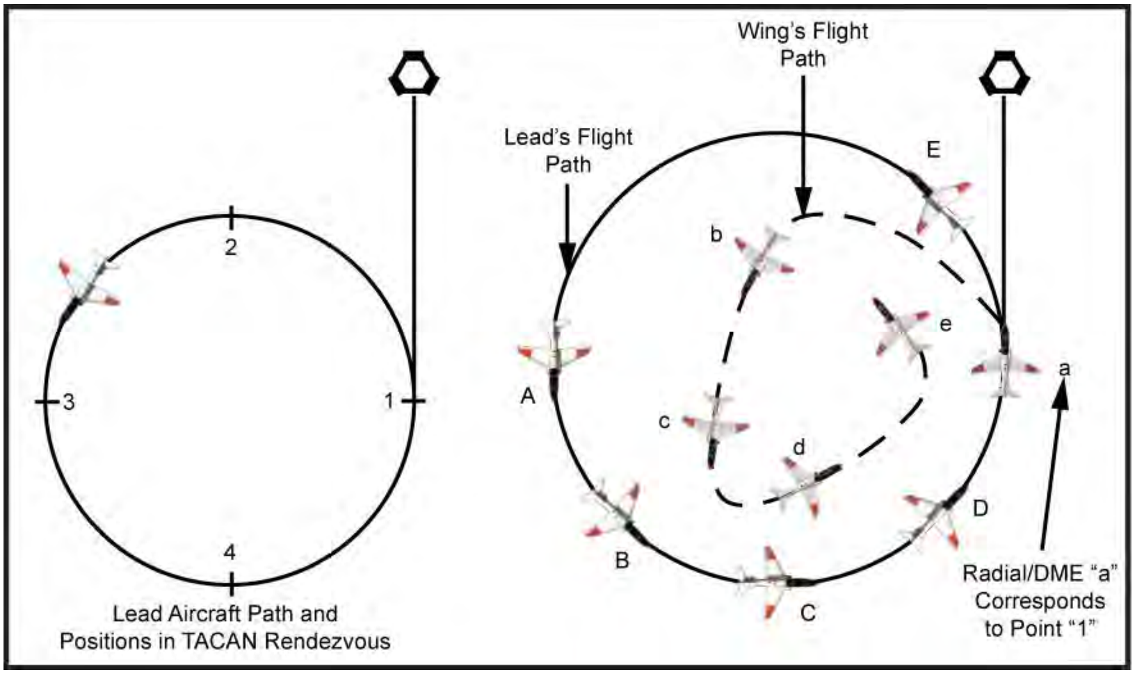

Figure 3-11 TACAN Rendezvous

In Figure 3-11, as the Wingman arrives at Point 1, the Lead is at Point 3. (A/a) The Wingman should maneuver his aircraft to point his nose ahead of the Lead's aircraft (B/b). Using lead and lag the Wing IP will rendezvous with the Lead. To expedite the rendezvous, the Lead may choose to join on the Wingman. Aircraft positioning may make such a scenario (lead joining on Wing) more effective. In either case, the student in the joining aircraft will monitor closure and call out airspeeds as required.

12. **Flat Scissors Drill**

- PADS: 15K'/300 KIAS/1.5 NM Abeam (CTM = 40degrees AOT @ 6000')

The Flat Scissors Drill (Figure 3-12) will be initiated from a perch setup as delineated in the Tac Admin portion of this chapter. At the "*Fox-2*" or "*Clear to maneuver*" call, the defensive SNFO will initiate the appropriate comm calling for the IP to "*Break Left/Right*" over the ICS and calling "*Flares*" over the UHF. The offensive aircraft will continue to press the attack, pulling excessive lead. The defending SNFO should note the high closure rate caused by the excessive lead and should note to his IP the continued attack with a "*Lift vector on*" call. The attacker will then execute an in-close overshoot. The defender will capitalize from this mistake by reversing. The defensive SNFO will direct this reversal, calling for the IP to "*Reverse nose-high; pull for his six.*" Once both aircraft are established in the Flat Scissors, both the offensive and defensive SNFOs will direct the maneuvering of the aircraft, each with their own responsibilities.

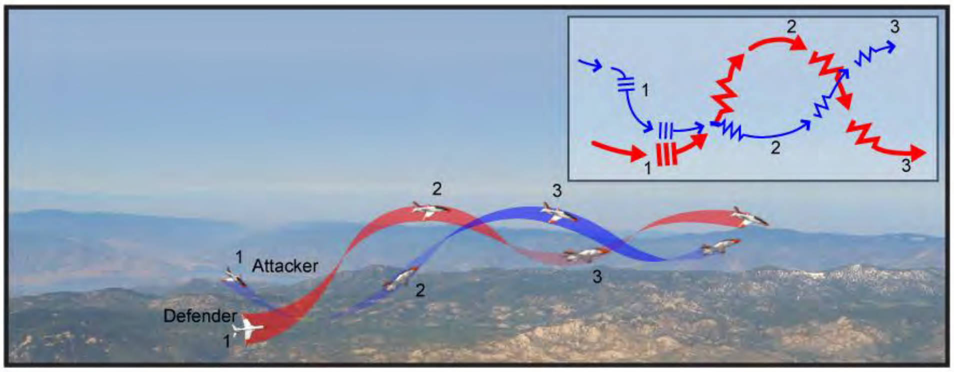

Figure 3-12 Flat Scissors Drill

13. **Offensive Maneuvering in a Flat Scissors**

The ultimate goal of the offensive aircraft in a Flat Scissors is to maneuver into a position to employ the gun. However, the primary responsibility is to maintain the offensive advantage. Because the Flat Scissors is a one-circle fight in which the goal is to slow the aircraft's down-range-travel more than the other aircraft, proper lift vector placement and reversal timing are the primary objectives. After each reversal, the SNFO will call for his IP to place the lift vector behind his opponent: "*Pull for his six*." After he has achieved the proper lag lift vector placement, reversal timing becomes the next objective.

The offensive aircraft is always striving to arrive in-phase, in-plane, with RAC under control. This is accomplished in the same fashion as was done in the SSD. If the range is at least 1,000 feet, it is preserved with an early turn. This is called by the SNFO over the ICS, "*Early Turn*." If the range is less than 1,000 feet nose-to-tail, the SNFO should continue to pull behind the opponent until the nose is behind him. Once the nose is behind the opponent, the offensive SNFO will call "*Reverse*." At any time, if a gun employment opportunity develops, the offensive SNFO should call "*Pull for the shot*."

14. **Defensive Maneuvering in a Flat Scissors**

The goal of the defensive aircraft in a Flat Scissors is to "maneuver to survive." Like the offensive aircraft, the defender will maneuver his aircraft so as to reduce his down-range travel through the proper use of lift vector placement. To accomplish this, the defensive SNFO calls "*Pull for his six*" after each reversal. In addition, the defender is always trying to keep the offensive aircraft out-of-phase and out-of-plane to deny him a high percentage gun tracking shot. Reversal timing is critical. The defensive SNFO will call for the defender's reversal with a "*Reverse" call*:

a. No earlier than the attacker going into lag

b. No later than the attacker crossing the defender's extended six

The timing of the reversal within this window is entirely dependent on the track crossing rate of the offensive aircraft. The sooner the reversal can be executed, the more out-of-phase the defender can get with the attacker. With a high track-crossing-rate, the defender should reverse as soon as the attacker's nose falls behind him. If the track-crossing-rate is low, the defender might have to wait until the attacker crosses his six. Most importantly, if the defender sees the attacker solving for the "Big Three," the first axiom of defensive BFM must be observed: "maneuver to survive." In this situation, the defensive SNFO will call "Guns ‘D’" any time an impending gun employment opportunity by the attacker is recognized.

15. **Rolling Scissors Drill**

- PADS: 15K'/300 KIAS/1.5 NM Abeam (CTM = 40degrees AOT @ 6000')

Like the Flat Scissors Drill, the Rolling Scissors Drill (Figure 3-13) will be initiated from a perch setup as delineated in the Tac Admin portion of this chapter. At the “*Fox-2*” or “*Clear to maneuver*” call, the defensive SNFO will initiate the appropriate comm., calling for the IP to "*Break Left/Right*" over the ICS and calling "*Flares"* over the UHF.” The offensive aircraft will continue to press the attack, pulling excessive lead. The defending SNFO should note the high closure rate caused by the excessive lead and should note to his IP the continued attack with a "*Lift vector on*" call. The attacker will then execute an in-close overshoot and the defender will capitalize on this mistake by reversing. The defensive SNFO will direct this reversal, calling for his IP to "*Reverse nose-high; pull for his six*." The defender will pull his nose up in the reversal to arrive above the attacker with a 90 degree heading difference off the attacker’s nose. Since this is a cooperative maneuver, at the overshoot, the attacker will turn level across the horizon to position himself underneath the defending aircraft.

The goal of the attacker is to reach the 90 degree heading difference between the two aircraft at a position directly under the defender with a minimum separation of approximately 2,000 feet. This stacked separation, with a 90 degree heading difference, is the neutral starting point of the Rolling Scissors. Once the high aircraft has achieved a position behind the low aircraft's 3-9 line (but no later than the low aircraft starting nose-high), the high SNFO will call for his IP to "*Roll*" and then "*Lag him*." As the aircraft is approaching the bottom of a neutral roller, the SNFO will call "*Nose-high, pull for his six*." As with the Flat Scissors, the goal of an aircraft in a roller is to reduce the down-range travel. If offensive in the roller, the SNFO can start working lead pursuit uphill to gain angles or for weapons employment: "Lead him.” As always, crew coordination is paramount. SNFOs should be giving their IPs airspeed calls as the aircraft goes up, and altitude calls as the aircraft goes nose-low. Additionally, anytime a weapons employment opportunity is recognized, SNFOs should be calling "*Pull for the Shot*" or "*Guns ‘D’/Break (left/right), flares*" as appropriate.

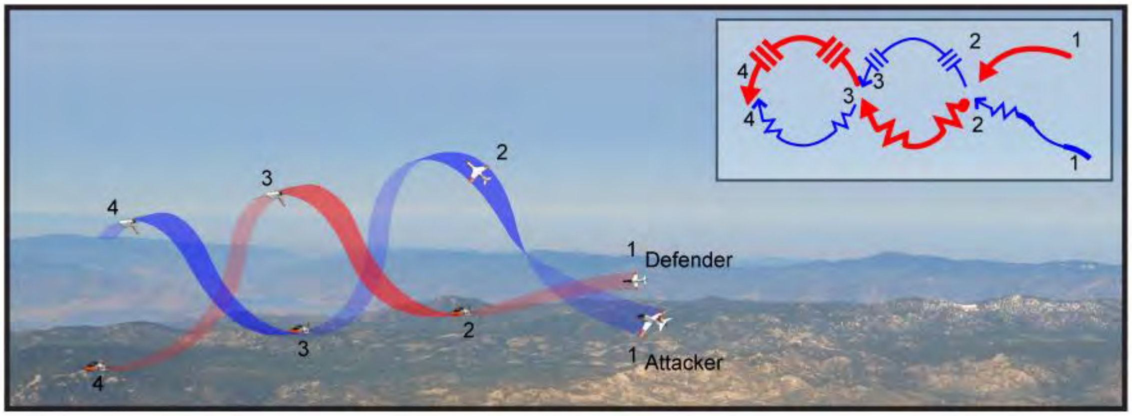

Figure 3-13 Rolling Scissors Drill

Due to the limited thrust-to-weight of most aircraft, the Rolling Scissors tends to be a descending fight, with each subsequent roll bringing the two aircraft closer to the hard deck. Approximately 3,000' is required for a T-45 to execute one complete roll in a Rolling Scissors. As the aircraft in a roller approach the deck, one of them will have to redefine the Rolling Scissors due to insufficient altitude to accomplish a complete rolling maneuver. This redefinition is typically accomplished through a horizontal reversal at the top of the roller, resulting in the fight transitioning to a Flat Scissors. Should SNFOs recognize that they have less than 3,000' above the deck at the top of the roller, they should call "*Reverse*" vice "*Roll*" to transition the fight into a Flat Scissors.

16. **Intro-to-Ds/Uncalled Ds**

To continue with the "building block" approach to BFM, canned defensive scenarios will be introduced on BFM 4002 and practiced on all subsequent BFM flights. Three distinct attacks will be flown, each requiring specific defensive responses:

a. High-Low Yo-Yo (Hi-Lo)

b. In-Close Overshoot (ICO)

c. Valid Attack to Guns 'D' (VAGD)

The Intro-to-Ds will demonstrate all three of the scenarios on the BFM 4002. On subsequent BFM flights, only two of the three scenarios will be presented, requiring the SNFO to both identify the scenario and respond with the correct procedures. The "Intro-to-Ds" and "Uncalled Ds" scenarios will begin from the standard 40 degrees AOT Perch Set parameters introduced during the Tac Admin portion of this chapter. At the "*Clear to Maneuver*" or "*Fox-2*" the SNFO will initiate maneuvering through use of the following comm:

a. Defensive SNFO (ICS) - "*Break Left/Right*"

b. Defensive SNFO (UHF) - "*Flares*"

17. **High-Low Yo-Yo Defense**

This scenario will simulate an attack by a bandit that initially attacks with excessive closure and incorrectly corrects with a High Yo-Yo (out-of-plane lag maneuver).

A "*Lift vector on*" call will be made by the SNFO any time "sensor nose" continues to be a factor, forcing a break turn into the threat. At some point after CTM, the attacking bandit will initiate a High Yo-Yo as an out-of-plane maneuver to prevent an imminent overshoot.

As the bandit begins the High Yo-Yo with a roll to wings level and pull out-of-plane (or a rolling pull), the defensive student will call "*Nose-off, ease*" on the ICS (Figure 3-14, A). The "*Nose-off*" call informs the pilot that the attacker's nose/lift vector is not an immediate threat. The "*ease*" call directs the defensive IP to ease the turn (easing G's) to regain as much of the depleted energy as possible until the attacker's nose/lift vector becomes a factor again.

When the attacker creates enough separation, he will shift his lift vector in front of the defender (lead pursuit) by aggressively going nose-low. This Low Yo-Yo (out-of-plane lead maneuver) is executed to decrease separation. The attacker's nose/lift vector becomes a threat again at this point. As the attacker rolls to pull his nose down (cracks his wings) out of the High Yo-Yo, the defensive student will again call "*Lift vector on*" (Figure 3-14, B).

Prior to the attacker's aircraft reaching the horizon, the defending SNFO should call for a nose-low turn into the attacker. The defender should anticipate this follow-on move by the attacker attempting to close the gap between aircraft. Thus, it is very important to timely call "*Nose-low left/right*" (Figure 3-14, C) in order to offset the attacker's energy gain in his nose-low attitude. If the attacker is allowed to reach, or go below the horizon, before you direct a defensive nose-low turn into him, the attacker would gain an energy package that would be difficult to oppose. If these defending maneuvers are properly timed, they should result in a less defensive position, decreased separation between aircraft and possibly an overshoot. At a minimum, these maneuvers should increase the attacker's time-to-kill.

These maneuvers generally result in a two-circle flow. Each SNFO is responsible for follow-on BFM (defensive/offensive) as required and shall not stop directing the fight until a logical conclusion has been reached and/or the training objective has been met, signaled by a KIO.

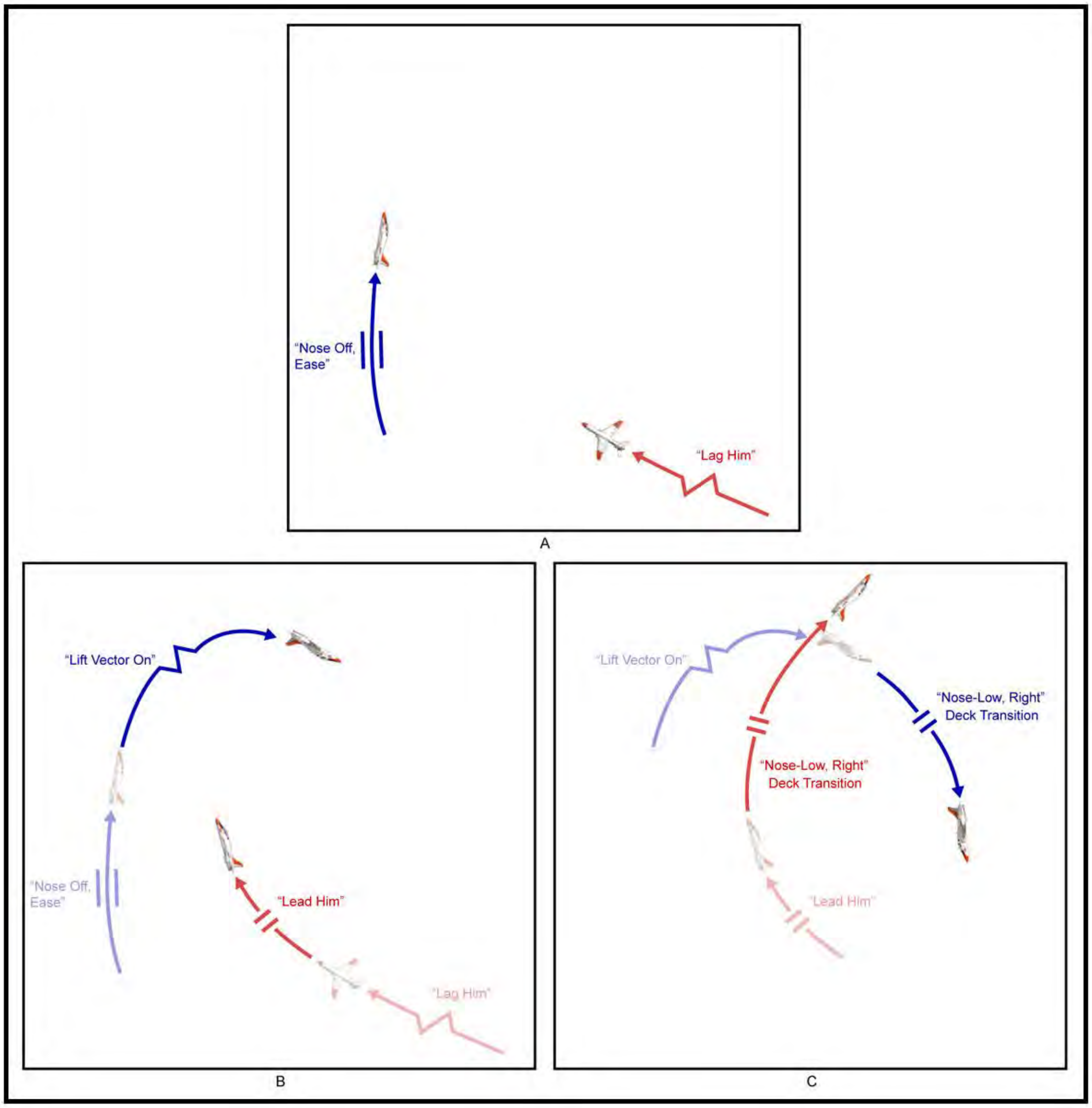

Figure 3-14 High-Low Yo-Yo Defense

18. **In-Close Overshoot**

This scenario will demonstrate a bandit attack with excessive closure that results in an overshoot of the defender's wing-line or "3-9 line." This attack presents a reversal opportunity for the defender.

At the CTM/Fox-2 the attacker will continue to threaten the defender with his nose. The defensive student will honor this threat with a "Lift vector on" ICS call to his pilot (Figure 3-15, A). The "*Lift vector on*" call will serve to maintain a break turn into the threat aircraft, which will complicate the bandit's attack by increasing his AOT and closure. The break turn will force the attacker to overshoot the defender's flight path at close range and inside the control zone (Figure 3-15, B).

Recognizing the in-close overshoot, the defensive student will capitalize on this reversal opportunity and call "*Reverse, pull for his six*" (Figure 3-15, C). A timely reversal may result in a follow-on 3-9 overshoot and a role reversal in which the defender gains positional advantage. Depending on aircraft energy, bandit's correction and timeliness, this overshoot can result in a neutral or defensive Flat or Rolling Scissors.

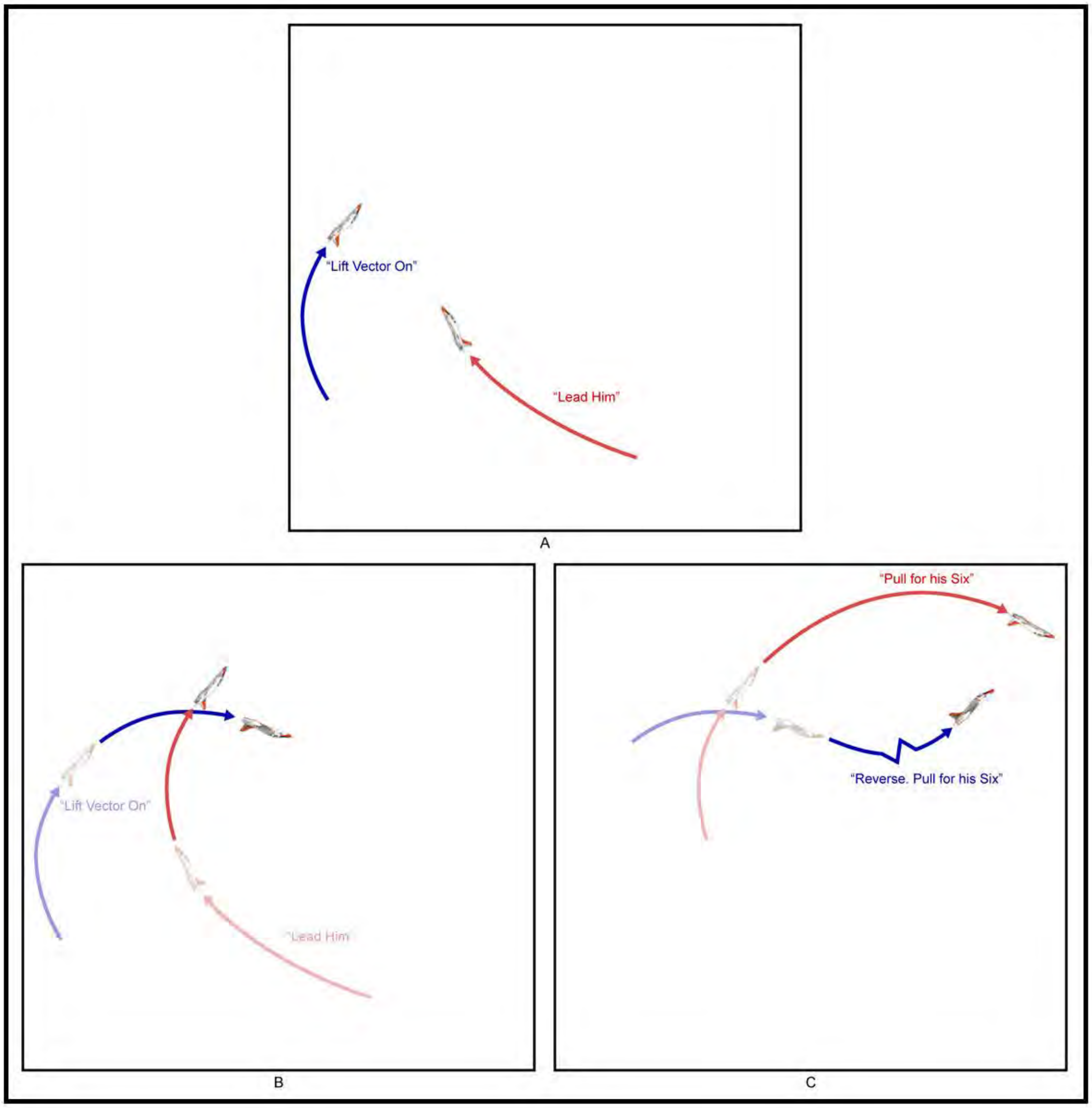

Figure 3-15 In-Close Overshoot Defense

19. **Valid Attack to Guns 'D'**

This scenario will demonstrate an attack by a bandit that is able to maneuver and achieve a guns attack. The defensive response will be a last ditch defensive maneuver (Guns 'D').

At the CTM/Fox-2, the attacking bandit will threaten the defender with his nose. The defensive student will honor the threat with a "*Lift vector on*" ICS call to his pilot (Figure 3-16, A), maintaining the break turn into the threat as long as "sensor nose" is a factor.

The key determinant of whether to pull for an overshoot or execute a Guns 'D' will be whether the attacker has solved for the "Big Three." If the attacker has solved for lead, range, and POM, then a Guns 'D' is appropriate. Otherwise, the defender should continue the break turn to maximize a possible overshoot. As the bandit pulls lead for an imminent guns shot (approaches 1500' Rake/Snapshots), the defensive student will call "Guns 'D'" (Figure 3-16, B). Upon hearing this command, the pilot will execute a last ditch out-of-plane Guns 'D' as described earlier in this chapter. Follow-on BFM considerations and maneuvering are the same as for the Yo-Yo Defense (Figure 3-16, C).

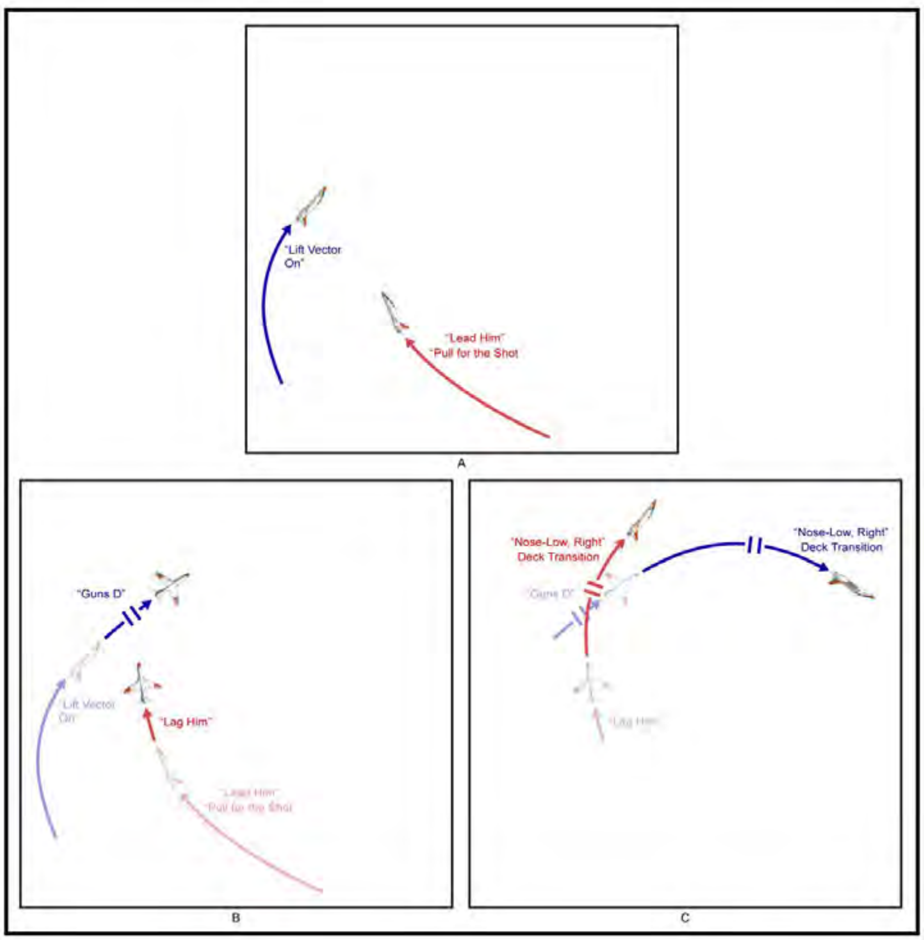

Figure 3-16 Valid Attack to Guns 'D'

20. SNFO Responsibilities

Figures 3-17, 3-18, and 3-19 summarize the required SNFO calls for each of the three canned scenarios. While these tables are nice learning aids, they are not to be copied for use in the cockpit. These calls must be committed to memory.

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: "*Break right!*" UHF: "*Flares.*"	Break turn into bandit
Sensor nose still on	"*Lift vector on.*"	Maintain break turn into bandit
Wings level, out-of-plane, High Yo-Yo maneuver	"*Nose-off, ease.*"	Ease turn, unload, get knots back- energy addition
Attacker starts to commit nose back to defender	"*Lift vector on.*"	Hard turn back into bandit
Attacker's aircraft reaching the horizon.	"*Nose-low right/left (into the attacker)*"	Nose-low turn into bandit
Deck Transition	Deck Transition Calls (Alt/Nose Position)	Energy rate/Positional Deck Transition (as appl.)
Follow-on BFM as required		Follow-on BFM as required

Figure 3-17 High-Low Yo-Yo SNFO Required Comms

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: "*Break right.*" UHF: "*Flares.*"	Break turn into bandit
Sensor nose still on	"*Lift vector on.*"	Maintain break turn into bandit
Overshoots extended six o'clock	"*Reverse, pull for his six*"	Reverse to force a 3-9 overshoot if possible
Follow-on BFM as required		Follow-on BFM as required

Figure 3-18 In-Close Overshoot SNFO Required Comms

Attacker Action	Defensive Student Response/Call	Defensive IP Action
Clear-to-Maneuver	ICS: "*Break right.*" UHF: "*Flares.*"	Break turn into bandit
Sensor nose still on	"*Lift vector on.*"	Maintain break turn into bandit
Presses attack, in guns range and able to pull lead for a shot	"*Guns 'D'.*"	Execute Guns 'D' to defeat shot
Deck Transition	Deck Transition Calls (Alt/Nose Position)	Energy rate/Positional Deck Transition (as appl.)
Follow-on BFM as required		Follow-on BFM as required

Figure 3-19 Valid Attack to Guns 'D' SNFO Required Comms

21. **Offensive/Defensive Perch BFM**

a. PADS: 18K'/250-350 KIAS/1.0 – 2.0 NM Abeam (CTM = 40degrees AOT @ Set range)

On the BFM 4003 and BFM 4004 flights, perch BFM will be introduced to the SNFO. The purpose of perch is to introduce the concepts and sight pictures associated with offensive and defensive BFM from a canned 40 degrees AOT scenario (Figure 3-20). SNFOs will be exposed to either the offensive or defensive scenario on BFM 4003 with the alternate scenario being demonstrated on BFM 4004. Offensive and Defensive Perches will be conducted from the standard 40 degrees AOT Perch setup described in the Tac Admin portion of this chapter. Three separate perch scenarios will be demonstrated:

a. 9,000' slant range, attacker outside the bubble

b. 6,000' slant range, attacker at bubble entry

c. 3,000' slant range, attacker inside the bubble

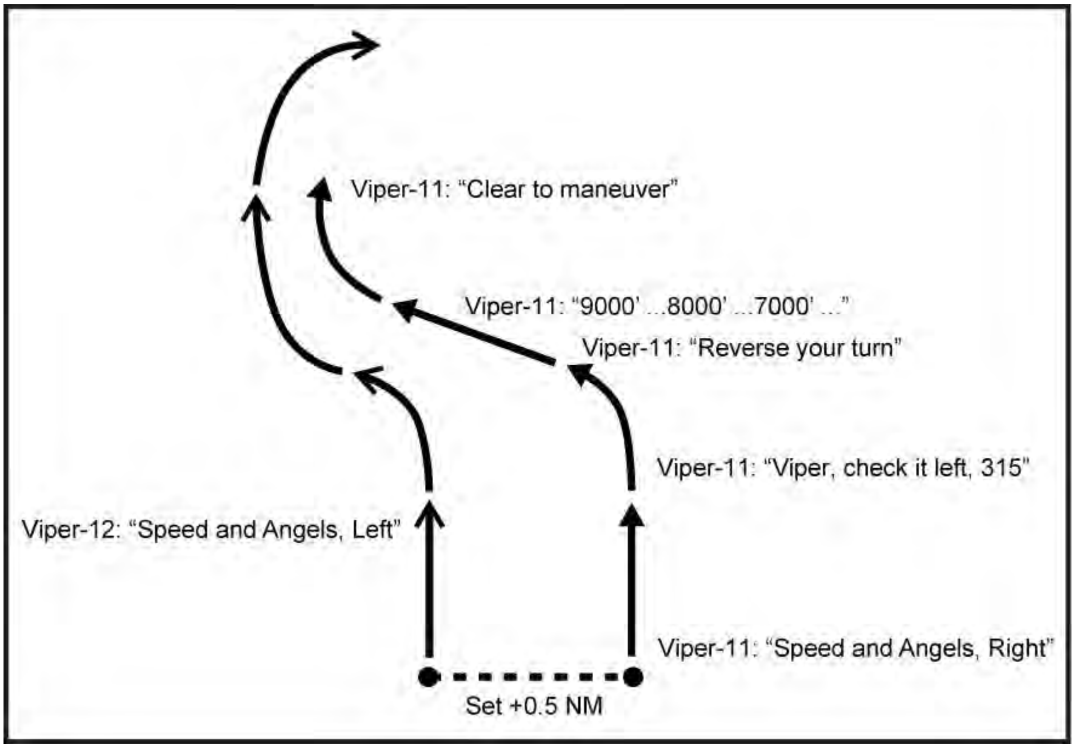

Figure 3-20 Offensive Defensive Perch Set

The PADS and training objectives for each of the perch scenarios are delineated as follows:

a. Offensive Perch

i. 9K' Offensive Perch - 18K'/350 KIAS/2.0 NM

(a). Bubble Entry

(b). Attack Window Entry Mech

(c). Rate War/Misaligned Turn Circles

(d). Second Bubble entry

ii. 6K' Offensive Perch - 18K'/350 KIAS/1.5 NM

(a). Bubble Entry

(b). Attack Window Entry Mech

(c). Ditch Follow, Timing/Mechanics

(d). Deck Transition

iii. 3K’ Offensive Perch - 18K’/250 KIAS/1.0 NM

(a). Attack Window Entry Mech

(b). Ditch Follow/Guns ‘D’, Timing/Mechanics

(c). Deck Transition

(d). Finishing

At the “*Fox-2*” or “*Clear to Maneuver*” call, the offensive SNFO’s first concern is bubble entry. To facilitate entering the bubble, the offensive SNFO will call for his IP to “*Lead him*.” Once the SNFO recognizes the sight cues that define bubble entry, he will direct his IP to ease his pull to the attack window by calling “*Lag him*.” Attack Window Entry Mech will be initiated by the SNFO through the use of a “*Lift vector on*” call until the aircraft decelerates into the rate band, whereupon the SNFO will call “*Capture 300*.”

Should the defender ditch, the offensive SNFO will direct the follow with comm that is similar to Attack Window Entry Mech, calling for the IP to “*Lag him*” until the same line-of-sight rates dictate the timing for the ditch follow. SNFOs will initiate the ditch follow via a “*Lift vector on*” call. Of course, in the ditch follow, like any other nose-low maneuver, the SNFO will be responsible for making deck transition calls. As the scenario approaches the deck and transitions to a logical conclusion, i.e., Flat/Rolling Scissors, weapons employment, etc., SNFOs will recognize and direct appropriate follow-on BFM.

a. Defensive Perch

i. 9K’ Defensive Perch - 18K’/350 KIAS/2.0 NM

(a). Break Turn

(b). Bubble Entry

(c). Misaligned Turn Circles/Rate War

(d). Second Bubble Entry

(e). Bug

ii. 6K’ Defensive Perch - 18K’/350 KIAS/1.5 NM

(a). Break Turn

(b). Bubble Entry

(c). Ditch, Timing/Mechanics

(d). Deck Transition

iii. 3K' Defensive Perch - 18K'/250 KIAS/1.0 NM

(a). Ditch/Guns 'D', Timing/Mechanics

(b). Deck Transition

(c). Guns Weave

At the "*Fox-2*" or "*Clear to Maneuver*" call, the defensive SNFO's primary concern is the execution of a defensive break turn, both to defeat a missile shot and to take away angles from the attacking aircraft. This will be accomplished by the defensive SNFO calling "*Break Left/Right*" over the ICS and "*Flares*" over the radio. Per the priorities set forth in the Defensive Axioms in Chapter 1, the priority while the attacker is outside the bubble is to take away as many angles as possible. This will be directed by the SNFO with a "*Lift vector on*" call until he recognizes the sight picture associated with bubble entry. Upon bubble entry, the SNFO will match the performance of the attacking aircraft, calling "*Nose-off, ease*" when his opponent eases or "*Lift vector on*" anytime his opponent is pressuring. If at any time the defensive SNFO recognizes a bug scenario (180 degrees out merge), the SNFO will call for a "*Bug*" and "*Unload*" at the merge. In the bug, the SNFO must strive to maintain sight of the attacker and if the bug will not be successful, call for a break turn back into the attacker with flares.

Once the attacker meets the ditch criteria, the defensive SNFO will direct the redefinition of the fight through the use of a "*Ditch*" call. In the ditch, the SNFO will direct the proper orientation of the lift vector through a "*Lead him*" call. Anytime the aircraft is nose-low, the SNFO should follow with deck transition calls. As the scenario approaches the deck and transitions to a logical conclusion, i.e., Flat/Rolling Scissors, weapons employment, etc., SNFOs will recognize and direct appropriate follow-on BFM (to include scissors maneuvering, guns weave, rate war, etc.).

Each of the three perch setups are summarized in Figures 3-21, 3-22, and 3-23.

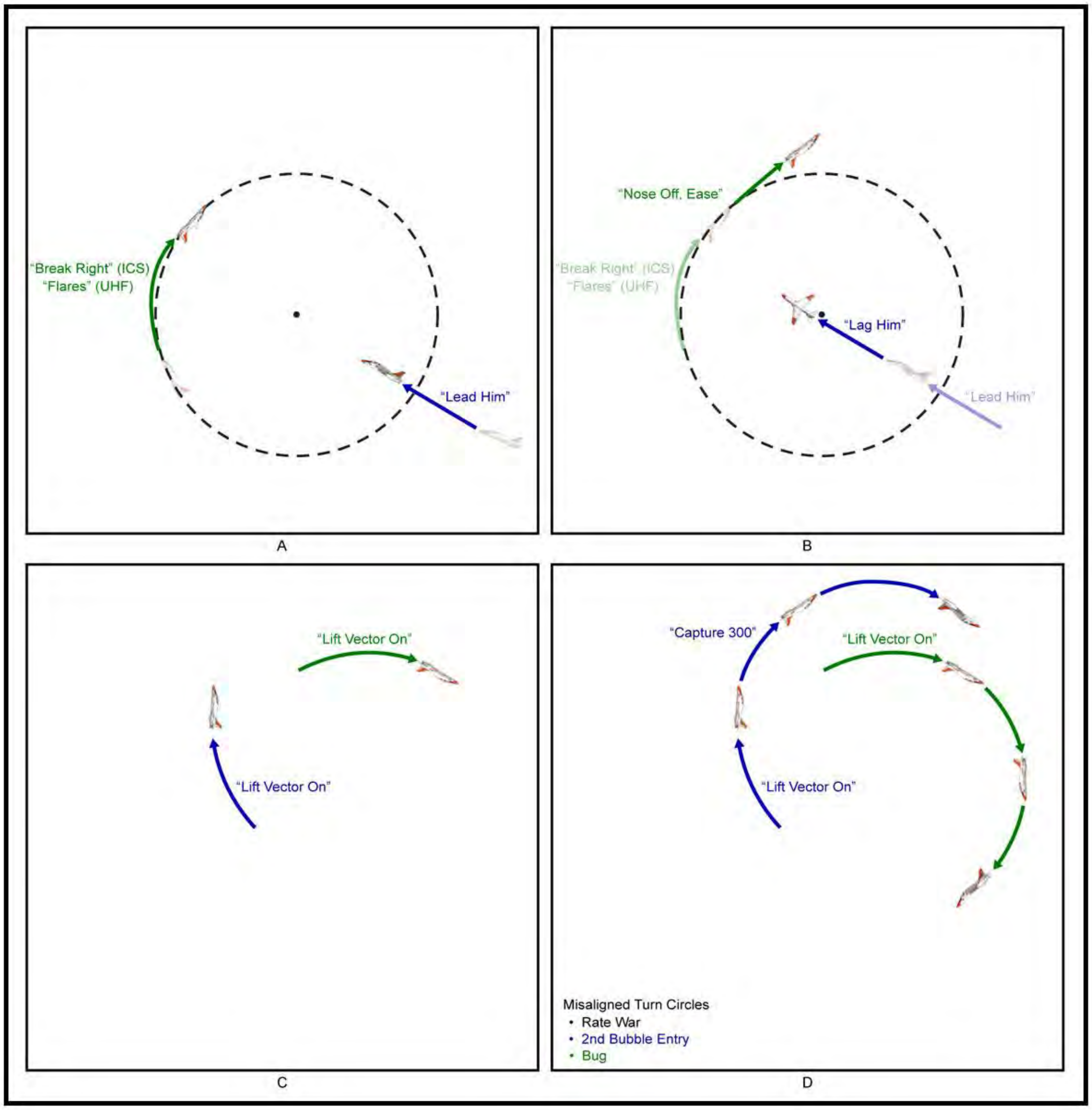

Figure 3-21 9,000' Perch

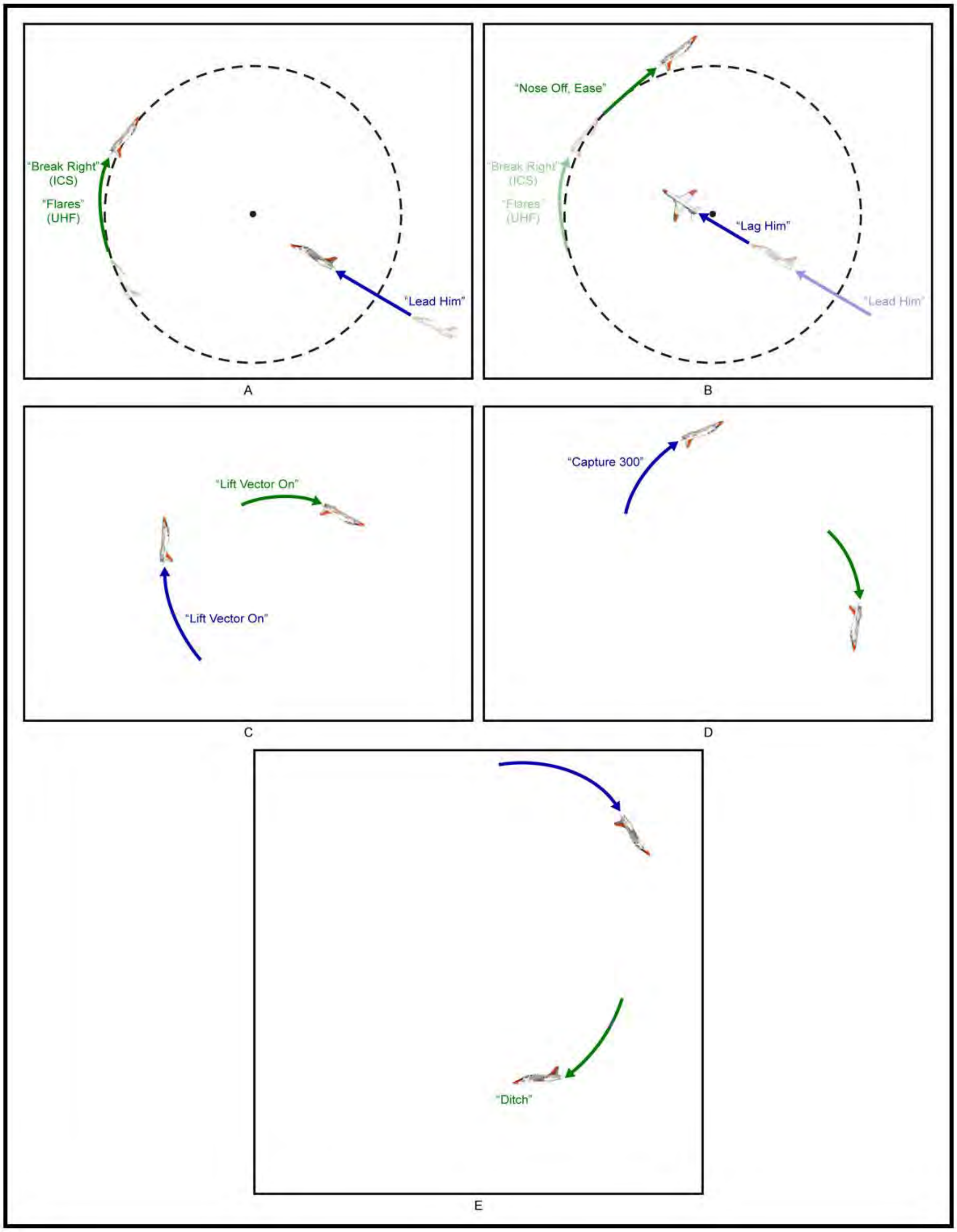

Figure 3-22 6,000' Perch

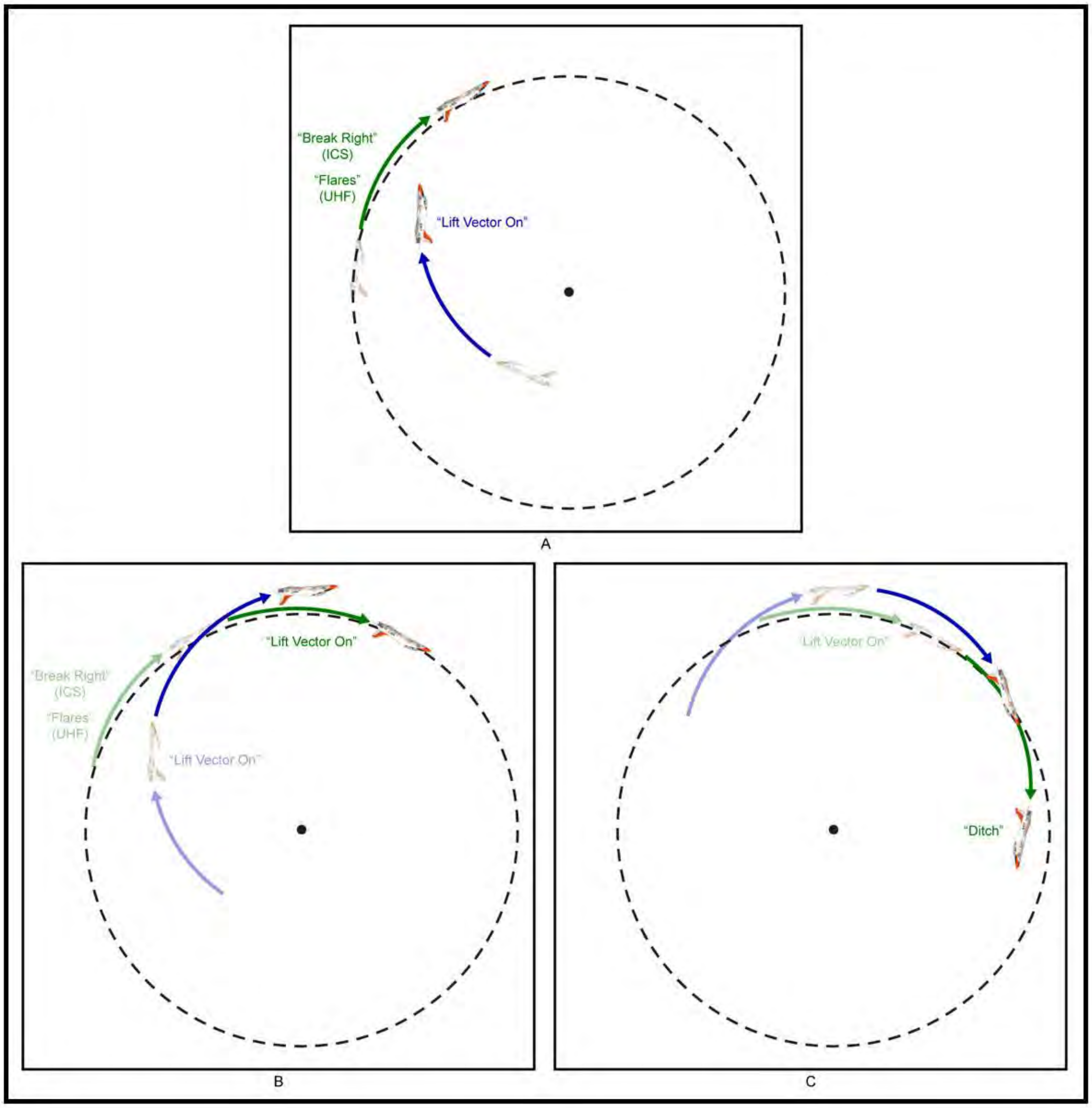

Figure 3-23 3,000' Perch

308. HIGH ASPECT BFM

The next building block in the BFM syllabus is a 1v1 engagement initiated from a neutral setup. The goal is to arrive at the merge with a well thought out game plan that maximizes the strengths of our aircraft and our weapons system and mitigates the strengths and exploits the weaknesses of our opponent. As the game plan is executed, you should endeavor to recognize the previously demonstrated offensive or defensive sight pictures and transition appropriately to either offensive or defensive BFM. High Aspect BFM will be demonstrated to the SNFO in two stages: first through a demonstration of the types of flow available (First Move Option Exercise); and finally in a series of High Aspect Engagements which will focus on game plan development and basic execution.

1. **High Aspect Sets**

The culmination of the VT-86 BFM syllabus occurs with the introduction of 1v1 Neutral High Aspect engagements during the BFM 4004 and BFM 4190 flights. Like the First Move Option Exercise, these neutral sets will be executed from the Butterfly Setup. The focus of the 1v1 Neutral High Aspect sets is three-fold:

a. Sound game plan development

b. Basic execution

c. Transition from high aspect to offensive/defensive BFM

2. **Game Plan Development**

In the BFM 4004 and BFM 4190 flights, the primary focus of the High Aspect sets will be game plan development. As discussed in the BFM Theory chapter, game plan is a function of three components: Mindset and Flow based on our expected Threat. Prior to arrival at the briefing, SNFOs will have developed a game plan that they intend to execute for that particular flight based on the threat that they expect to face. The specifics of game plan for the purposes of the VT-86 syllabus are detailed as follows:

a. Threat: For BFM 4004 and 4190, each SNFO will be given a different weapons loadout by which to formulate their game plan. SNFOs will take into account the strengths and weaknesses of their own platform as compared to their opponent. For BFM 4005, the Lead aircraft will formulate a game plan based on an all-aspect IR missile with no gun facing a Wingman with a rear quarter only IR missile and gun. On the BFM 4190, the loadouts will swap. The goal of alternating weapons loadouts on the BFM 4005 and BFM 4190 flights is to force the SNFO to develop a different game plan for each flight.

b. Mindset: Mindset is a complicated concept and will be covered in greater detail in the fleet. For the purposes of the VT-86 BFM syllabus, the concept is simplified, concentrating on the energy management aspect of the mindset discussion. Two mindsets that may be employed as part of BFM game plan development will be used: positional and energy fights. Realize that these are terms picked exclusively for the VT-86 syllabus and will have different and more in-depth terminology in the fleet. Here at VT-86, these mindsets are defined as:

i. Positional: As part of the game plan, this is a willingness to sacrifice energy (airspeed) to gain or deny angles/turning room. This mindset is generally utilized when the opponent has a superior performing aircraft as compared to ours.

ii. Energy: As part of the game plan, this is an unwillingness to sacrifice energy, conserving airspeed to allow for other options (vertical performance, bug, etc.). This mindset is generally utilized when our aircraft has a superior turn performance as compared to our opponent.

c. Flow: Hand-in-hand with the mindset discussion is the consideration of desired flow. The BFM Theory chapter detailed how flow provides for different amounts of separation between aircraft. SNFOs will choose a desired flow based on the amount of weapons separation desired between aircraft during an engagement.

i. One-Circle: If our opponent has a superior weapons system/loadout as compared to our own, we would want to limit the amount of separation between aircraft during an engagement. In that case, one-circle flow would be the flow of choice.

ii. Two-Circle: If we have a superior weapons system/loadout over our opponent, then we would want as much separation between aircraft as possible, allowing us time and space to employ a weapon. In that case, we would opt for two-circle flow.

As an example of game plan development, if our aircraft was limited to gun only against a similar performing opponent with an IR missile capability, our game plan may sound something like: “Positional fight, utilizing one-circle flow to counter the IR missile threat.”

Most importantly, because the game plan is based on the threat, once it is established, we do not change game plans. Rather, we execute as planned and if our game plan is not working, we look for opportunities to disengage.

3. **Game Plan Execution**

a. Pre-engagement - With our game plan in hand, the student will coordinate his game plan execution with his IP prior to each initial merge. At a minimum, SNFOs should indicate their desired target airspeed at the merge (300-330 KIAS for nose-low, 300-330 KIAS for level, and 330-350 KIAS for nose-high) and their desired initial first move (nose-high, nose-low) based on their mindset.

b. At the Merge - At each merge, SNFOs should direct their IP to turn in a direction that will force the flow they desire (e.g., "*nose-low, left*" or "*nose-high, right*"). The turn direction is based on the mindset and flow determined by the game plan.

c. Post Merge - Following each merge, we need to analyze the engagement and evaluate whether it corresponds to our predetermined game plan. At a minimum, SNFOs should consider the following:

i. Describe. Which way did our opponent turn? SNFOs should report direction of the bandit to their IP.

ii. Determine Flow. What is the type of flow? SNFOs will report to their IP the established flow.

iii. Evaluate. Are we in the flow we wanted in accordance with our game plan?

iv. Adjust. If we are in our desired flow, we should execute in accordance with our game plan (1C: "*max perform, pull for his six*"; 2C: "*nose-low, capture 300*"). If we are not in our desired flow, how do we get back to the next merge to force our desired flow at that merge? (e.g., "*nose-high, lift vector on*")

v. React. Once we recognize that an engagement has transitioned from neutral to either offensive or defensive BFM, we will perform accordingly. The particulars of how SNFOs should direct the offensive/defensive transition will be laid out in more detail in the following section.

4. **Offensive/Defensive Transition**

The purpose of High Aspect BFM is to recognize the transition of an engagement from a neutral start to either an offensive or defensive scenario, and react accordingly. It is the most critical phase of the engagement and usually the most difficult to execute. The purpose of the BFM syllabus up to the BFM 4004 was to introduce the SNFO to the offensive/defensive sight pictures and objectives. Now, in the BFM 4004 and 4190 SNFOs will put these skills into practice.

a. Offensive BFM - Recall from the theory discussion that anytime you recognize the sight cues that define offensive BFM, you should start working to control range, angles and closure. That is first accomplished by entering your opponent's bubble. Like the perch setups, anytime you recognize the sight cues associated with being outside the bubble, you will direct the IP to "*lead him*" to facilitate bubble entry. Once established inside the bubble, "*lag him*" would be the appropriate call, indicating to the IP that he should work toward the attack window. When you see the sight picture that would define the attack window, you should call "*lift vector on*" to direct the IP to perform Attack Window Entry Mech. Anytime you see a weapons employment opportunity, you should aggressively call for the shot ("*trigger down*" or "*pull for the shot*").

b. Defensive BFM - Anytime you recognize the defensive sight cues (i.e., opponent coming nose-on first), you should start transitioning to defensive BFM. A methodical execution of the four Axioms of Defensive BFM will give the defender the best chance of surviving:

i. Maneuver To Survive - Recognition of "sensor nose" and responding with "*Break Left/Right*"/"*Flares" or "Guns 'D'*" as appropriate.

ii. Attacker Outside the Bubble: Pull Attacker as Far Forward as Possible. Recognition of sensor nose-on and responding with "*Break Left/Right*"/"*Flares*" (19-21 units). Recognition of sensor nose-off and responding with "*Hard Left/Right*" (17 units).

iii. Attacker Inside the Bubble: Decrease in Target Aspect = Increase in pull and vice versa. You should direct "*Lift vector on*" when pressured, and "*Nose-off, ease*" as your opponent eases.

iv. Sensor Nose-on and Cannot Pull Forward of 3/9 Line = Redefinition/Ditch. If the altitude to ditch is available, you should call "*Ditch*." If you find yourself on the deck with no altitude to trade for angles, you should call "*Reverse*."

309. 1V1 ENGAGEMENT COMMUNICATIONS

Clear, concise, directive comm is essential for a successful 1v1 fight. The goal in VT-86 is for the SNFO to demonstrate an understanding of BFM sight pictures, execution and procedures through use of specific comm calls.

The following calls are intended to provide the student with some guidance regarding the directive comm to be used during the VT-86 BFM syllabus. Realize that many of the calls will most likely not be used by an NFO in the fleet but are used in the training command to validate the understanding of the BFM concepts.

1. "Flares"

The only UHF call required from an SNFO during a BFM engagement. The "flares" call will be used anytime an SNFO recognizes "sensor nose" in order to preclude an IR missile shot from being taken by his opponent. Should a "*Fox-2*" call be made, indicating an opponent's weapons employment, the defensive SNFO will call "flares" to simulate the deployment of expendables. "*Flares*" calls are usually used in conjunction with a break turn call.

2. Airspeed Calls

Airspeed calls should be initiated by the SNFO any time the IP initiates a nose-high maneuver. Airspeed calls directly translate to the degree of nose-high maneuvering available. Generally, the T-45 needs approximately 250 KIAS minimum to initiate a nose-high OOP maneuver, and a minimum of approximately 300 KIAS to go pure vertical.

3. **Altitude Calls**

Altitude calls should be initiated by the SNFO any time the IP initiates a nose-low maneuver. Altitude calls directly translate to the magnitude of nose-low maneuvering available before reaching the deck. Generally, the T-45 requires approximately 6,000 feet of altitude to execute a pure nose-low, Split-S maneuver. During a deck transition, SNFOs should be making altitude calls:

a. Every 3-5 seconds

b. Every 1,000 feet of altitude loss

These guidelines are minimum requirements for altitude calls; more is better.

4. **"Break Left/Right"**

A break call is a directive call for the pilot to max perform the aircraft at 19-21 units in order to defend against missile employment, or sensor nose, or to take away angles any time the opponent is in a WEZ. It is usually associated with a "*flares*" call.

5. **"Bug"**

This call is used anytime the SNFO wishes to disengage from an engagement for any of the following:

a. Preplanned game plan is not working

b. In a disadvantageous position (high/low merge)

c. Time-to-kill and/or fuel is becoming a factor

SNFOs should strive to call for the bug early as they approach the merge so that the IP can set it up appropriately. The goal is to achieve a 180 degree out pass from a defensive scenario.

6. **"Capture 300"**

Used anytime the SNFO wishes to capitalize on the Sustained Turn Rate Band:

a. On the deck in two-circle flow

b. Working in-plane in two-circle flow and trading altitude for turn performance is not desired (Attack Window Entry Mech)

7. **"Ditch"**

Used by the SNFO to initiate a redefinition in the vertical (ditch) when an attacker has met the ditch/redefinition criteria.

8. **"Early Turn"**

Generally used in an offensive scenario to:

a. Take advantage of an "Exclusive Use Turning Room" scenario (nose-high approaching a vertical merge).

b. Solve for excessive range (>1,000') and work in-plane, in-phase.

This is call is generally associated with a snapshot scenario, guns weave, Flat Scissors or Rolling Scissors.

9. **"Guns 'D'"**

Used by the SNFO to initiate a guns defense anytime his opponent is solving for the "Big Three:" lead, range and plane-of-motion.

10. **"Hard Left/Right"**

This call is used by the SNFO to initiate a hard turn (17 units) in order to take away angles when defensive, and his opponent is outside the bubble but not in a WEZ or "sensor nose" is not a factor.

11. **"Lag Him"**

This call is used by the offensive SNFO to put the pursuit curve in lag:

a. After bubble entry, to work toward the attack window

b. In a ditch-follow while waiting for ditch-follow timing

c. In a roller, nose-low, in the opponent's bubble

12. **"Lead Him"**

This call is used by the offensive SNFO to place the pursuit curve in lead:

a. To facilitate bubble entry

b. To gain angles/employ weapons nose-high in a roller

c. To employ weapons

It is used by the defensive SNFO to facilitate proper lift vector placement in a ditch.

13. **“Lift Vector On”**

This call is typically used by the SNFO under the following conditions:

a. Offensive: When inside the bubble to preserve turning room/lateral separation between aircraft (Attack Window Entry Mech, Ditch Follow).

b. Defensive: Any time the opponent is pressuring (i.e., inside the bubble)

c. Neutral: To maneuver to the next merge.

14. **“Max Perform”**

This call is used to perform the aircraft at the lift limit (19-21 units), other than in response to a "sensor nose" or weapons employment. Specifically, in each type of flow, execution is as follows:

a. One-circle: To minimize turn radius.

b. Two-circle: When performing above the rate band and airspeed can be bled to maximize turn rate

15. **“Nose-high, Left/Right”**

This call is used to initiate a nose-high, out-of-plane maneuver in the specified direction either at a merge or at an in-close overshoot. It should be followed by an airspeed call.

16. **“Nose-low, Left/Right”**

This call is used to initiate a nose-low, out-of-plane maneuver at a merge in the specified direction. It should be followed by altitude and deck transition calls.

17. **“Nose-off, Ease”**

This call is used by the defensive SNFO when the attacker is inside the bubble and executing a lag pursuit curve (High Yo-Yo or ease) and is no longer pressuring the defender.

18. **“Pull for His Six”**

This call is utilized to direct the IP to place the lift vector behind the other aircraft to reduce down-range travel, typically in one-circle flow (Flat/Rolling Scissors, one-circle execution).

19. **“Pull for the Shot”**

This call is used by the offensive SNFO anytime he recognizes an impending missile or gun employment opportunity.

20. **“Reverse”**

This call is used by the defensive SNFO in the following scenarios:

a. Upon meeting reversal-timing criteria during an in-close overshoot scenario.

b. In a defensive Flat Scissors. The call is made no earlier than the attacker going into lag and no later than the attacker passing the defender's extended six (based on track-crossing-rate).

c. In a neutral to slightly offensive Flat Scissors. The call is made after the nose is aft of the opponent’s 3-9 line.

d. At the top of a roller with insufficient altitude to roll again. The call is made when aft of the 3-9 line in order to transition to a Flat Scissors.

e. On the deck when the defender has met ditch criteria but cannot ditch.

f. In a guns weave, just prior to the attacker meeting the lead requirement.

21. **“Roll”**

This call is used at the top of a Rolling Scissors, once established aft of the opponent's 3-9 line (or no later than the opponent going nose-high), to indicate when to commit nose-low.

22. **“Trigger Down”**

This call is used by the offensive SNFO in a snapshot scenario (or in the Snapshot Drill) to direct gun employment when he has met the lead requirement.

23. **“Unload”**

This call is used at the merge of a bug or disengagement scenario. It directs the IP to execute an unloaded acceleration to increase energy.

24. **“Watch the Deck”**

This call is used by the SNFO during a deck transition in the following situations:

a. When violating the "Rule of 10," no more than 10 degrees for every 1,000' above the hard deck.

b. When altitude is less than 500' above the deck and the nose dips below the horizon.

25. **“300-330, Nose-low”**

This call is a first move execution command, for a nose-low option, given prior to the start of an engagement to indicate the desired initial direction and target airspeed.

26. **"300-330, Level"**

This call is a first move execution command, for a level turn option, given prior to the start of an engagement to indicate the desired initial direction and target airspeed.

27. **“330-350, Nose-high”**

This call is a first move execution command, for a nose-high option, given prior to the start of an engagement to indicate the desired initial direction and target airspeed.

310. CONCLUSION

The BFM stage is designed to give you a solid foundation of concepts and definitions and 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. You should strive to master these basic skills, as you will expand upon them throughout your entire career.

CHAPTER FOUR
FIGHTER MISSIONS AND HISTORY

400. INTRODUCTION

The primary purpose of the air combat role of the strike fighter aircraft is to obtain and sustain air superiority over contested airspace. The fighter's purpose is to prevent the enemy from using their air assets effectively (Figure 4-1). To successfully accomplish this, the strike fighter crew must execute an intercept in such a manner as to:

- Attain a position in space between the attacking aircraft and the defended force (positional advantage).

- Control the intercept geometry to achieve an optimal weapons Launch Acceptability Region (LAR) and deny an enemy WEZ. This is done to maximize the probability of kill (P_k), while simultaneously preventing the enemy from achieving weapons release.

- Arrive at the merge (if needed) with an advantage, either in position and/or in energy, and use basic fighter maneuvering to deter or destroy the enemy.

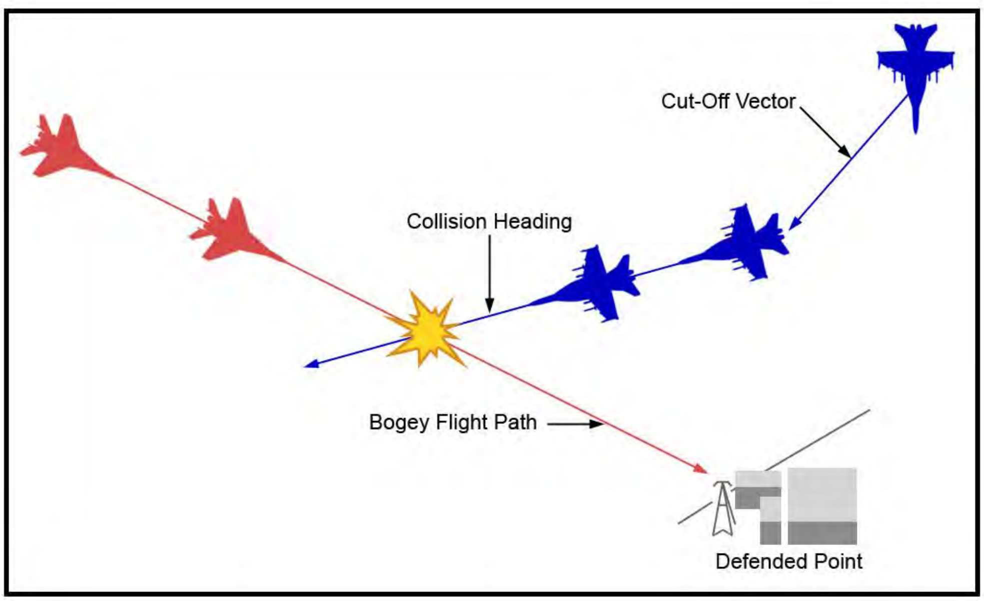

Figure 4-1 Fighter Purpose

401. AIR SUPREMACY AND SUPERIORITY

Air supremacy is defined as the complete dominance of the air power of an opposing force resulting in the complete control of the skies.

Air superiority is defined as the control of a contested airspace without prohibitive interference by an opposing force. Just by these two definitions, strike fighter aircrew can see that Air Supremacy cannot be achieved without Air Superiority.

1. Factors to Obtain Air Superiority

Each battle space will have unique factors that must be considered to achieve mission success. Since World War I, the necessity for Air Supremacy to win major conflicts has been undisputed. Some of the requirements to gain air superiority include, but are not limited to:

a. Enemy and own force capabilities

b. Rules of Engagement

c. Geographic area

d. Fuel considerations and logistics

e. Terrain

f. Weather

g. Geopolitical environment

402. METHODS OF INTERCEPTING

Normally, there are two primary methods that a strike fighter may use to close on a bandit:

- Establish a cutoff vector in order to obtain positional advantage.

- Establish a collision course.

A cutoff vector is one that will place the interceptor in a position between the bandit and the defended force. A collision course is a vector that will allow the strike fighter to close on the bandit in the fastest possible manner.

A collision course is a straight line course where the angle at which the strike fighter sees the bandit (angle-off) and the angle at which the bandit sees the strike fighter (target aspect or aspect angle) remains constant with decreasing range. In a co-speed situation, the two angles will be equal, but in opposite directions. This is also known as constant bearing, decreasing range (CBDR). When a speed differential exists, the angles will not be equal.

Remember, the strike fighter aircrew seeks to achieve optimum LAR on the enemy while simultaneously denying the enemy WEZ parameters on the strike fighter.

403. TYPES OF INTERCEPTS

There are three types of pursuit intercepts flown during the intercept: Pure Pursuit, Lead Pursuit, and Lag Pursuit.

1. **Pure Pursuit**

Pure pursuit is the primary means for achieving position in the rear quarter of the bandit. Essentially, pure pursuit occurs when the strike fighter constantly turns to keep the nose of his aircraft pointed directly at the bandit. Depending on the geometry initially generated, increasingly harder turns may be required to achieve a position at the bandit's six o'clock.

Pure pursuit is a form of collision when the fighter has a speed advantage or if both the fighter and bandit are in a pure pursuit scenario (fighter dead ahead of bandit).

Pure pursuit (Figure 4-2) may be used to give the bandit a difficult target to visually acquire.

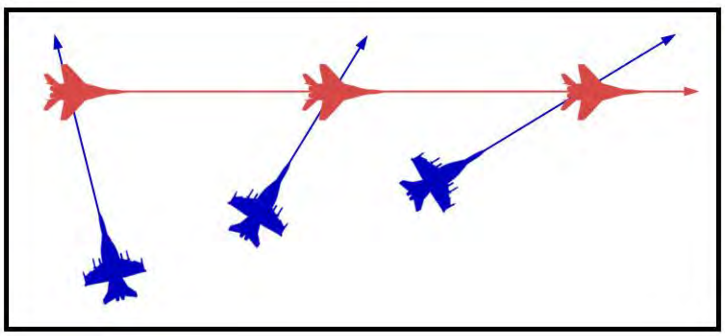

Figure 4-2 Pure Pursuit

2. **Lead Pursuit**

Lead pursuit is a situation where the strike fighter places his nose in front of the bandit. The amount of lead is how far in front of the bandit’s nose the strike fighter is pointing. A collision intercept is a form of lead pursuit.

Lead pursuit (Figure 4-3) may be used to:

a. Fire a forward quarter missile.

b. Increase closure and decrease range to the target.

c. Allow for a gun solution in the rear quarter.

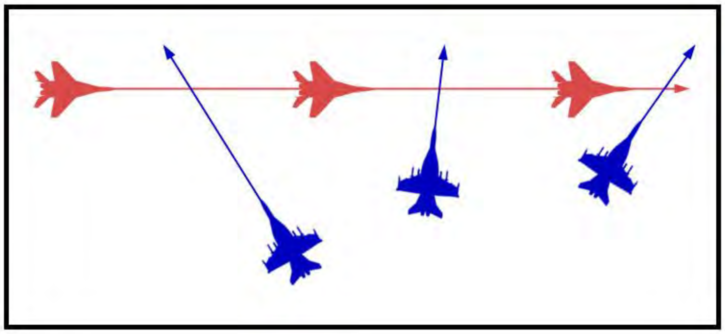

Figure 4-3 Lead Pursuit

3. **Lag Pursuit**

Lag pursuit is a situation where the strike fighter places his nose behind the bandit. The amount of lag is how far behind the bandit the fighter places his nose.

Lag pursuit (Figure 4-4) may be used to:

a. Extend range in the rear quarter to complete a sidewinder missile solution.

b. Decrease closure and increase range.

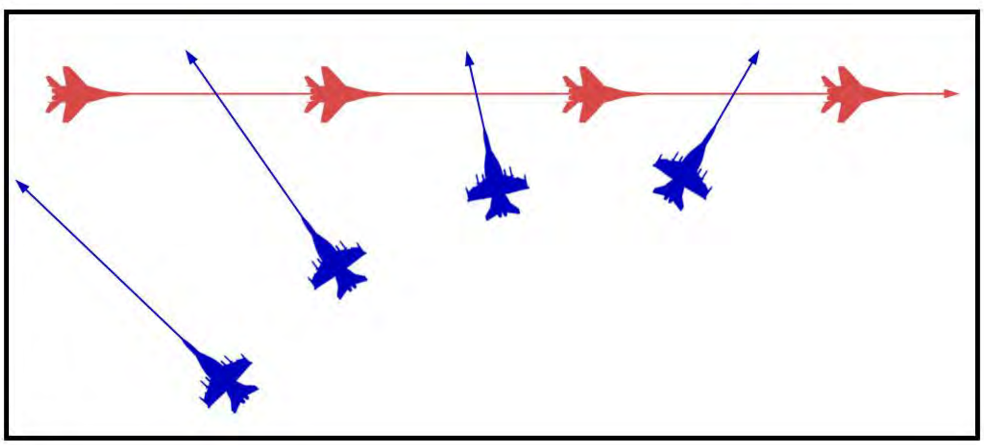

Figure 4-4 Lag Pursuit

404. NAVAL STRIKE FIGHTER MISSIONS

The F/A-18 Hornet was the nation's first purpose-built multi-role aircraft and the first to carry a dual Fighter/Attack designation. It represented a significant departure from previous designs, such as the F-4 Phantom and F-14 Tomcat which were purpose-built, air-to-air missile delivery platforms.

The F/A-18 series began with the F/A-18A and its two-seat trainer the F/A-18B. These aircraft were designed to be able to perform both air-to-air and air-to-surface activities in the same mission. They were also to replace the F-4 and the A-7 Corsair II by performing missions previously performed by both aircraft. Hornets also began to replace the F-4 in Marine Corps units.

In 1987, production began of the improved F/A-18C, and its associated trainer, the F/A-18D. The Marine Corps needed a replacement for the RF-4B, OA-4M, OV-10D and A-6E, and turned to a modified version of the F/A-18D that replaced the rear flight controls with sensor controllers and modified the cockpit for compatibility with night vision devices (NVD)s. Additionally, two aircraft in each Marine D-model squadron were modified for reconnaissance by addition of a pallet that replaced the gun in the nose. The last F/A-18D was delivered to the Marine Corps in 2000.

In the late 1980s, the Navy needed a replacement for the A-6E and F-14. They chose a redesign of the F/A-18 and designated it the F/A-18E/F Super Hornet (Figure 4-5).

The E/F model Super Hornets have:

a. 25% larger airframe

b. Square intakes and larger leading edge extension (LEX)

c. Additional store stations

d. More powerful engines

e. Increased fuel capacity

f. Increased range and endurance

g. Improved APG-73 radar, later upgraded to the APG-79 Active Electronically Scanned Array (AESA) radar

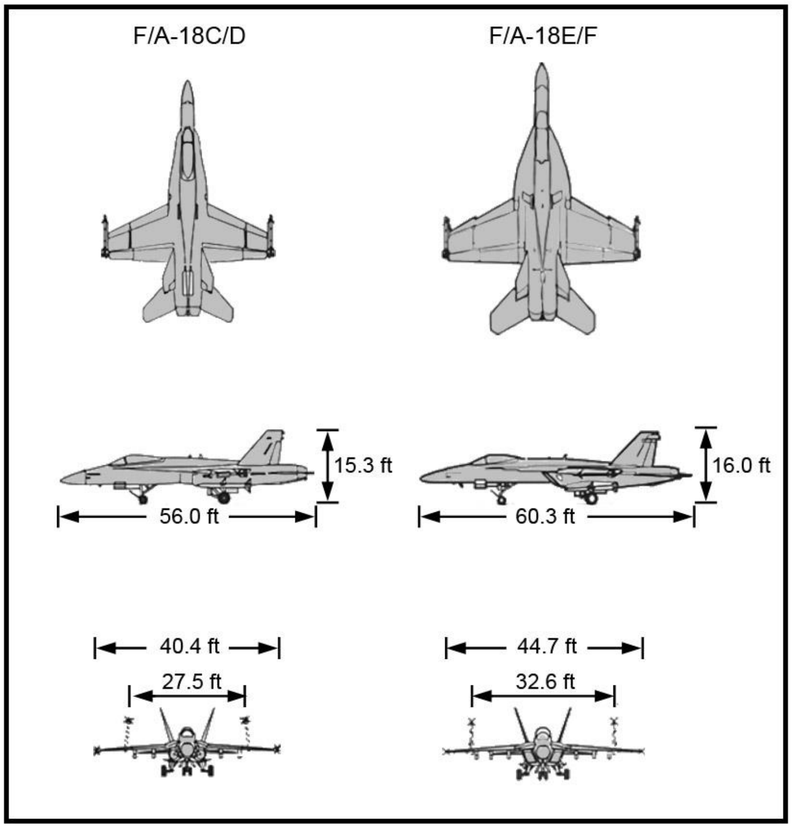

Figure 4-5 F/A-18C/D Hornet vs. F/A-18E/F Super Hornet

1. **VFA Mission**

The VFA Strike Fighter Mission is to provide combat ready strike fighter assets to conduct carrier based, all-weather, attack, fighter, and support missions as required by the Carrier Air Wing Commander, Strike Group Commander, or higher authority. The missions include Precision Strike, Close Air Support (CAS), Forward Air Control (Airborne) (FAC(A)), Offensive Counter Air (OCA), Defensive Counter Air (DCA), Reconnaissance (Recce), Surface Surveillance Coordination (SSC), Aerial Refueling, and Suppression of Enemy Air Defenses (SEAD).

Descriptions of these missions are as follows:

a. Precision Strike consists of the employment and delivery of Laser, TV, IR or GPS guided weapons to destroy enemy targets with a high probability of destruction and minimal collateral damage.

b. Close Air Support is air action by fixed- and rotary-wing aircraft against hostile targets that are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.

c. Forward Air Control (Airborne) is a qualified Joint Terminal Attack Controller (JTAC) who performs terminal attack control from the aircraft in a forward area.

d. Offensive Counter Air (OCA) consists of attacking enemy air defenses and their support systems. Defensive Counter Air (DCA) consists of defending a high value asset or point of interest (e.g., the battle group).

e. Airborne Reconnaissance missions include gathering imagery of points of interest for intelligence purposes.

f. Surface Surveillance Coordination (SSC) is used for early warning to the battle group as well as engaging enemy vessels.

g. Aerial refueling includes mission tanking towards the objective and recovery tanking overhead the aircraft carrier.

h. Suppression of Enemy Air Defenses (SEAD) includes the temporary suppression via destructive (i.e., missiles or bombs) or electronic means (i.e., jamming) of enemy air defense systems which a local mission, to support CAS, theater wide. This is the primary mission of the E/A-18 Growler.

With such a wide range of missions, the F/A-18 E/F must be able to carry multiple types of weapons to achieve mission success. The variety of weapons the aircraft is capable of employing are displayed in Figure 4-6**.**

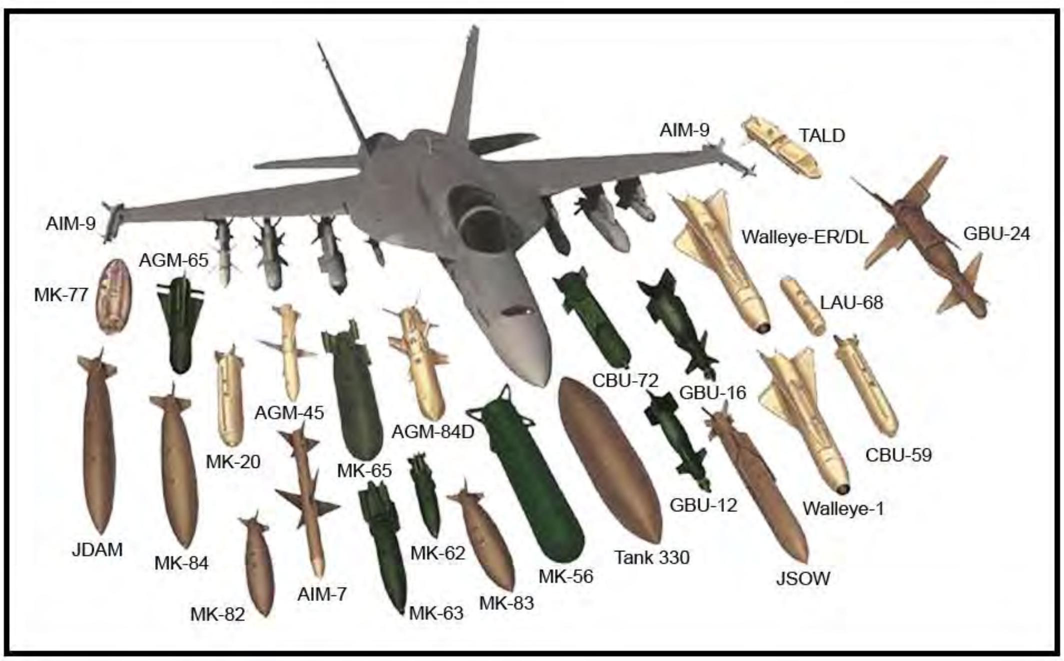

Figure 4-6 F/A-18E/F Weapons

2. Six Functions of Marine Corps Aviation

The six functions of Marine Corps Aviation are: assault support, anti-air warfare, offensive air support, electronic warfare (VMAQ), aircraft and missile control, and aerial reconnaissance. Each function is intended to support the air-ground task force (MAGTF) Commander.

a. Control of Aircraft and Missiles integrates the other five functions by providing means for MAGTF Commander to exercise C2 authority over Marine aviation assets.

b. Anti-Air Warfare is the action required to destroy or reduce to an acceptable level the enemy air and missile threat.

c. Offensive Air Support includes any air operations conducted against enemy installations, facilities, and personnel to directly assist in the attainment of MAGTF objectives through the destruction of enemy resources or by the isolation of the enemy's military forces.

d. Electronic Warfare is any military action involving the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack the enemy.

e. Assault Support is the use of aircraft to provide tactical mobility and logistic support for the MAGTF, the movement of high-priority cargo and personnel within the immediate area of operations, inflight refueling, and the evacuation of personnel and cargo.

f. Aerial Reconnaissance is used to obtain information concerning terrain, weather, and the disposition, composition, movement, installations, Lines of Communication (LOCs), electronic and communication emissions of enemy forces.

3. VMFA Mission

The VMFA mission is to support the MAGTF Commander by providing supporting arms coordination, conducting multi-sensor imagery reconnaissance, and destroying surface-targets and enemy aircraft day or night under all weather conditions during expeditionary, joint or combined operations.

Marine Corps F/A-18 A+/C squadrons do not have supporting arms coordination or multi-sensor imagery reconnaissance missions. These two missions are what set VMFA(AW) squadrons apart. There are currently two F/A-18D squadrons each at MCAS Miramar, California and MCAS Beaufort, South Carolina. Additionally, one VMFA(AW) squadron is based at MCAS Iwakuni, Japan.

4. **VAQ and VMAQ Mission**

The VAQ mission is to provide combat-ready Electronic Attack (EA) assets to conduct carrier based, all weather, EA missions as required by the Carrier Air Wing Commander, Strike Group Commander, or higher authority.

With the EA-6B Prowler nearing the end of its airframe life, the Navy also needed a replacement for this venerable Electronic Warfare asset. They turned again to the F/A-18 Super Hornet. The E/A-18G Growler is designed to perform electronic warfare and defense suppression missions. It is a highly modified F/A-18F. Although it retains some air-to-air capability, the Growler is specifically designed to fill the role of carrier-based electronic warfare.

The Growler saw its first use in combat in 2011 as part of Operation Odyssey Dawn, the establishment of a no-fly zone over Libya.

The Marine Corps still utilizes the EA-6B for an electronic attack platform in the VMAQ squadrons.

405. COUNTER AIR MISSIONS

1. **Offensive Counter Air**

OCA is defined as any mission designed to destroy, disrupt, or neutralize enemy aircraft, missiles, launch platforms, and their supporting structures and systems both before and after launch (Figure 4-7). OCA missions include attack operations, fighter sweep, escort, and SEAD.

Figure 4-7 F/A-18F Performing OCA

OCA mission planning considerations include, but are not limited to: Rules of Engagement, type and number of targets, collateral damage potential, integrated air defenses, friendly assets, time of day, weather, terrain, and fuel availability.

2. **Defensive Counter Air**

DCA is defined as all defensive measures designed to detect, identify, intercept, and destroy or negate enemy forces attempting to attack or penetrate the friendly air environment. DCA is often referred to as a point or area defense. Point defense is for a specific asset, such as the White House or the aircraft carrier. Area defense is for a broader geographic protection, such as a country or border.

DCA mission planning considerations include, but are not limited to: Rules of Engagement, point or area defense, mobility of the defended asset (e.g., aircraft carrier), type and number of enemy forces, friendly asset availability, time of day, and weather.

406. FIGHTER HISTORY

The history and evolution of fighter aircraft dates from the early years of World War I and continues to the present day strike fighters. While the machines and weapons have undergone evolutionary and revolutionary changes demanding ever increasing technical expertise, the aggressive and professional spirit of strike fighter aircrew has remained constant.

Mankind's first powered flight took place on a cold winter morning in Kill Devil Hill, North Carolina, on 17 December 1903. Orville and Wilbur Wright tossed coins, and Orville won the toss and thus became the first person on Earth to fly in a powered aircraft. His first flight lasted 12 seconds and travelled 120 feet. Today, the first flight could take place inside the cargo bay of the C-5 Galaxy (Figure 4-8). Nonetheless, aviation had begun.

Figure 4-8 From Kitty Hawk to the C-5 Galaxy

1. **World War I**

When WWI began in 1914, aircraft were primarily considered an extension of an army's observation capability. Airplanes flew with unarmed scouts locating targets and reporting enemy movements for their artillery, infantry, or cavalry forces to attack. The aircraft were slow with limited maneuverability and included observation blimps. Eventually, scouts began carrying side arms to attack the enemy aerial observers.

As design challenges emerged for firing weapons and flying the aircraft, one solution was the two-place crew: a pilot and gunner. The significant advantages of the rotating machine gun seat design and an additional set of eyes were accompanied by the disadvantages of additional weight and limited maneuverability.

Two-seat fighter designs were fielded in WWI and WWII and continue to the present day. One only has to see the flight demonstration of an F/A-18F to recognize that speed, weight, and maneuverability are no longer limitations for two-seat strike fighters.

2. **Famous WWI Aces and Aircraft Flown:**

a. SE-5a pilots:

i. Billy Bishop, RAF, Canada, (72)

ii. Edward Mannock, RAF, UK, (61)

iii. James McCudden, RAF, UK, (57)

b. Sopwith Camel

- William Barker, RAF, Canada (50)

c. Nieuport 28/SPAD 13

i. Rene Fonck, AM (75, top scorer)

ii. George Guynmeyer (53)

iii. Charles Nungesser (43)

iv. Eddie Rickenbacker (26)

d. German Aces of Note:

i. Baron Von Richthofen (80, top scorer overall)

ii. Ernst Udet (62).

3. **World War II – Pacific**

On December 7, 1941, six Japanese carriers 200 miles north of Oahu launched over 400 aircraft to support the attack on Pearl Harbor. Forty-eight fighters remained on patrol over the carriers. The remaining aircraft were divided into two attack waves of 183 and 171 planes.

The U.S. military was not prepared for the Japanese attack, which dealt a significant blow to the Pacific Fleet, especially the battleships moored at Ford Island, and the aviation units stationed around the island of Oahu. However, the Japanese primary targets were the aircraft carriers, which were not in port. LEXINGTON was delivering planes to Midway and ENTERPRISE was returning to Hawaii after delivering Marine Corps planes to Wake Island.

Figure 4-9 USS Hornet Launches Doolittle Raid Against Tokyo

America's first strike back came on 18 April 1942, when US Army LTC James H Doolittle led a raid of 16 B-25B bombers from the flight deck of the USS HORNET (Figure 4-9) to bomb Tokyo and other Japanese cities. Although the damage they did was minimal, it was a great public relations victory and provided a much needed morale boost in the early days of the war.

4. **The Battle of the Coral Sea**

In May 1942, the first naval battle in which the combatants struck at each other only with carrier-based aircraft was fought at the Battle of the Coral Sea. From 4-8 May 1942, the US Navy acted to prevent the Japanese from invading the island of New Guinea at Port Moresby, which would have severed the supply lines to northern Australia. The battle was a tactical defeat for the Americans, but a strategic victory. The U.S. sunk the light Japanese carrier SHOHO at the loss of the USS LEXINGTON and heavy damage to the USS YORKTOWN. YORKTOWN would return to Pearl Harbor to be rapidly repaired and returned to service, but the Japanese fleet carriers had to return to Japan to replenish their air groups. As a result, the ZUIKAKU and SHOKAKU were not available to assist in operations the next month. Although losses had been severe, the Japanese had been repulsed by naval aviation. The age of the battleship was over. From then on, carrier aviation would reign supreme in naval warfare in the Pacific.

5. **Midway - The Turning Point**

On 4 June 1942, the Japanese attacked Midway with a large carrier force consisting of four aircraft carriers. After initial success in destroying most of the Marine defenders obsolete fighters (in fact the worst defeat ever suffered by Marine Corps fighter pilots), the Japanese were rearming and refueling for another attack on Midway. Then, word came that their scouts had discovered at least one American carrier. The Japanese commander halted rearming of aircraft for land attack and ordered that aircraft be reconfigured for sea action. This delay would prove deadly.

Based on information gathered by Naval Intelligence, Admiral Nimitz, the commander of the U.S. Pacific Fleet, sent his three remaining carriers, Hornet, Enterprise and the recently repaired Yorktown to Midway to surprise the Japanese and repel the invasion. The Japanese intended to use the invasion to draw the American fleet into a decisive battle, but did not realize the Americans would be waiting for them.

At around 10:00 on 4 June 1942, U.S. carrier torpedo planes made multiple unescorted attacks on the carriers and were slaughtered (37 of 42 lost). However, their sacrifice unknowingly drew Japanese fighter patrols to low level. By chance, between 10:20 and 10:30, three squadrons of Dauntless SBDs from USS Enterprise and Yorktown arrived overhead. In what is probably the luckiest few minutes in the U.S. Navy's history, the SBDs inflicted fatal damage to three of the four Japanese carriers in what appeared to the Japanese to be a well-coordinated attack. The attack was, in fact, extreme luck on the part of the Americans. The effects of their bombs were amplified by the ordnance and fuel lines strung about their target's decks. The next day, they returned to sink the fourth carrier. Yorktown was sunk, but Japanese naval supremacy had ended. After Midway, the Japanese would never be able to replace the hundreds of experienced aircrew they lost.

For the remainder of the war, Japanese naval aviation would be operating at a disadvantage, unwilling to remove experienced pilots from front line roles to train new pilots. The American Navy, on the other hand, rotated their pilots to training commands so that the most recent experience with the enemy could benefit the newest aviators.

By the time the war ended in 1945, America's Pacific Fleet had grown from 3 carriers in 1942 to 18 fleet carriers, and over 50 escort carriers. The once mighty Imperial Japanese Navy, which entered the war with 10 carriers and the 2 largest battleships ever built, was decimated. There are many excellent resources available that discuss Naval Aviation during WWII. Many modern squadrons trace their lineage to the squadrons of WWII. Many ships are named for WWII heroes. As a professional military officer, SNFOs are encouraged to learn more about the history of the Navy and Marine Corps operations in the Pacific in WWII, since those operations laid the foundation for how the Navy-Marine Corps team works today.

6. **WWII – Europe**

At the outbreak of WWII, and in keeping with their pre-war doctrine, the *Luftwaffe* fully supported the German army. The years of fighting in the Spanish Civil War, along with disciplined training and development, allowed the Germans a tremendous advantage across all of mainland Europe. After rapidly over running the Allied Expeditionary Forces in France and Belgium, the remaining allied forces very narrowly avoided disaster as they evacuated to Great Britain from Dunkirk. Pearl Harbor was still over a year away. The Royal Air Force stood alone against the onslaught of German bombers.

7. **Battle of Britain**

After defeating the French in six weeks during the spring and early summer of 1940, the stage was set for Germany's invasion of England. The Battle of Britain began in July 1940. The advantages of early warning radar on the coasts of England and the Hurricane and Spitfire aircraft and crews surprised the Germans (Figure 4-10). The British Spitfire and Hurricane were the only fighter aircraft holding their own against the German Me-109 at the onset of the war. The Spitfire, with better speed and maneuverability, engaged the Me-109s while the Hurricanes, slower and greater in number, engaged the German bombers. At night, the airborne radar equipped Blenhiems and Beaufighters, engaged the German night bombers. England defeated the Germans, but just barely. The Battle of Britain demonstrated the need for close teamwork between intercept controllers and the fighters they control.

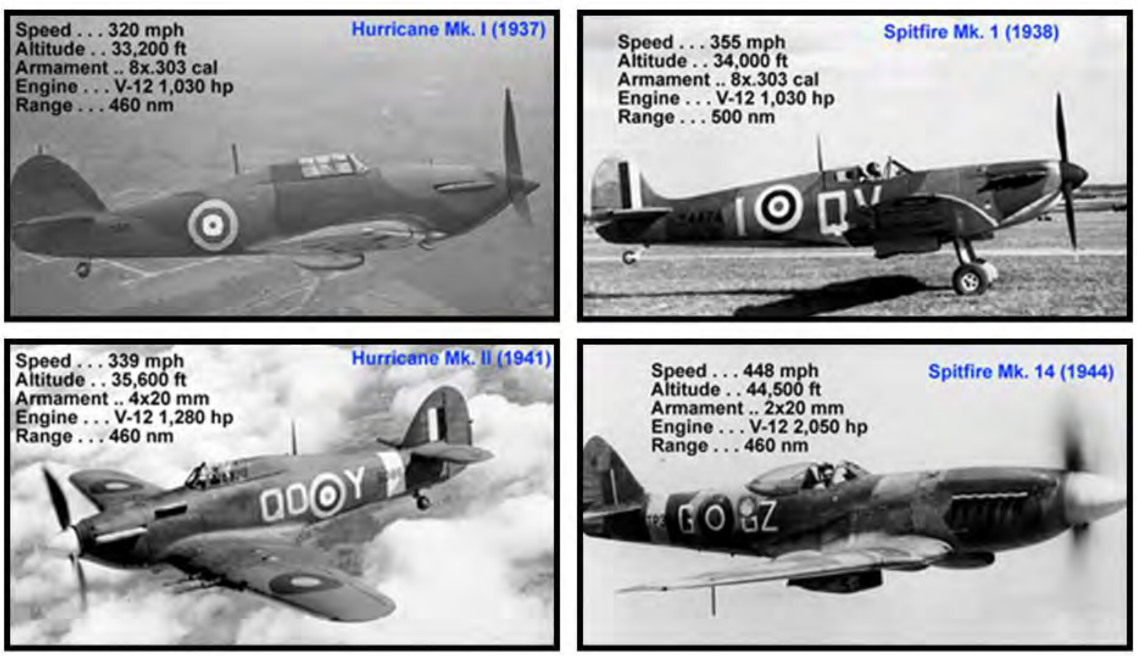

Figure 4-10 RAF's Best Fighters in 1940

8. **The Allies Come Back**

After Germany called off the invasion of Britain, the focus of the war in Europe shifted to North Africa. U.S. Naval aviation operated in support of anti-submarine operations and convoy escort, as well as transporting aircraft to allies in North Africa and Malta.

Prior to the U.S. entering the war, British carrier aviation was partially responsible for sinking the German battleship Bismarck. After Pearl Harbor, the U.S. Navy entered the war in force. U.S. Naval aviation supported operations in Europe and transported entire Army Air Corps fighter groups into theater. Although there were no great carrier battles in the European Theater, the role of carriers in transporting replacement aircraft in the early days of the war allowed the allies to carry the fight to the enemy.

9. **Transition to Jets - Korea**

Following WWII, jet engine technology was recognized as the future of Naval Aviation. Although it took a decade to mature, by the end of the Korean War, carrier flight decks were filled with a mix of jets and prop fighters (Figure 4-11). At the end of the war, three of the five fighter squadrons in a carrier air wing were F9F Panthers. Also in the mid-1950s, angled flight decks made their first appearance, allowing for simultaneous launches and recoveries.

Figure 4-11 Korean War Fighters

10. **Korea and the First Jet Aces**

The Korean War produced the first jet aces. Most of these pilots had some WWII experience, and were extremely effective despite the MiG-15 being considered superior to U.S. designs until the F-86. On its arrival, the F-86 proved a formidable match to the MiG.

One of the U.S. aces, USAF COL Francis Gabreski, became the first “two war” ace, with 31 kills in WWII and 6.5 in Korea. His story is remarkable in that he was also one of the few pilots to get airborne from Wheeler Field, HI, on December 7, 1941.

Due to the Navy and Marine Corps missions in Korea, each service produced only one ace. Major John Bolt, USMC, became an ace on exchange duty with an F-86 squadron. LT Guy Bordelon became an ace flying F4U-5N night fighter variants of the Corsair.

At the end of the Korean War, the carrier air group had evolved into a mix of jet fighters and propeller driven attack aircraft (Figure 4-12).

Figure 4-12 Composite Air Group with Prop and Jet Aircraft

11. **Vietnam - From Guns to Missiles and Back**

By the 1960s, the advancements in technology lead aircraft designers to believe that guns were no longer required on fighter aircraft. This philosophy lead to designs like the F-4 Phantom II with no internally mounted cannon.

However, with rules of engagement requiring visual identification of hostile fighters, and missile technology still being rather primitive, U.S. pilots found themselves at a disadvantage in the skies over Southeast Asia. Simpler gunfighters, like the MiG-17 and MiG-19, could close with and gun down U.S. aircraft as they maneuvered to missile launch parameters.

Fortunately for the U.S. Navy, the F-8 Crusader was a true gunfighter and experienced considerable success against MiG-17s and MiG-19s. As a result, guns were fitted to future versions of all fighters. Even the F-35 Lightning II has provisions for a gun.

12. **Post-Vietnam**

The post-Vietnam era marked the beginning of the Fourth-Generation fighters. Examples of these include the F/A-18, F-16, F-14, and F-15. Emphasis on speed, sophisticated weapons systems, reduced detection capability, counter measures, infra-red, night vision, and stealth, are just a few of the technologies incorporated with the Fourth Generation fighters.

Figure 4-13 F-35B Lightning II - Marine Corps STOVL Version

Another important aspect of the Fourth-Generation of combat aircraft is the emphasis on multi-mission capability. Not only is the ability to have multi-mission, real time, flexibility a tremendous asset, it also reduces the production and maintenance costs to operate these aircraft. The tradeoffs for this flexibility and cost savings are some degradation in certain missions and the enemy's ability to dedicate intelligence to fewer allied platforms.

The F-35 Lightning (Figure 4-13) and F-22 Raptor marked the beginning of the Fifth-Generation strike fighters in the U.S. inventory. These aircraft differ from Fourth-Generation fighters in their extreme maneuverability and unprecedented integration of mission systems. These new systems allow the aircrew to avoid or engage threats as soon as they are detected, often without the threat knowing the fighter is present.

407. MODERN THREAT CAPABILITIES AND RECOGNITION

Following WWII, the advent of beyond visual range (BVR) missiles meant that strike fighter aircrew would no longer have to identify aircraft they were engaging. This approach proved to be fatally flawed. By the Vietnam conflict, Navy and Marine F-4 aircrews found themselves having to visually identify all aircraft prior to engagement. This requirement negated their BVR advantage and resulted in the rebirth of dog fighting.

Aircraft recognition is a required aircrew skill. Being able to visually identify aircraft is a starting point. In follow-on training you will be required to associate sensors and weapons systems with particular aircraft and sub-models in order to better prepare and brief your mission. The farther out an aircraft can be detected, recognized, and identified, the more time aircrew have available to make an engagement decision. However, in the air, identification can be difficult as many aircraft share design features (Figure 4-14).

Aircraft size also plays a role in how far away you can see or identify an aircraft.

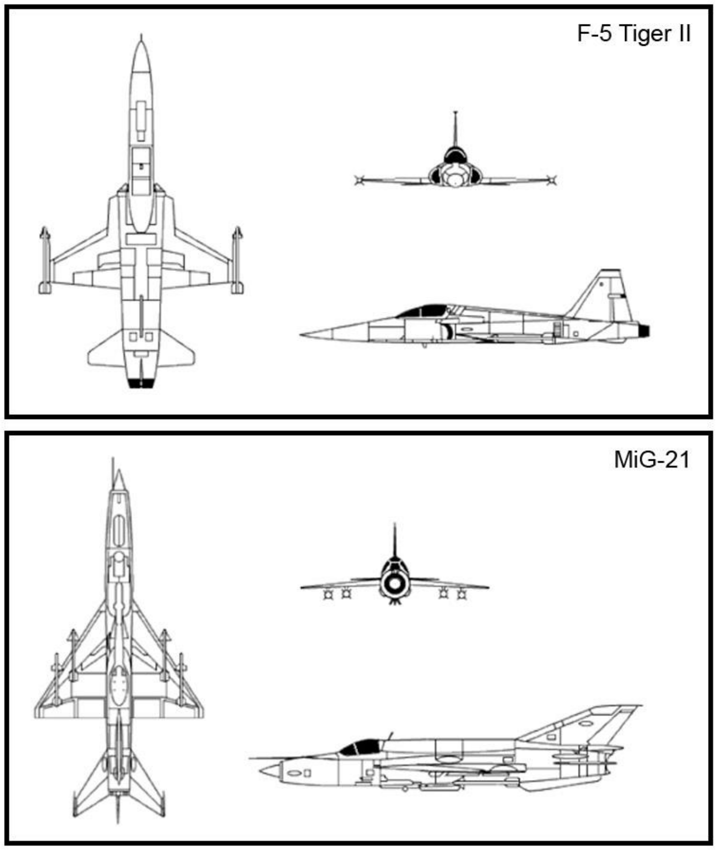

Figure 4-14 F-5E Tiger II and MiG-21

As an example, although they bear a passing resemblance to each other, the F-5 and the MiG-21 are remarkable similar in size. Their small size makes detection in the visual arena difficult, even with radar cueing.

1. **NATO Reporting**

Just as the F/A-18 have different variants, so do Russian-built aircraft. NATO reporting name adds a letter to the name, which is different from the actual manufacturer's designation.

Care should be taken to ensure that you are referring to the aircraft by one name or the other. Bias your name recognition toward the NATO reporting name. Subtle changes in manufacturing designation may not mean a significant change in capability.

For example there are distinct differences in capability between a FULCRUM-A and a FULCRUM-C. Similarly, F/A-18D aircraft from Lot XIV and Lot XV are both F/A-18D models, have different, non-compatible engines but very similar employment and sensor capabilities.

Russian and Chinese license made versions of Russian aircraft and missiles are referred to by their NATO reporting name. As a convention, this reporting name begins with a letter that designates the type or function of the system. As strike fighter aircrew, you should be familiar with this convention below:

a. A: Air-to-Air Missiles (Archer, Apex)

b. B: Bomber Aircraft (Badger, Bear)

c. C: Cargo Aircraft (Condor, Coke)

d. F: Fighter Aircraft (FULCRUM, Foxbat)

e. G: Surface-to-Air Missiles (Goa)

f. H: Helicopters (Hind, Havoc)

2. **Aircraft Identification Fundamentals**

All aircraft are built with the same basic elements, recalled as Wings, Engines, Fuselage, and Tail (WEFT) (Figure 4-15):

WEFT Features			
Wings	Engines	Fuselage	Tail
Type Position Slant Shape Taper	Type Number Location Intakes Exhausts	Shape Nose Mid Rear Cockpit Special	Location Slant Number Shape

Figure 4-15 WEFT Identification Factors

The WEFT features are unique to each aircraft, and will assist strike fighter aircrews with positive identification. The key to using these features is studying aircraft and knowing what the NATO identifications are for the aircraft being identified. Aircrew need to invest ample amounts of time on-deck studying aircraft from all corners of the globe. The Battle Group is mobile and strike fighter aircrew will operate anywhere in the world.

Friendly aircraft that strike fighter aircrews should be able to identify include, but are not limited to:

a. F-15E Strike Eagle

b. F-16C Fighting Falcon

c. F/A-18A+/C/D Hornet

d. F/A-18E/F/G Super Hornet

e. F-35 Lightning II

f. E-2C/D Hawkeye

g. E-3 Sentry

h. KC-10 Extender

Conversely, strike fighter aircrew should be able to identify potential enemy aircraft that include, but are not limited to:

a. F-4 Phantom II

b. F-5 Tiger

c. F-14B

d. Mirage 2000

e. MiG-21

f. MiG-29

g. Su-27/30

All the above aircraft are good starting places to begin to build a library of knowledge for aircraft identification. When studying, use the WEFT features as the means to discriminate between aircraft and properly identify.

3. **Threat Air-to-Air Missiles**

The proliferation of aircraft and missiles resulted in the aircraft modifications to carry any missile compatible with their air frame or are rewired to allow for the carriage of missiles from multiple suppliers. Many "threat" aircraft may be carrying Russian, French, British or American made missiles or a combination. Being able to neutralize and defeat enemy weapons, and their supportive systems, begins with strike fighter aircrew being able to identify and understand these weapons and their capabilities.

These missiles fall into three categories:

a. Semi-Active Radar (SAR) Guided BVR Missiles. SAR missiles require continuous radar support information from the host aircraft radar system for terminal guidance. Examples include Vympel R-23/24 (AA-7 “APEX”), Matra Super 530 and Super 530D, Vympel R-27 (AA-10 “ALAMO”) (Figure 4-16).

Figure 4-16 ALAMO (left) and Super-530

b. Active Radar (AR) Guided BVR Missiles. AR missiles are able to support themselves with internal radar and do not require information from the host aircraft for terminal guidance. Examples include the Vympel R-77 (AA-12 “ADDER”), MBDA MICA, and MBDA Meteor (Figure 4-17).

Figure 4-17 MBDA Meteor with Ramjet Intakes

c. Infra-Red Guided WVR Missiles. IR missiles use heat signature from targeted aircraft for guidance. These missiles are widely proliferated and are generally considered shorter-range and/or Within Visual Range (WVR) weapons. Examples include the Matra R550 Magic, Rafael Python III, IV and V, Vympel R-60 (AA-8 "APHID"), and the Vympel R-73 (AA-11 "ARCHER") (Figure 4-18).

Figure 4-18 MiG-29 with A/A Missiles

4. **Threat Surface-to-Air Missiles**

In addition to recognition and understanding of airborne threats, strike fighter aircrew need to be familiar with and understand the types of surface-to-air threats that may potentially impact mission accomplishment.

The following surface-to-air missiles (SAMs) and Anti-Aircraft Artillery (AAA) are lethal and require aircrew knowledge to neutralize and defeat.

a. Man Portable Air Defense Systems (MANPADS). MANPADS are typically shoulder fired rockets with IR guidance. These weapons are easy to carry and becoming increasingly capable with technology. Examples include the FIM-92 Stinger, SA-7 "GRAIL" (Figure 4-19), SA-14 "GREMLIN," SA-16 "GIMLET," and SA-18 "GROUSE."

Figure 4-19 SA-7 "GRAIL"

b. Command Guided Radar Surface to Air Missiles (SAM). Command guidance is equivalent to radio control of the missile. The missile itself has no seeker and is told where to fly to intercept the target by signals from the launching system. Examples include the SA-2 “GUIDELINE,” SA-3 “GOA,” SA-8 “GECKO,” and SA-15 “GAUNTLET.”

c. Semi Active Radar Homing SAMs. Semi-Active Radar Homing missiles use an internal seeker to detect and guide on the reflected energy from a tracking radar or target illuminator. Some systems combine illuminators and tracking radars on the same chassis, such as the SA-6 where they are collectively known as “Straight Flush.” Examples include SA-6 “GAINFUL” (Figure 4-20), SA-11 “GADFLY,” and the MIM-23 HAWK.

Figure 4-20 "STRAIGHT FLUSH" Radar System with SA-6 SAM

d. Anti-Aircraft Artillery (AAA). Anti-Aircraft Artillery, or AAA (triple-A) is any weapon system above 12.7 mm (.50 caliber) specifically designed to engage airborne targets. Generally, these systems fire explosive shells which have contact, time-delay or altitude fuses. "Light" AAA is up to 30 mm in caliber. "Medium" AAA is from 30 mm to 80 mm (Figure 4-21). "Heavy" AAA is anything above 80 mm. Examples include the ZPU-23 23 mm, S-60 57 mm, and S-60 57 mm.

e. Mobile and Combination Systems. Mobile systems are designed to accompany troop formations and provide for local air defense, mobile AAA systems are also fairly well deployed worldwide. Most incorporate a fire-control radar to aim the guns, increasing their accuracy. Combination systems utilize short range IR or laser guided SAMs with light AAA guns on one chassis. Coupled with a radar system for target detection and tracking, these systems are especially effective against attack helicopters, but are also effective against low flying aircraft. The SA-19 "GRISON" depicted below is an example of a modern combination system active in today's combat environment.

Figure 4-21 2S6 Combination Air Defense System

This chapter covered an extensive amount of information beginning with the strike fighter purpose in the air-to-air environment. Basic intercept pursuit curves and geometry were emphasized. Remember that Air Supremacy is the ultimate goal in the air combat environment. The history of military aviation was broadly covered and the major technological developments that lead to Fourth and Fifth Generation Strike Fighters in today's combat environment. The last sections focused on threat recognition and identification as well as airborne and ground.

CHAPTER FIVE
AIR INTERCEPT CONTROL

500. INTRODUCTION

The strike fighter aircrew does not operate in a vacuum. Rather, the fighters are part of an integrated team that includes the systems and system operators that work together to create a complete air picture. This complete picture is communicated to all the members of the team to ensure the proper management of airborne threats. Strike fighter aircrew must understand the capabilities, limitations and roles of all the components of the intercept control system.

501. BASIC RADAR

An Air Intercept Controller (AIC) is the person trained to provide communications, radar direction, and cueing (which they term control) to fighter aircraft during an intercept. Controllers are thoroughly versed on established control procedures, combat performance of aircraft, fuel consumption data, requirements to affect a landing in adverse weather, aircraft ranges with respect to remaining fuel, vectoring aircraft and passing information between command and control authorities and intercepting aircraft.

Both the Air Intercept Controller and the function or Air Intercept Control use the acronym AIC. When aircrew discuss AIC, they are referring to both the systems and the people in place to provide the AIC function.

AIC provides an operational picture of the airspace of concern as well as a communication conduit to other command and control nodes throughout the battle space. The controllers are the conduit by which this information is passed.

AIC training defines three types of control, from which fighters define the types of intercept control that will be discussed later in this chapter:

- Close control: intercept of aircraft is the controller's responsibility.

- Tactical control: intercept of aircraft is pilot's responsibility, but the controller will continue to pass information and instructions.

- Broadcast: the pilot plans and executes intercept with CIC providing information as needed.

Unlike the fire control radars used by the fighters, the radar used by AIC typically use long range radars, in some cases even ATC radar, with detection ranges of up to 250 NM. These radars can also resolve IFF signals in excess of 200 NM. These systems usually rotate through 360 degrees in their scan pattern at a low rate. This combination of factors means that the long range acquisition is at the cost of resolution. Because of this, AIC is not able to provide close control to fighters at long range using only their available radars.

Strike fighter aircrew must recognize the importance of complete, accurate, and thorough briefs and debriefs with controllers. In training, working area constraints are always briefed and monitored by controllers and aircrew.

502. E-2 HAWKEYE, E-3 AWACS AND SURFACE-BASED SYSTEMS

AIC radars may be surface or air based. The U.S. military has built two aircraft to provide Airborne Warning and Control System (AWACS) mission. These two aircraft are the E-2 Hawkeye and the E-3 Sentry (Figure 5-1).

1. **E-2C/D Hawkeye**

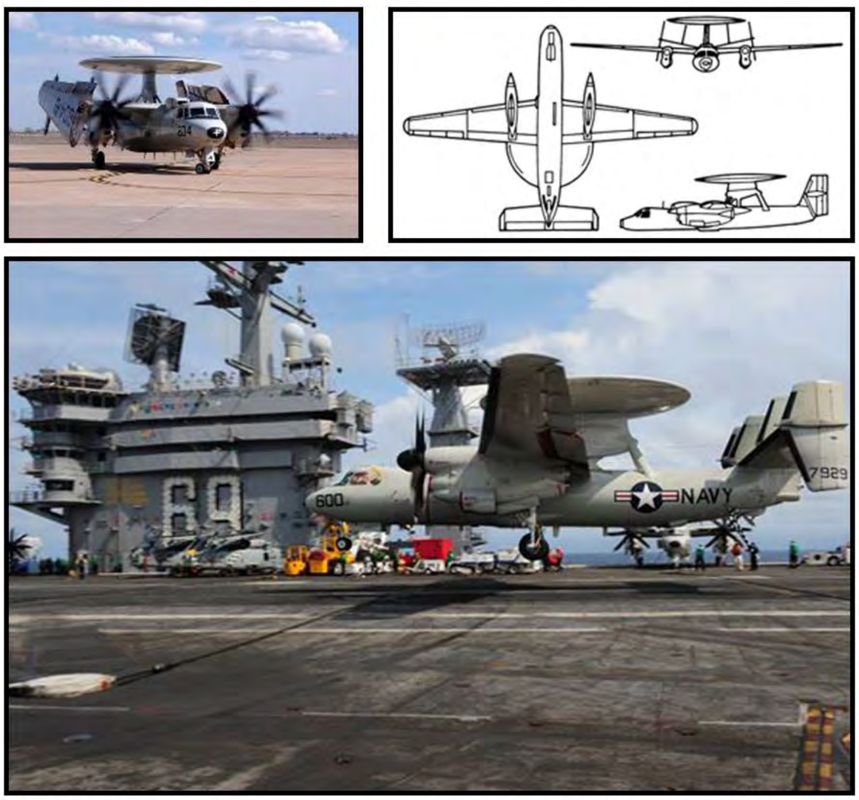

Figure 5-1 E-2C/D Hawkeye

The E-2 Hawkeye is the carrier-based Airborne Early Warning (AEW) platform with a 24-foot diameter saucer-shaped radome housing the APS-138 or APS-145 radar. The E-2 can detect targets more than 230 miles away, track over 250 targets, and provide control for more than 30 separate Airborne Intercepts (AI). The Hawkeye crew is also responsible for the "big picture" coordination of surface and air warfare assets. The E-2C/D Hawkeye aircraft can detect targets more than 230 miles away, track over 250 targets, and provide control for more than 30 separate airborne intercepts simultaneously. Hawkeyes are assigned to each carrier air wing (CVW) in the VAW squadron.

2. **E-3 Sentry**

The E-3 Airborne Warning and Control System (AWACS) is the Air Force's specially modified Boeing 707 that houses a sophisticated airborne command and control center. The operating altitude of the E-3 (Figure 5-2), combined with the capability of the radar, allows it to detect targets from 200 to 300 nautical miles, depending on target size. Like the E-2, the E-3 AWACS is resistant to electronic jamming by enemy forces. The E-3, like all long-range radar platforms, is limited in its ability to provide close control to the fighters at the merge. The E-3 airframes are being updated with the latest battlefield data link and management systems. E-3s are found in Air Command and Control Squadrons in various wings in the United States Air Force and other friendly air forces. Their very long on station times make them a national asset that aircrew will encounter in any large, joint or coalition operation.

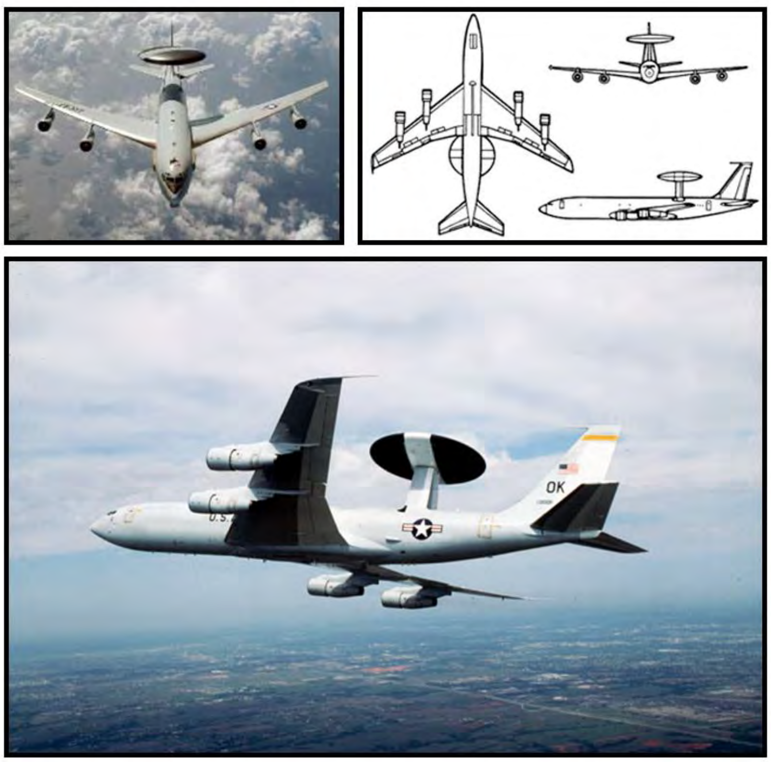

Figure 5-2 E-3D Sentry

3. **Surface-Based Systems**

In addition to E-2 and E-3 aircraft, there are a number of surface based radars that are used for AIC functions. These include the AN/SPS-48, a shipboard, 3-dimensional radar found onboard large combatants like carriers and amphibious assault ships, the AN/SPS-43, a shorter ranged system found on carriers which provide ASR and carrier controller approach functions as well as doubling as an AIC asset, and the AN/SPS-49, a two-dimensional search radar that provides range and bearing information to airborne contacts. The AN/SPS-49 is a complement to the SPS-48 system.

The premier ship-based system is the Aegis/SPY-1 radar system (Figure 5-3). The SPY-1 radar is phased-array radar tied into the Aegis fire control system. The Aegis system is a state of the art system that manages the entire battle space around the strike group and not just the air picture. SPS-49 radars are also found on any Aegis equipped ships. These ships are just as capable as a carrier to provide AIC support. Onboard ships, whether Aegis or SPS radar equipped, intercept controllers will most often be enlisted sailors in the Operations Specialist (OS) rating. These sailors will vary greatly in experience or skill: from young sailors fresh out of training, to a veteran Senior Chief.

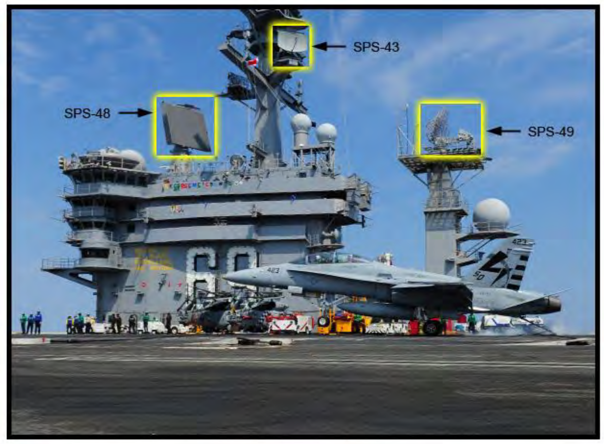

Figure 5-3 Aegis-Guided Missile Destroyer (Left) and Carrier Superstructure (Right)

4. **Marine Corps Air Command and Control System (MACCS)**

In a Marine Air Wing (MAW), AIC functions are performed by the Tactical Air Operations Center (TAOC). These personnel are organic to the Marine Air Control Squadron (MACS) as part of the Marine Air Control Group (MACG). The TAOC performs these functions for the MAGTF commander:

a. Detects, identifies and classifies aircraft and missiles within the assigned sector

b. Selects and assigns appropriate weapons to engage and destroy air threats

c. Recommends air defense sectors, subsectors and engagement zones

d. Deploys sensors and supporting systems to provide air surveillance

e. Displays and disseminates appropriate air/ground information to higher, adjacent and subordinate units

To accomplish this, the Marine Corps deploys two radar systems for the AIC role. These are the AN/TPS-53, a three-dimensional, phased-array system similar to the SPS-48, and the AN/TPS-63, a two-dimensional system very similar to ATC radar (Figure 5-4). The TPS-53 is used for intercept control and battle management, while the TPS-63 provides both AIC and ATC functionality. Although intercepts controlled from the ground were once termed GCI much in the same way AIC was used, AIC has become the standard term for any intercept control.

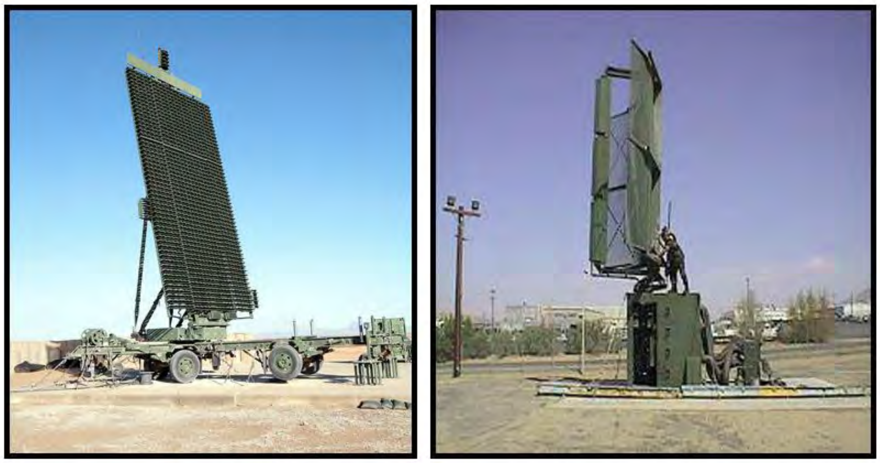

Figure 5-4 TAOC Radars

503. PLANNED POSITION INDICATOR (PPI) ATTACK DISPLAY

AIC radars use a type of display called a planned position indicator, or PPI, attack display. A PPI attack display gives controllers a “God's eye view” of the area. Most PPI displays are circular and traditionally have the radar at the center of the display. However, modern PPI attack displays may display only a sector or a portion of the radar’s entire scan. Figure 5-5 shows the actual PPI attack display used by SEABREEZE controllers to control aircraft in the W-155. Note how the display is circular, but offset to the south with the W-155 areas highlighted. This allows the controllers to provide precise control in their sector of responsibility. AIC PPI displays, such as those on the E-2, E-3 or Aegis systems, give the controller off-centering ability, range scaling, and cursors, allowing the controller to screen out sectors, focus on a particular area, or quickly provide ranges and bearings to contacts.

The AIC display can show both raw radar returns, called “primary targets” and the associated IFF return, called a “secondary target.” In fleet operations, this information can be combined with information from data link systems to provide an enormous amount of information to controllers including fuel state, weapon load and even radar status. The display is offset to the south to cover W-155. The radar is located at NAS Pensacola, Label A on Figure 5-5. W-155 and its subdivisions are part of the sector lines annotated by Label B also on Figure 5-5.

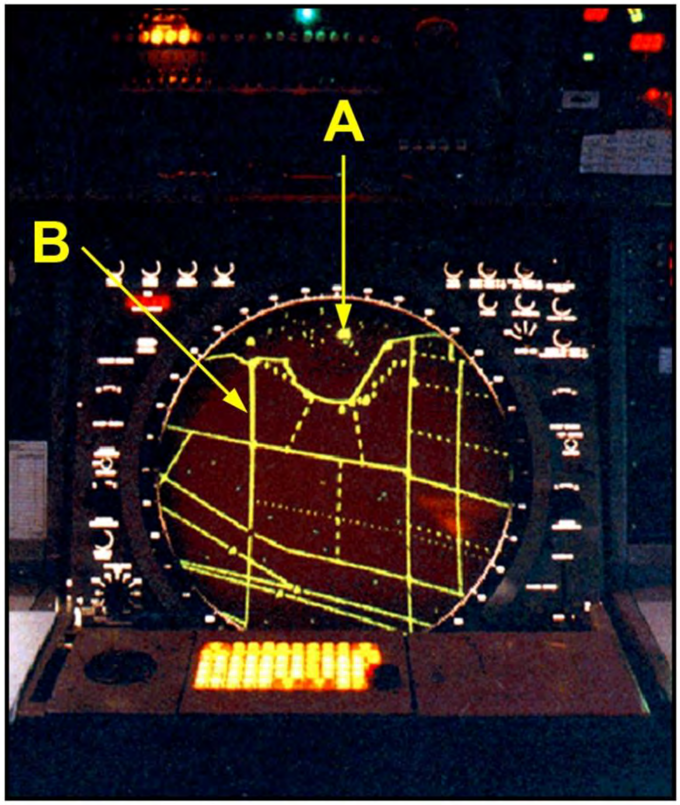

Figure 5-5 SEABREEZE's AIC Display for W-155

504. AIC – ATC TRANSITION AND SAFETY OF FLIGHT

Upon departure from NAS Pensacola, the aircraft will be under positive control of Pensacola Approach ATC. Once clear of traffic and NAS airspace, the aircraft are transferred to the Fleet Air Control and Surveillance Facility, or FACSFAC (pronounced "faks-fak"), for the warning area. This agency's call sign is "SEABREEZE" in Pensacola. FACSFAC provide positive control into and out of the special use airspace (SUA) and will assign operating areas to the fighters.

Once established in the warning area, the fighters will be directed to contact AIC for their mission. At mission completion, the fighters will contact FACSFAC, which will coordinate their transition back into the ATC system.

When operating in SUA with AIC control, AIC controllers will assist fighters in managing their location to ensure they do not trespass into threats, in combat, or stray out of their assigned areas in training. While in a restricted or warning area, AIC does not provide positive control of fighters, but will provide advisories of other aircraft (also called "interlopers") that may be traveling through the area. In a MOA, the fighters are operating VFR and the controllers will usually be in contact with ATC to provide information about any aircraft that may affect the fighter's maneuvering.

Ultimately, however, when operating in special use airspace, the location and safety of the flight is the flight Lead's responsibility.

505. CONTROL TYPES AND FORMATS

1. Control Types

Broadcast control is communication from the controller to all aircraft on the net/control frequency and provides information in a way that is useful to all aircraft. This communication format does not reference any specific friendly unit.

Tactical control is communication from a controller to a specific strike fighter, CAP station, section, or division. Tactical control is tactically and specifically useful to that specific strike fighter element only. However, all other blue forces may be able to use some of the transmitted information to build SA (like altitude).

2. Control Formats

The format of information in either type of control may use either of two formats, bullseye or BRAA (Bearing, Range, Altitude, Aspect).

In bullseye format, contact information passed by the controller, referenced to a specific geographic reference with latitude and longitude coordinates used by all friendly aircraft. Thus, if you do not know where bullseye is, the information is useless to you. Bullseye information is passed in a similar format to BRAA but is referenced to the bullseye vice a specific strike fighter element. Bullseye format can be used with either broadcast control or tactical control.

BRAA is an acronym for Bearing, Range, Altitude, and Aspect referenced from the strike fighter to the called contact. The purpose is to give a specific strike fighter group quicker situational awareness to a called contact.

a. Bearing - magnetic bearing from the strike fighter to the group

b. Range - slant range in nautical miles from the strike/fighter to the group

c. Altitude - in thousands of feet

d. Aspect - As shown in Figure 5-6

Broadcast control will be in bullseye format while tactical control may be in either bullseye or BRAA format.

3. **AIC Information**

During any intercept scenario, any AIC transmission pertaining to a detected group will include the following information

a. Location of the group – In broadcast control, the group's location will be defined from a common reference point. In tactical control, the group's location may use a reference point (bullseye format) or the fighter's nose (BRAA format).

b. Altitude to the nearest thousand feet.

c. Direction of movement – In broadcast control, this will be a cardinal or sub-cardinal direction (i.e., "North" or "Northwest"). In tactical control, this will be a reference to the target aspect the group is presenting to the referenced fighter flight. These aspects are shown in Figure 5-6: (A) 0-30 TA "HOT"; (B) 30-60 TA "Flank"; (C) 70-110 TA "Beam"; (D) 110+ TA "Drag". Flank, beam and drag descriptors will be accompanied by a sub-cardinal direction to denote aspect and track direction.

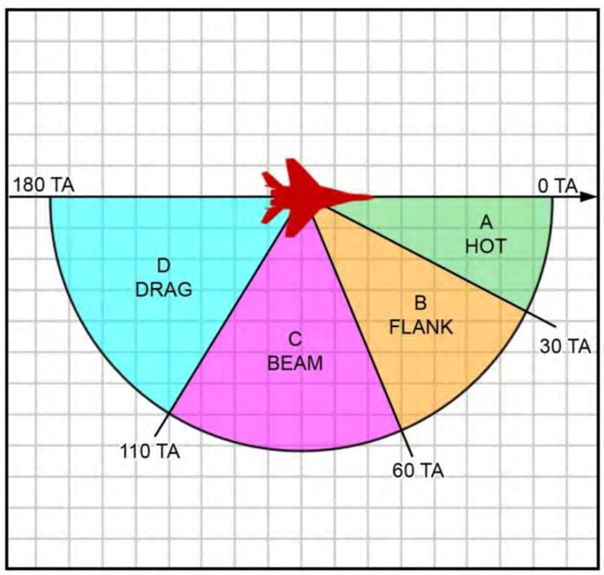

Figure 5-6 Target Aspect

d. Declaration – The declaration determines the level of permission the fighter has to destroy the group. There are four declarations:

i. Hostile – The group meets rules of engagement criteria (ROE) criteria for engagement

ii. Friendly – Group is friendly.

iii. Bandit – The group is positively identified as enemy, but does not meet ROE criteria to engage.

iv. Bogey – The group's identity is unknown; it may be the fighter's responsibility to obtain a positive identification through sensor or visual means.

v. Standby/Unable – Although not a declaration, AIC is attempting, or is unable to determine the identity of the group. Standby implies group identity is pending; unable implies AIC cannot make the ID.

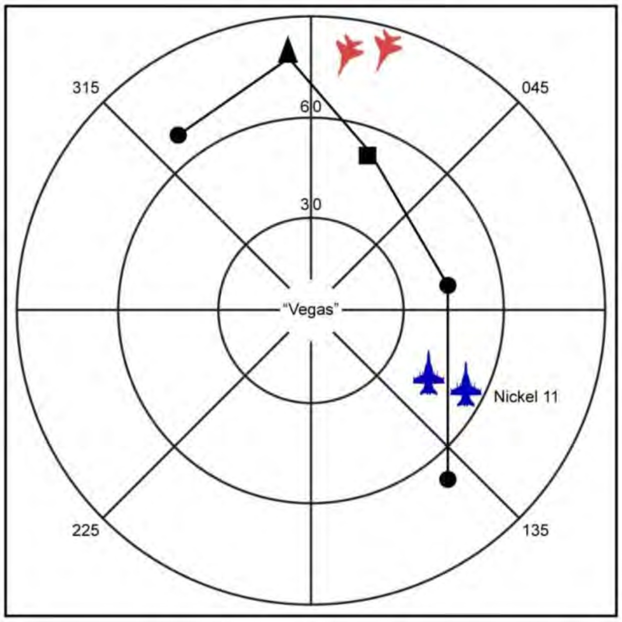

Figure 5-7 AIC Information in Bullseye or BRAA Format

In Figure 5-7, fighters are flying a route with a hostile group to their North. The same situation can be communicated in three different ways with the definitive elements of each in **bold**:

a. Broadcast control, Bullseye format - "*Nickel 11, SABRE, Single Group, Vegas 015, 80, 22 thousand,* ***track southwest****, hostile*"

b. Tactical Control, Bullseye format - "*Nickel 11, SABRE, Single Group, Vegas 015, 80, 22 thousand****, hot****, hostile*"

c. Tactical Control, BRAA format - "*Nickel 11, SABRE, Single Group* ***BRAA 345, 90, 22 thousand, hot,*** *hostile*"

At range, before the fighters commit to the intercept, AIC will normally use broadcast control in a bullseye format. Once the fighters are committed to intercepting a group, AIC transitions them to tactical control in a bullseye format. Outside of 30 NM, the fighters will brief AIC to use bullseye format. Inside 30 NM, AIC will use BRAA format (Figure 5-8).

Figure 5-8 Significant Intercept Events

506. CONTROLLER/FIGHTER TEAM WORK

Effective intercepts require that the fighter and AIC controller work as a team to establish a common understanding of the situation, also called the air "picture." A thorough briefing with AIC prior to the mission will ensure that the controller understands the fighter's intent for employment and the situation prior to the on station time. Although many of the issues of coordination will be SOP, fighter aircrew should always brief and debrief their controllers to ensure communications are open and effective.

When the fighter requests a picture from AIC, AIC will respond with the location of all known hostile, bandit, or bogey groups. If the fighter has contact with a group that is not identified by AIC, then the fighter should identify that group, using the format in use at that time, and request a declaration. To avoid confusion, AIC will repeat the location of the group to the fighter and add the group's name, if known, and a declaration. For example:

Fighter - "*SABRE, Nickel 11 contact, BRAA 315, 40, 33 thousand, hot, declare*"

AIC - "*Nickel 11, single group BRAA 315, 40, 33 thousand, hot, single group, hostile*"

The fighter has a number of ways of determining group position from the radar display. These include:

- Cursor BRAA position (OFT and VMTS)
- Cursor bullseye position (VMTS)
- Kneeboard spider card

Placing the cursor over the contact will provide BRAA to the contact in the OFT and both BRAA and bullseye position of the group in VMTS.

In the OFT, a bullseye reference card, also called a spider card, can be used to assist in building situational awareness. The card is normally a blank bullseye grid, in which the fighter can assess whatever information is relevant to the mission. This information may include:

- CAP positions
- Routes
- Locations of defended assets
- Locations of known hostile surface threats

A blank spider card example is referenced in Figure 5-9 for SNFO to copy and use.

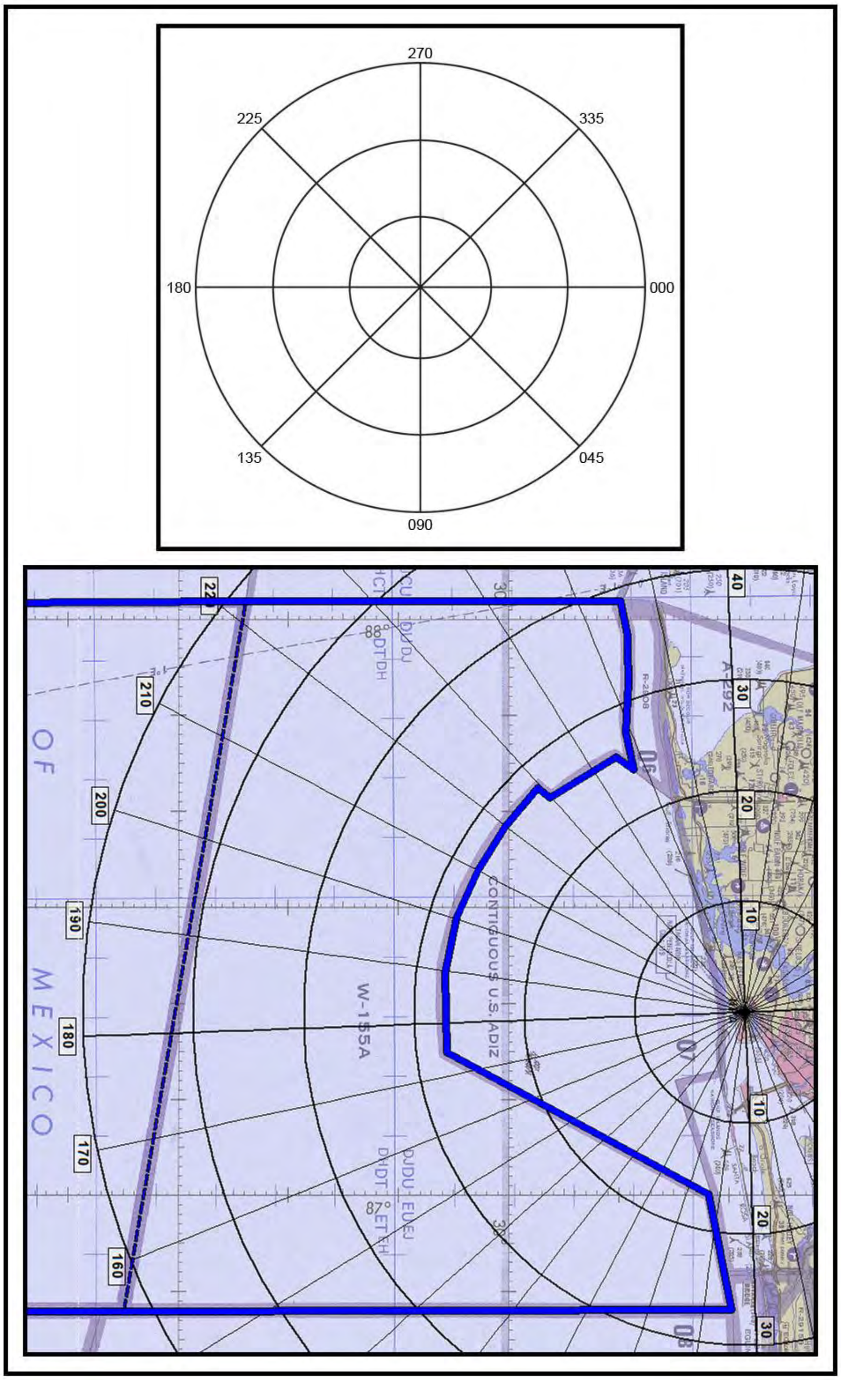

Figure 5-9 Spider Card

507. CONCLUSION

The fighter/AIC controller relationship is very important. The fighter should include AIC controllers in planning, briefing and debriefing of any mission in which AIC controllers are involved. Fighter aircrew must be thoroughly familiar with control methods and formats in order to be an effective air-to-air participant.

CHAPTER SIX
DIRECTIVE AND DESCRIPTIVE COMMENTARY

600. INTRODUCTION

Directive and descriptive communications provide the foundation for effective intercept communications. The use of applicable and appropriate communication brevity terms can facilitate easier understanding of the tactical situation and allow for simple, universally understood tasking to be accomplished with minimal communications. With the limited time available for transmission of information in the air, standard terminology allows complex ideas to be expressed with minimal verbiage. These terms must be concise, comprehensive, and free of any confusing qualities.

Communications brevity, or comm brevity, standardizes tactical communication terms so that all listeners on a communications net understand the situation in the fewest or shortest possible transmissions. Comm brevity is used across the U.S. military and North Atlantic Treaty Organization (NATO). Intimate familiarization with multi-service brevity terms is required for mission success. The aircrew at VT-86 will be responsible for knowing and applying the comm brevity words at the end of this chapter. These terms are taken from joint publications and are standard across the U.S. military and other friendly forces.

601. TYPES OF COMMENTARY

There are two types of intra-cockpit aircrew commentary: directive and descriptive:

- Directive commentary is specific instructions to members of the aircrew. At VT-86, directive commentary is used to direct the pilot to change the aircraft's altitude, heading, or airspeed in order to attain the optimal position for intercept control and employment of weapons.

- Descriptive commentary provides the aircrew information concerning the progress of the intercept and the relative position of a bandit from the fighter. At VT-86, it is used to "paint a verbal picture" of the intercept for the pilot.

Effective communication is critical to mission accomplishment. There can be no misunderstandings between the front and rear cockpits, or between the fighter and intercept control. The aircrew must be able to utilize both directive and descriptive communications in order to ensure a common air picture is understood and that tasks are executed in a timely and correct manner. A successful intercept and combat engagement is dependent on the appropriate and timely flow of both types of information.

602. VOICE INFLECTION AND MODULATION

Voice control is just as important to effective communication as proper terminology. Intercept communications, both inside and outside the cockpit, must be calm and void of any tendency to become loud and high pitched with excitement. However, increasing one's volume and pitch is certainly one way to express the importance of the words being spoken. Avoid long pauses, periods of indecision, expletives, and unnecessary talking. During tactical events, the cockpit should be a sterile environment so that every communication is meaningful to the other crew and flight members. Enunciation must be clear and concise. Words should be clipped and sharp so that syllables are not drawn out.

603. DIRECTIVE COMMUNICATIONS

Directive communications are sent with the intent that the receiver will perform an action without question upon receipt. Directive communications are distinguished from descriptive communications by the use of voice inflection, forcefulness, or tone. Without an audible change in vocal tone, important directive communication may get lost in the "background noise" of the intercept.

Because WSOs are not in physical control of the aircraft, they must learn to use directive communication effectively in the cockpit. Directive comm instructs the pilot to take specific positive action necessary to execute the mission. In effect, the weapons officer controls the fighter via commands to the pilot. A fighter may be maneuvered by changing its bank, pitch, and/or airspeed. In addition, the WSO issues directive radio communications to control the intercept outside the cockpit as well. Directive communications in the cockpit fall into five categories:

- Turn Commands
- Turn Modification Commands
- Altitude Commands
- Airspeed Commands
- Intercept Control Communications

1. **Turn Commands**

Turn commands control the heading of the fighter. With the exception of an easy turn, direction of turn is stated first so that the pilot will begin the roll and then capture the appropriate rate.

a. "*Easy left/right*" - Half standard rate turn at approximately 15 degrees angle of bank (AOB).

b. "*L/R standard*" – 30 degrees AOB standard rate turn.

c. "*L/R hard*" - A Mil Powered turn, using G to maintain airspeed turn.

d. "*Break L/R*" - Max performance, tactical maneuver (same as in BFM).

2. **Inside 10 NM**

The SNFO may utilize the following comm on ICS to direct the intercept.

a. "Go pure (pursuit)" - Pilot will place the contact/aircraft on the nose.

b. "Put 'em at XX" - Pilot will place the contact at the commanded angle off (AO).

c. "Lead 'em" - Pilot will place and hold the contact/aircraft 30 degrees in lead.

d. "Lag 'em" - Pilot will place and hold the contact/aircraft 30 degrees in lag.

3. **Turn Modification Commands**

These commands are used once established in a turn to modify the turn rate.

a. "*Harder*" – Pilot will increase turn performance to the next highest (easy to standard, standard to hard, etc.).

b. "*Ease*" - Pilot will begin a smooth roll toward wings level.

c. "*Hold*" - Pilot will maintain current AOB.

d. "*Steady up*" - Roll out on the current heading.

e. "*Steady (Heading)*" - Turn at the commanded rate and rollout at the commanded heading.

f. "*Reverse*" - Immediate roll to capture the same AOB in the opposite direction. Can also specify the turn rate to capture in the opposite direction "*Reverse Hard*."

4. **Altitude Commands**

Directive commands to adjust altitude include the following:

a. "*Descend to* ___" - The pilot will descend to specified altitude or designated number of feet while maintaining constant airspeed.

b. "*Climb to* ____" - The pilot will climb to specified altitude or designated number of feet while maintaining constant airspeed.

c. "*Level off*" - The pilot will attempt to capture current altitude. Also used as a correction if pilot has missed designated altitude "*Level off, 15 thousand*" if descent or climb rate passing 15K was not under control.

5. **Airspeed Commands**

Airspeed commands are used to change airspeeds or configurations that affect airspeed. Some directive airspeed commands are comm brevity, which mostly apply to flight management.

a. "*Set* ___" - Accelerate to the IAS or IMN designated. If no speed is specified speed is allowed to increase to the maximum allowed for the aircraft. "*Buster*" is comm brevity to set military power.

b. "*Hold speed*" - Given when aircraft reaches a desired or intermediate speed, which was not otherwise specified.

c. "*Throttle back, set speed* ___" - Pilot decreases speed until the aircraft reaches the IMN commanded.

d. "*Idle/boards*" - Pilot will go immediately to idle and extend the speed brakes.

6. **Intercept Control Commands**

Comm brevity terms that are directive and commonly used in an intercept include:

a. "*Commit*" - Call to commit on the indicated AIC picture

b. "*Cold*" or "*Cold L/R*" - Turn away from threat; not to be confused with cold aspect, which is descriptive information as part of AIC communications

c. "*Hot*" or "*Hot L/R*" - Turn toward the threat; not to be confused with hot aspect, which is descriptive information as part of AIC communications

d. "*Target*" - Assigns targeting responsibilities to flights or flight members

Directive comm always takes precedence over descriptive comm. The SNFO should never hesitate to interrupt descriptive communication to give a necessary directive command. Directive comm should be given with a sharp authoritative voice and with a different inflection to preclude any possibility of misinterpretation as descriptive comm.

Any time a maneuver is directed which exceeds the fighter's performance capabilities, the pilot will comply with the direction up to the fighter's limits.

604. DESCRIPTIVE COMMENTARY

Descriptive communications provide amplifying information to increase the situational awareness of the receivers. It should be clear, concise, and convey the most accurate information available. Descriptive communications can also rely heavily on comm brevity. However, if brevity does not fit the situation, clear concise plain language can be used as a last resort.

Descriptive communications can be divided into two subsets:

- Intra-cockpit descriptive commentary
- Globally applicable descriptive communications

1. **Intra-Cockpit Descriptive Commentary: The AREO Report**

The AREO report states, in order, the bandit's azimuth, range, elevation, and overtake (rate of closure (V_C)). AREO informs the pilot where to look for a contact during the transition from BVR to WVR. AREO reports will be made on the ICS within the aircraft. As with all descriptive comm, AREO reports should be given smoothly in a natural tone of voice. AREO reports should begin no earlier than 10 NM, since visual acquisition outside of 10 NM is not likely. The frequency of AREO reports should not be less than every 2 NM, and should increase as range decreases to the merge until the pilot calls "*Tally*." Once a tally by the pilot is achieved, AREO calls are no longer required.

Information in the AREO comes directly from the radar attack display as shown below:

a. Azimuth - reported in degrees left or right of the nose. Degrees are implied and does not need to be stated. If less than 5 degrees, report as "*On the nose*"

b. Range - reported in nautical miles as interpreted from the radar

c. Elevation - reported in degrees high or low. If no elevation difference, report "*Level*"

d. Overtake - Rate of Closure (Vc). (This is an optional item)

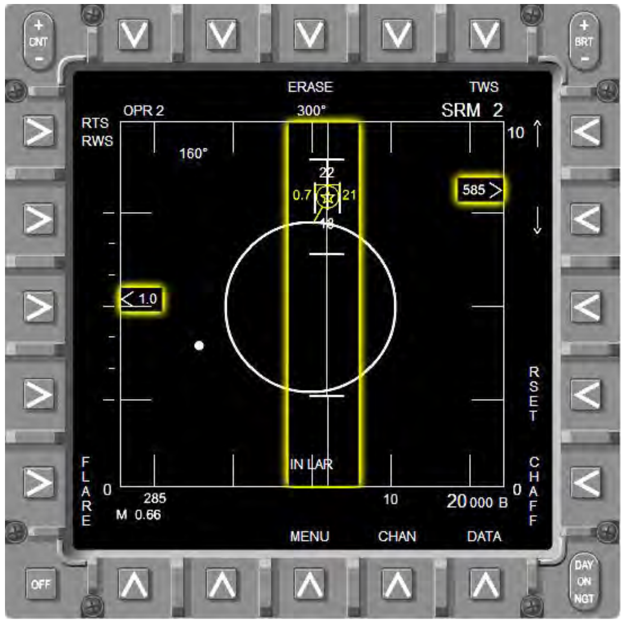

Figure 6-1 AREO Report Information from Radar Attack Display

For Figure 6-1, the correct call should be:

SNFO (ICS): "*On the nose, 8 miles, 1 high, 585 over*"

AREO reports should not be given when the intercept situation requires directive commentary to control intercept progression.

2. **Globally Applicable Descriptive Communications**

The initial contact communications made by the fighter or AIC are descriptive. These include calls made in both bullseye and BRAA format. These communications must be clear, concise, and accurate as possible. When more than one group or more than one fighter is present, clear, concise descriptive comm will build SA for the other fighters and for AIC, while poor communication can destroy everyone's SA. These intercept specific descriptive communications include:

a. Declarations

i. "Bogey" - unknown contact, proceed with intercept, weapons release not authorized

ii. "Bandit" - Confirmed enemy, weapons release not authorized

iii. "Hostile" - Confirmed enemy, weapon release is authorized

iv. "Unable" - ID capability not available, proceed with intercept

b. Altitudes will be given in thousands of feet

- "Fifteen thousand" is said as fifteen thousand.

c. Other globally applicable descriptive intercept communications brevity

i. "Cons/conning" - Non-friendly aircraft leaving contrail

ii. "Marking" - Friendly aircraft leaving contrail

iii. "Hot/flank/beam/drag" - Contact's aspect relative to the fighter in tactical AIC control

iv. "Track (direction)" - Contact's direction of travel; used in broadcast AIC control

v. "Heavy" - Group contains more than two contacts.

vi. "Echelon" - Two or more groups separated in both azimuth and range

605. COMM BREVITY GLOSSARY

Aircrew should be familiar with communication brevity terms. An incomplete glossary of these terms is included as Appendix A.

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CHAPTER SEVEN
INTERCEPT DISPLAY AND FLIGHT PATH VISUALIZATION

700. INTRODUCTION

The aircrew must correctly position the fighter's weapons system in preparation for weapons release. The SNFO must understand the orientation of the basic geometry of the intercept. The first step in understanding the intercept's geometry is a thorough understanding of intercept displays and the orientation of both the bandit and fighter flight paths. Correctly orienting the fighter and bandit flight paths will allow aircrew to advantageously position the fighter and employ weapons systems.

701. INTERCEPT PERSPECTIVES

There are three ways the intercept may be viewed:

1. **AIC or "God's Eye View" Perspective**

This is a two dimensional, top down orientation to the intercept as presented by the PPI attack display to the intercept controller. Regardless of the source of intercept control (AIC/GCI/E-2/AWACS/AEGIS), the air intercept controller's radar system and displays provide the earliest and most encompassing, "God's eye" situational awareness with 360 degree situational awareness. The large area covered, and the perspective by which it is shown, mean that the AIC will have a much better idea of what is going on around the fighter than the fighter aircrew will. Although, with the advent of data-links and network centric warfare systems, this information can be shared with a modern fighter and even displayed on the fighter's sensors.

2. **Bandit's Perspective**

The bandit's perspective pertinent to the fighter is called target aspect. Target aspect (TA) is the position of the strike fighter from the bandit's perspective. TA can be a visual assessment and/or displayed on the radar. TA is always expressed in degrees with a left or right. Degrees are assumed and not stated; meaning that "30 Right TA" is written and spoken as "thirty right" and not "thirty degrees right."

3. **Fighter's View**

The most important view is the fighter's view. This is determined by angle-off (AO). Angle-off is the position left or right of the fighter's nose either visually, or on the radar attack display. Like TA, AO is always expressed in degrees with a left or right, with degrees implied and not written/spoken.

While AO and TA represent a first person perspective to the intercept from the fighter and bandit's viewpoints, respectively, the AIC's "God's eye" view allows the most complete view of the geometry of the intercept. Fighter aircrew need to learn to build the three dimensional view from the information presented on their displays and through effective intercept communication.

4. **Relationship Between TA and AO**

TA is how the bandit sees the strike fighter. AO is how the strike fighter sees the bandit. When both AO and TA are equal in magnitude and opposite in direction, a collision course in established.

Collision course is when TA and AO are equal in magnitude, but opposite in direction, for two co-speed, co-altitude aircraft (Figure 7-1). If two aircraft are co-altitude and on collision course, there is a high likelihood they will collide if neither makes a change to heading, altitude, or airspeed.

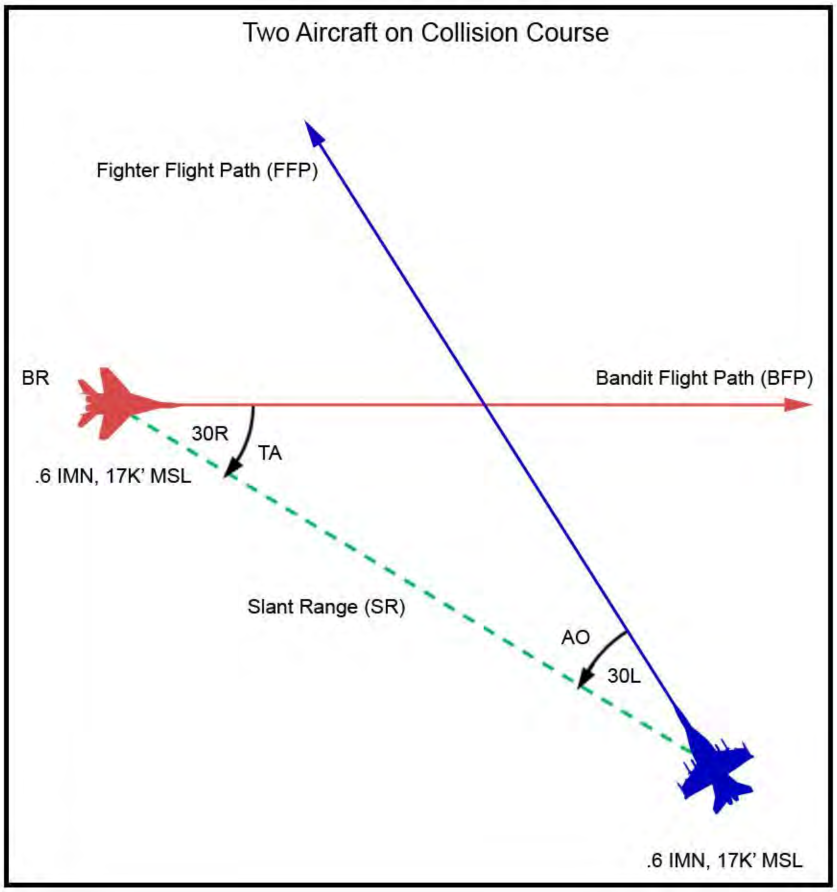

Figure 7-1 Two Aircraft on Collision Course

702. INTERCEPT DISPLAYS

There are a number of displays available to aid the fighter in determining the spatial relationships in an intercept. These include

- Radar attack display
- HSI (VMTS and OFT)

- EW page (OFT)
- Situational Awareness (SA) display (VMTS)
- Kneeboard spider card

1. **Radar Attack Display**

The radar attack display is the primary intercept display in the cockpit. The radar attack display shows information about the fighter's current position, the bandit's position and flight information, and weapon employment information.

Ownship information is called out from the radar attack display in Figure 7-2.

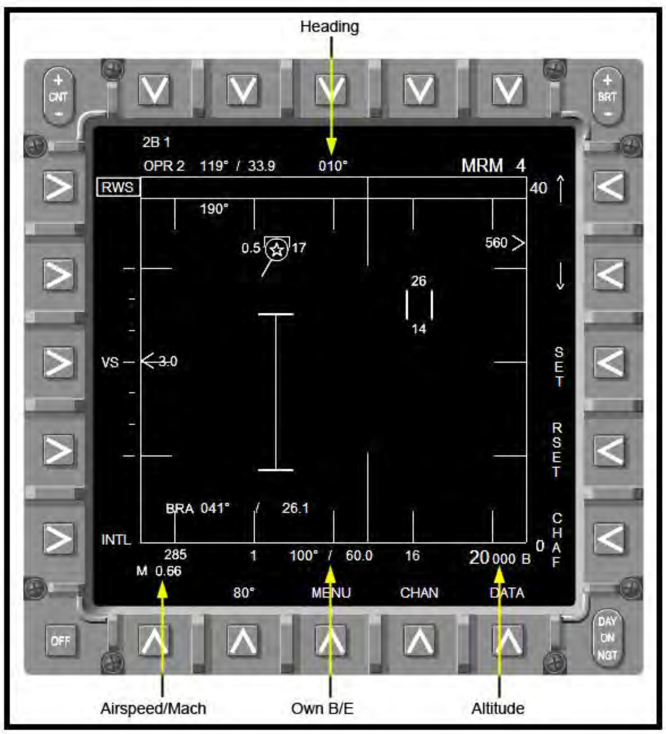

Figure 7-2 Ownship Information on VMTS Radar Attack Display

Ownship information displayed on the attack display includes:

a. Heading

b. Airspeed and IMN

c. Ownship bullseye position

d. Altitude

Note that ownship bullseye position is not displayed in the OFT, but is available in the VMTS aircraft.

In addition to ownship information, information about the launch and steering (L&S) trackfile is presented. This information on the radar attack display about the L&S includes:

a. Heading as computed by the radar

b. Airspeed in IMN

c. Altitude rounded up to the nearest thousand feet

d. Target Aspect vector providing TA with 0 degrees being straight down the display

e. Range as indicated as a caret on the range scale at the right of the display

f. V_C is indicated next to the range caret

g. Elevation caret indicating degrees above or below the aircraft

h. Differential altitude next to the elevation caret

i. Bearing and range to the cursor

j. Bullseye location of the cursor (VMTS only)

This information provides the fighter aircrew with every piece of information about the contact needed to affect a successful intercept. All of these indications, with the exception of ownship bullseye position and cursor bullseye position, are information from the fighter's perspective. Bullseye information provides an immediate connection to the AIC perspective by tying the attack display information to a top down view (Figure 7-3).

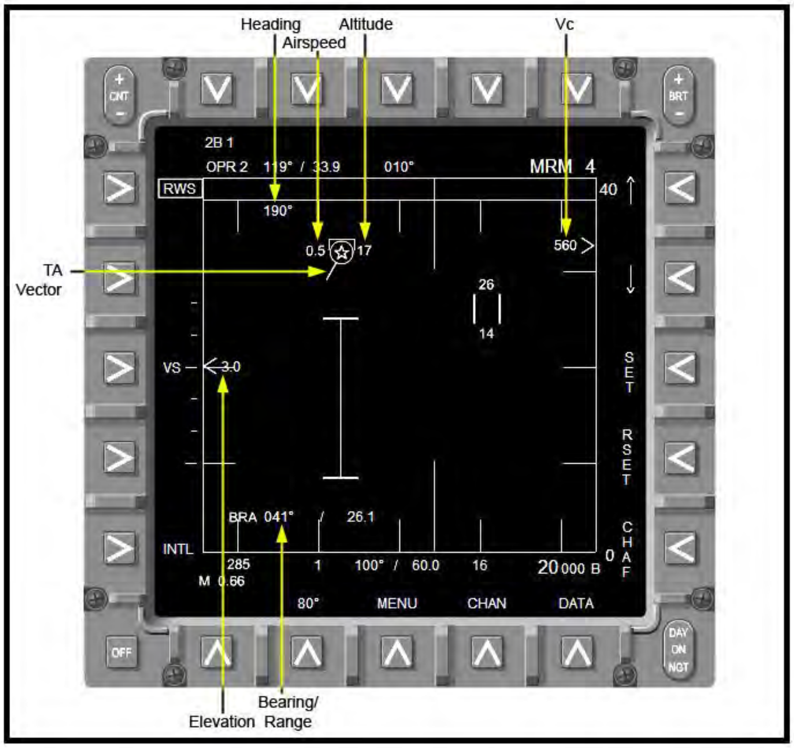

Figure 7-3 Contact Information on Radar Attack Display

2. **Horizontal Situation Indicator (HSI) Display (OFT and VMTS)**

The HSI is used in PLAN mode an intercept display to help visualize the intercept situation by translating intercept information into a recognizable navigation instrument (Figure 7-4). By recognizing that the fighter is at the center of the display, the bearing to the bandit can be easily identified on the compass rose. Using the range scale as a reference, the fighter can then establish the relative position of the bandit to geographical reference points, waypoints or route/area features as depicted on HSI symbology. However, the contact itself is not displayed on the HSI and the intercept is too dynamic for bandit location to be entered as a waypoint or offset. This limits the usefulness of the HSI to providing coarse intercept awareness.

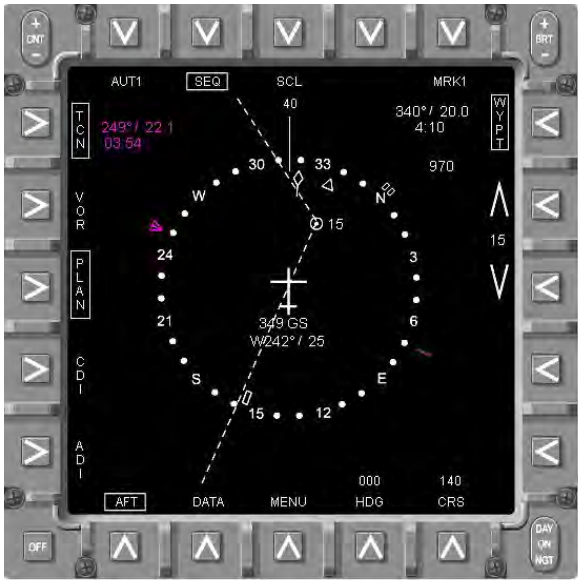

Figure 7-4 VMTS and OFT HSI Displays

3. Electronic Warfare (EW) Display

In the OFT, the EW display (Figure 7-5) provides an indication of the direction of arrival of detected threats, threat identification by type of emitter and threat status. The EW display also provides a quick reference to place the threat emitter in the beam by the marks at the aircraft's 12, 9, 6, and 3 o'clock position. No heading indication is given which limits the usefulness of the display on its own. Direction of arrival may not be accurate enough for defense; SNFOs should not rely on the EW page for calculating beam headings.

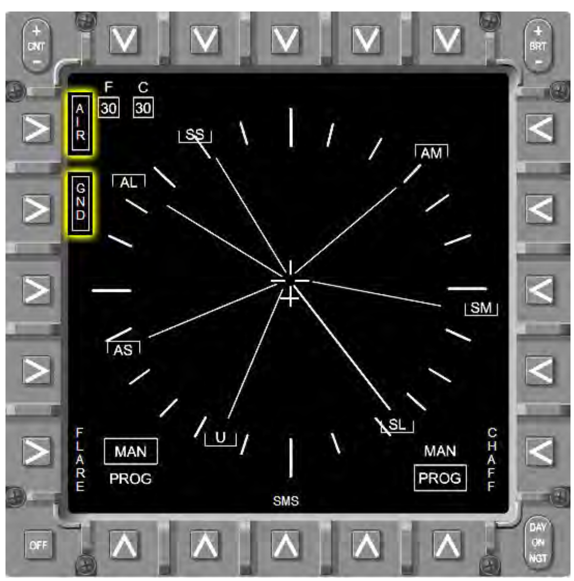

Figure 7-5 OFT EW Display

The EW display provides counters for chaff and flares, as well as dispense capability for both. It is accessed through the left MFCD EW option on the SMS display. The SMS option on the EW display returns the display to the SMS format. The OFT displays the threat symbols (Figure 7-6).

Symbol	Meaning
⊓	Air Threat
⊔	Ground Threat

Symbol	Meaning
AL	Air (>25NM <40NM)
AM	Air Medium (>10NM <25NM)
AS	Air Short (<10NM)
SL	Surface Long (>25NM <40NM)
SM	Surface Medium (>10NM <25NM)
SS	Surface Short (<10NM)
U	Unknown Emitter

Figure 7-6 OFT EW Page Symbols

Status change of the emitter is simulated by changes in the aural cues associated with the emitter. Different tones indicate the threat has locked the fighter and employed weapons.

4. **Situational Awareness (SA) Display (VMTS)**

The VMTS SA display combines the functionality of EW display and the HSI into a common display. The VMTS SA display (Figure 7-7) is very similar to those in use in the F/A-18. As shown, the fighter has waypoint steering information, sequence information, auto sequence option and range selection options as in the HSI. Additionally AIR and GND options allow the selection of display of airborne or surface threats, respectively. VMTS EW symbols are simplified and shown below in Figure 7-8.

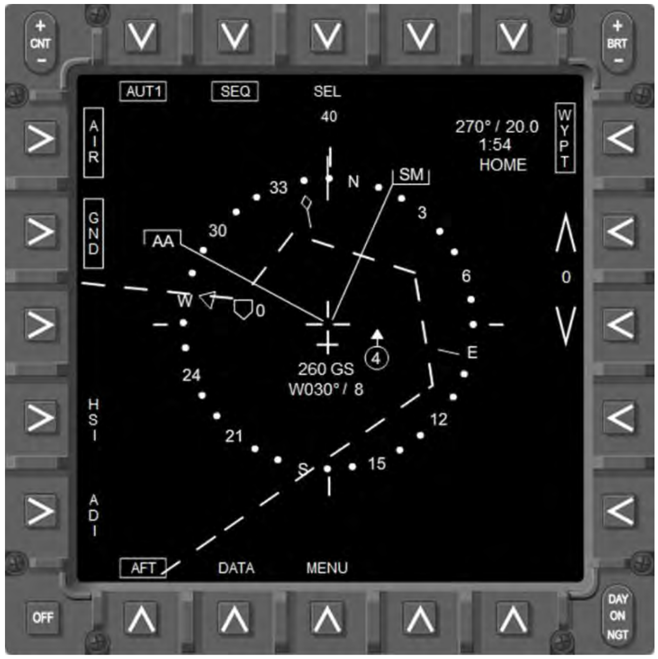

Figure 7-7 VMTS SA Display

Symbol	Meaning
⊓	Air Threat
⊔	Ground Threat

Symbol	Meaning
AA	Air Threat (any range)
SL	Surface Long (>25NM <40NM)
SM	Surface Medium (>10NM <25NM)
SS	Surface Short (<10NM)
U	Unknown Emitter

Figure 7-8 VMTS SA Page Symbology

The SA display allows the fighter to reference one display for route/area management, waypoint steering/geographic reference (GeoRef) and EW information, making it a much better display than the HSI or EW display during an intercept. The only disadvantage of the SA page is that chaff cannot be dispensed from the SA page. This must be done from the attack display.

5. **Kneeboard Spider Card**

The spider card on the kneeboard is also an intercept display in that it allows for near real-time plotting of group and fighter positions to build situational awareness. The kneeboard spider card is only as good as the information aircrew put on it and does not take the place of the attack display. Rather, the spider card should be used to enhance SA to the group positions relative to the route, area or target. The spider card will be used in intercepts where broadcast control in a bullseye format is used.

When flying a route or designating GeoRefs, it is highly recommended that these also be plotted on the spider card to allow for quick reference to the tactical situation.

6. **Intercept Displays, Active Listening and the Mind's Eye View**

The most important intercept situational awareness tool is the mind's eye view of what the situation is. This represents a fusion of the available information into a coherent mental image of the intercept situation. It combines the information presented on all cockpit displays to form a mental picture of what is happening in three dimensional space. This is a skill that must be developed.

The first step to being able to visualize an intercept begins mission preparation. The fighter aircrew must be thoroughly familiar with the briefed mission area, bullseye position, CAP or route placement, and expected threat presentations. Once airborne, the strike fighter aircrew can determine their aircraft position and the group contacts as communicated by AIC. A spider card can be very helpful for visualizing the intercept at this point in the mission but the most important skill to develop is active listening.

Active listening means the receiver, in this case the fighter aircrew, are able to feed back to the communicator exactly the information sent, not similar, paraphrased or their own interpretation. This ensures accurate and effective communications are taking place. In order to establish a correct mind's eye view, the fighter must do the following:

a. Actively listen to AIC communication to understand the bandit presentation/location.

b. Use available information, especially the radar attack display, to confirm the location of groups as transmitted by AIC.

c. Correlate with properly formatted communications that the information presented by AIC is what the aircrew see on their sensors.

d If the aircrew have information not presented by AIC, they must communicate that information to AIC and request a declaration to that group to ensure a common air picture is realized.

703. CORRELATING AIC INFORMATION

Once the aircrew have established their position and have received bandit location information from AIC, they can begin to build the spatial picture. In VMTS, correlation of this information is done through BRAA to cursor and Bullseye to cursor information on the radar attack display. In the OFT, this correlation is done via BRA to cursor information and projecting that information from the mind's eye view to the HSI and/or spider card.

In Figure 7-9, the cursor is not on the contact, this means that the cursor position information will not reflect bandit position. For example, AIC communicates:

"*Hammer, SABRE, Single group BRA 350, 35, 17 thousand, hot*"

The fighter correlates this by placing the cursor over the contact and noting the BRAA position. Since this matched what the fighter is seeing on the radar attack display, the fighter can ask for a declaration.

SNFO (PRI) - "*SABRE, Hammer, contact BRA 350, 33, 17 thousand, declare*"

AIC will respond with the entire BRAA location again and add a declaration, if not previously given.

AIC (PRI) - "*Hammer, Single group BRA 350, 30, 17 thousand hot, hostile*"

From this information the fighter knows the picture is a single group, and that the group is correlated to what the fighter sees. From the information on the radar attack display, the fighter can create the spatial image presented in Figure 7-10.

The information on the radar attack display provides the fighter heading, bandit heading, angle-off and target aspect. In addition, the range, rate of closure (V_C), and elevation are known. The fighter can now take the steps required to affect an intercept on the bandit. From the presentation here, it is obvious that the fighter must turn significantly to the left in order to intercept the bandit. This turn to intercept will change the intercept geometry into the intercept triangle. A thorough discussion of intercept geometry is the purpose of the next chapter.

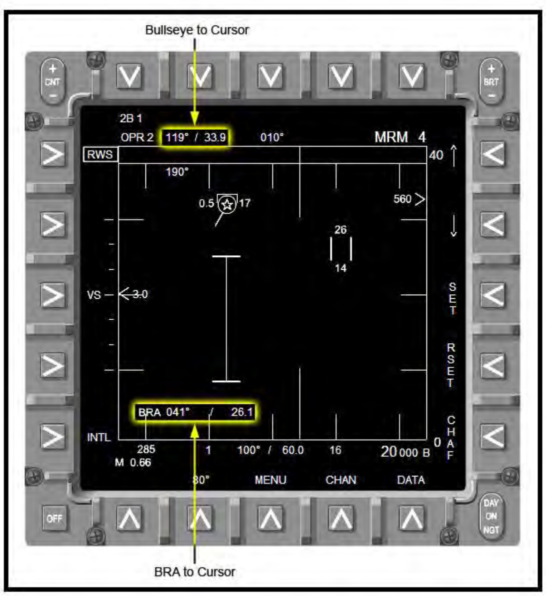

Figure 7-9 Bullseye and BRA Information on VMTS Radar Attack Display

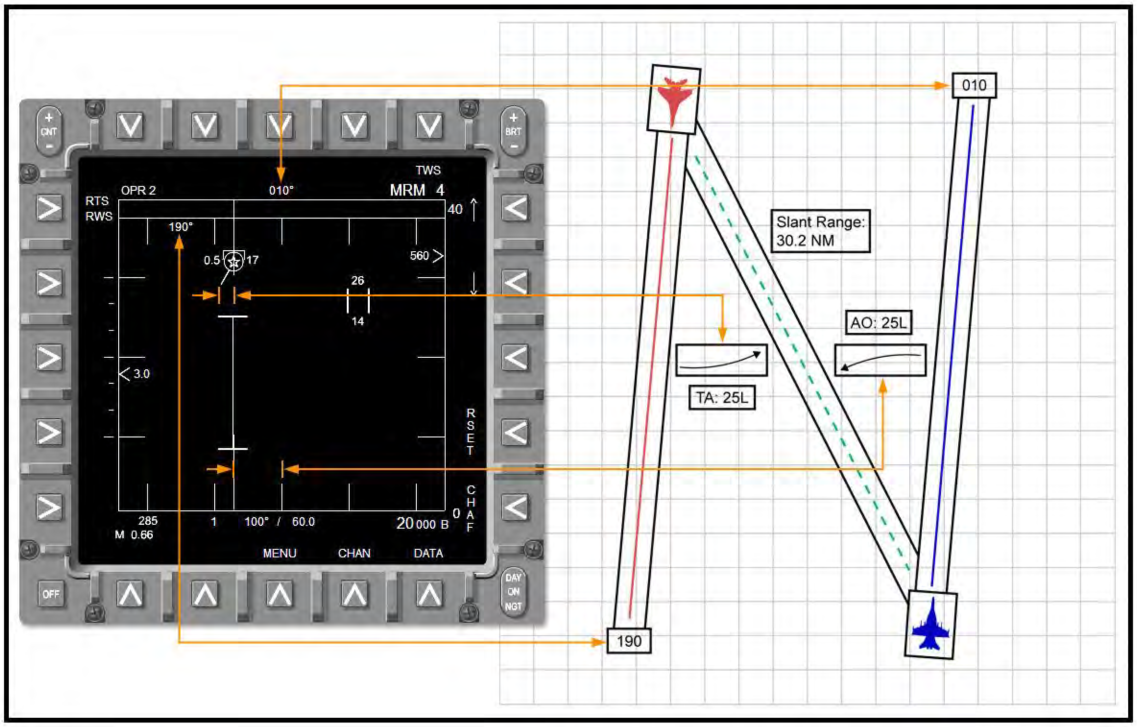

Figure 7-10 Intercept Visualization

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CHAPTER EIGHT
FUNDAMENTALS OF INTERCEPT GEOMETRY I

800. INTRODUCTION

Armed with the information presented through AIC communications and intercept displays, the fighter aircrew can recognize initial intercept geometry. Once the initial geometry is recognized, the fighter can take the necessary steps to modify that geometry to affect and intercept with the targeted group.

801. INTERCEPT TERMS

In order to discuss intercept geometry a vocabulary of intercept terminology must be established. Terms such as AO and TA have been discussed previously, but are included here for reference as they relate to other intercept terms. These terms include:

- Fighter Heading (FH) – Heading of the fighter which, if extended through space, defined the fighter's flight path

- Fighter Flight Path (FFP) – the logical extension of the direction of the fighter's travel through space on its current FH

- Bandit Heading (BH) – Heading of the intercepted aircraft

- Bandit Flight Path (BFP) – logical extension of the bandit's travel through space on the current BH

- Bandit Reciprocal Heading (BR) – Bandit reciprocal heading, also called bandit recip (BR) is the 180 degrees opposite direction from BH.

- Bandit Bearing (BB) – Line of sight (LOS) bearing between the fighter's position and the bandit's position. BB is independent of both FH and BH.

- Angle-off (AO) – Angle between FH and BB; called Antenna Train Angle (ATA) in the USAF

- Target Aspect (TA) – Angle between BH and the bearing from the bandit to the fighter;

- Aspect Angle (AA) – Number of degrees from the BR to BB; defines the number of degrees to the bandit's six o'clock. AA plus TA always equals 180 degrees. "High Aspect" BFM refers to high AA, not TA, as they are complementary and measure from opposite sides of the bandit. For example, 45 R TA implies 135 R AA, and vice versa.

- Elevation Angle – Number of degrees high or low the contact is detected; can be difficult to determine in a multi-bar scan.

- Heading Crossing Angle (HCA) – The number of degrees between FH and BH at the point of intercept. Also called Degrees to go (DTG)

- Cut – Measure of angle from FH to BR which is equal to 180 degrees minus HCA. Although not commonly used in operating forces, discussions using cut are easier than annotating "180 degrees-HCA" in intercept geometry discussions.

- Rate of Closure (V_C) – Sum of the components of fighter and bandit velocities that contribute to downrange travel

- Vertical Displacement – The amount of distance between FFP and BFP based on current fighter and bandit altitude

- Slant Range (SR) – Direct LOS distance between fighter and bandit

- Lateral Separation (LS) – also called lat sep, LS is the horizontal distance between the fighter's current position and BFP.

In addition to these terms, there are some important relationships between these terms that should be understood

The relationships between BH, TA, FH and AO are the most important in the intercept and need to be understood such that fighter aircrew immediately recognize the impact changing any of these parameters has on the intercept.

802. BANDIT HEADING, TARGET ASPECT AND LATERAL SEPARATION

Bandit heading determines target aspect. Target aspect will change instantaneously with a change in bandit heading. Likewise, a turn away from the fighter's nose can instantaneously create large target aspect, changing the geometry of the intercept.

Because TA represents the difference between the bandit's bearing and the bandit's flight path, a bandit that maneuvers by changing heading changes not only TA but the fighter's location to the bandit's flight path.

1. **Lateral Separation – Target Aspect Relationship**

Lateral separation is the horizontal distance from the fighter to the BFP. LS is turning room. LS (in thousands of feet) is computed by: LS = TA x SR x 100. Since SR will only change over time, but TA can change instantaneously, LS will change instantaneously with changes in TA and very slowly with changes in SR.

In Figure 8-1, the bandit begins with 30 L TA and 60K LS at 20 NM. By turning 30 degrees into the fighter, that is placing the fighter on its nose, the bandit has reoriented its flight path such that the fighter now has 0 LS and is seeing 0 TA. If the bandit maintains a nose-on position, there is nothing the fighter can do to create lateral separation.

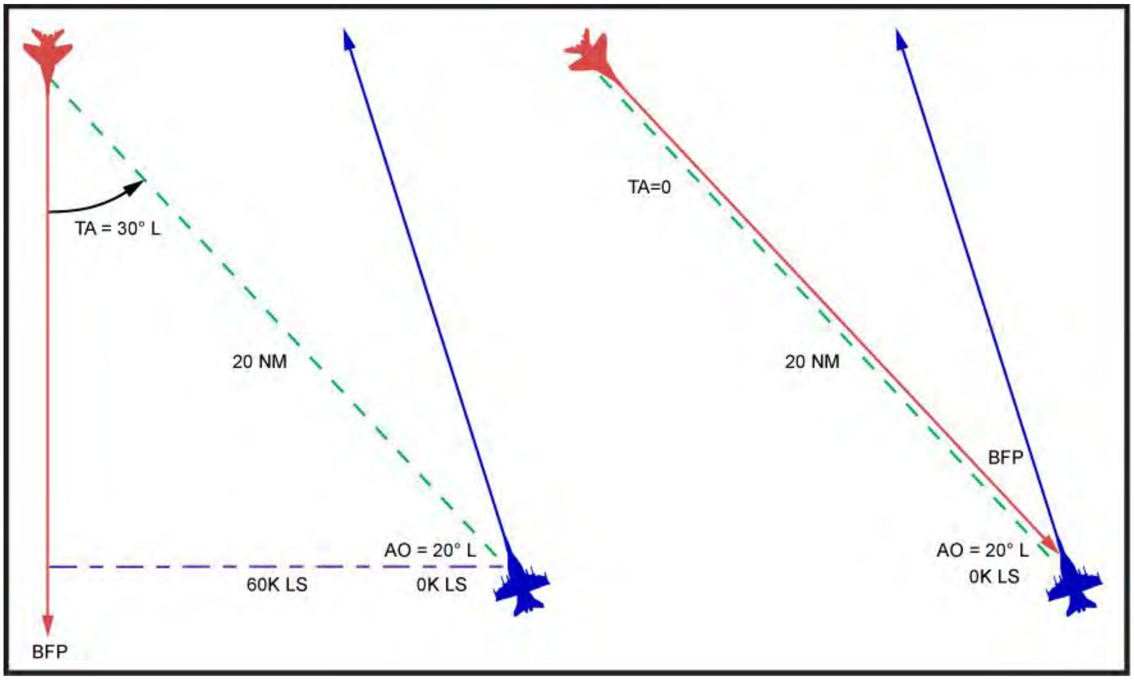

Figure 8-1 Bandit Heading Change

For example, a bandit at 20 NM with 20 TA will have 40,000 feet (written as 40K) of LS. If the bandit turns to put the fighter on the nose, the LS equation yields LS = 0, meaning there is no separation between the fighter and the bandit's flight path at that moment.

Lateral separation is an instantaneous measurement and will change as both slant range and target aspect change. In Figure 8-2, at 20 NM, the fighter has:

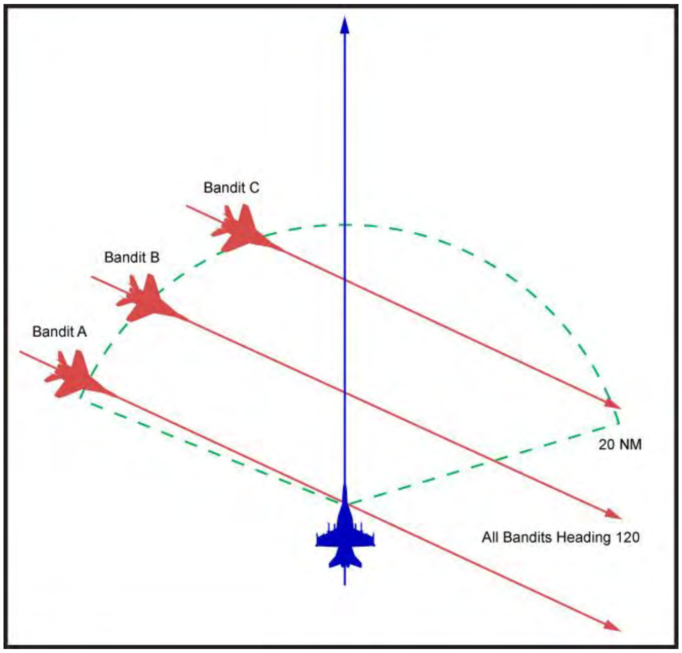

Figure 8-2 Fighter Location from BFP

a. 0 LS from Bandit A; the fighter is on Bandit As flight path (20 NM x 0 TA)

b. 40K LS on the right from Bandit B (20 NM x 20 TA)

c. 60K LS on the right from Bandit C (20 NM x 30 TA)

TA varies even though all of the bandit headings are the same. Also note that whenever the bandit is nose-on, the fighter has 0 LS. This means any bandit maneuver in heading will instantaneously affect LS, while the fighter movement will change LS over a time**.**

In summary, bandit maneuvers always change LS and TA. It is up to the fighter to determine what has happened and how to react to the maneuver. In stern conversions, the bandit will not maneuver, so the fighter must be able to recognize their location in relation to BFP based on TA determination and LS calculations

803. TARGET ASPECT AND V_C

Since TA is directly related to BH, and BH determines the amount of the bandit's velocity that contributes to V_C, the lower TA is, the higher closure will be. V_C can be easily computed, theoretically, by determining the component of the fighter's and bandit's velocities that are contributing to their mutual downrange travel (Figure 8-3).

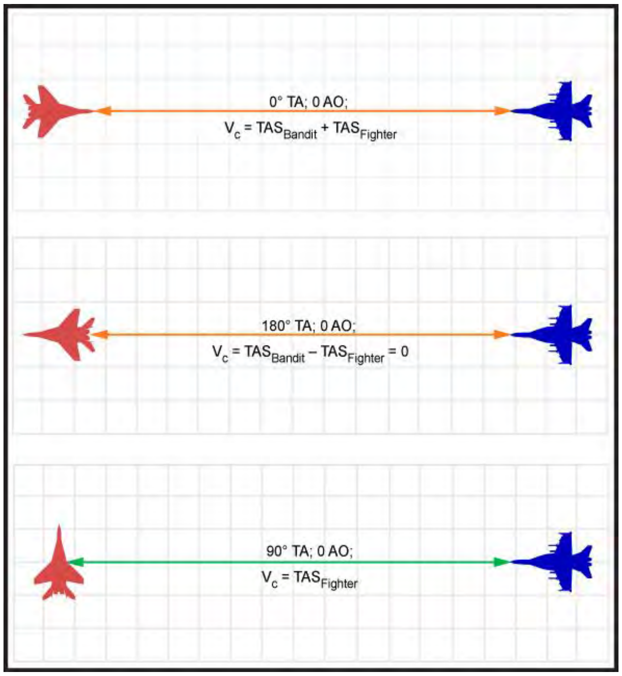

Figure 8-3 V_C and TA

With a co-speed bandit, maximum V_C will be double the fighter's speed (300 KGS + 300 KGS in AWI). With 90 TA, V_C will be equal to the fighter's speed (300 KGS + 0 KGS component to downrange travel) and the bandit will be hidden by the radar's clutter notch. With 180 TA, closure will be 0 (300 KGS + (- 300KGD of receding bandit).

This means the only time a 600 V_C will be seen is with 0 TA and the bandit on the nose. Normal V_C numbers for AWI intercepts are between 420 and 580 KTS.

804. TARGET ASPECT, FIGHTER HEADING AND ANGLE-OFF

Unlike changes in bandit heading, TA will not change immediately with a change in fighter heading. Rather, with a bandit on a constant heading, the movement of the fighter through space in relation to BFP is required for the fighter to affect TA.

Angle-off (AO) will change instantaneously with fighter heading, as any turn by the fighter changes the number of degrees off the nose the fighter sees the bandit.

Against a non-maneuvering bandit, such as those seen in stern conversions, TA can only be changed by the fighter maneuvering to change its position in relation to BFP, thereby changing the fundamental geometry of the intercept. This concept is shown in Figure 8-4.

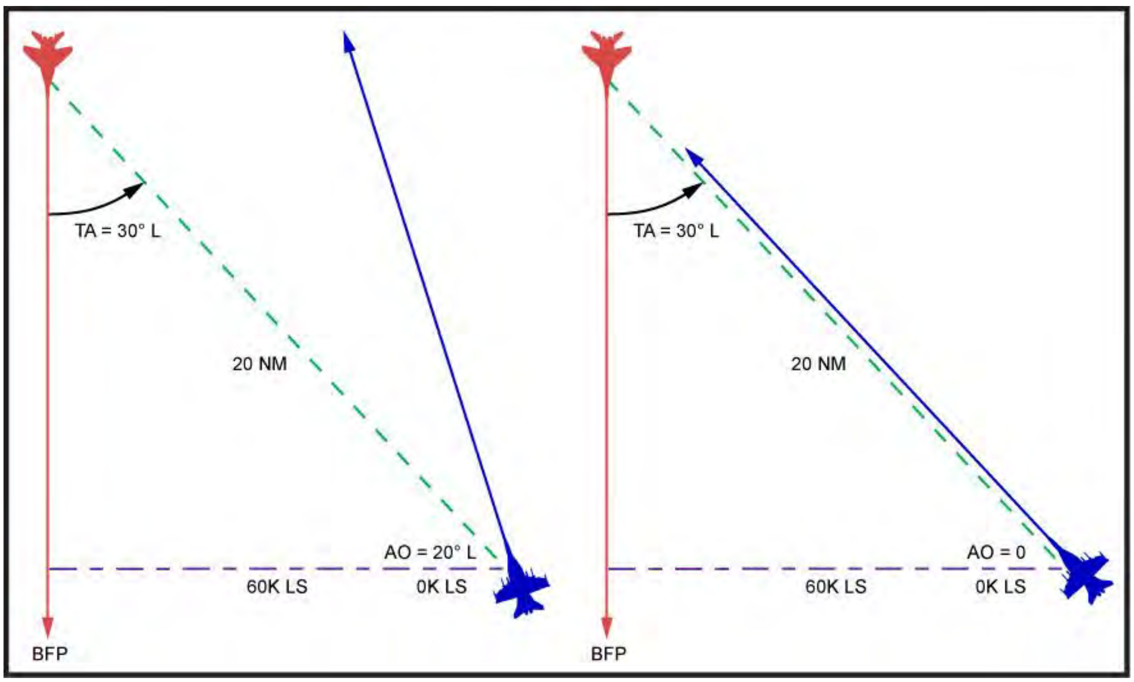

Figure 8-4 Effect of Fighter Heading Changes Only AO

805. VERTICAL DISPLACEMENT

Vertical displacement (Figure 8-5) is the perpendicular distance the fighter is located above or below the bandit's flight path. This represents the altitude difference between the fighter and bandit and should be computed in feet. Note that the formula for vertical displacement is the same as the one for LS with the vertical displacement (feet) = Elevation X SR X 100.

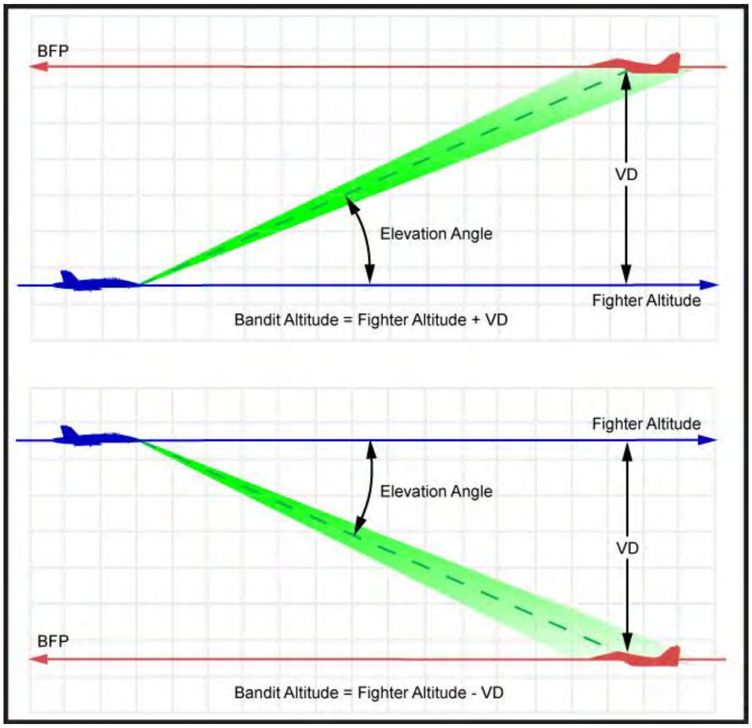

Figure 8-5 Vertical Displacement

If the bandit is 4 degree high at 20 miles, 4 x 20 x 100 means that the bandit is 8,000 feet above the fighter.

During and intercept, AIC will frequently know the altitude of the bandit and must compute the elevation angle in order to determine where to place the radar scan volume. Aircrew must be able to work the vertical displacement problem in reverse. For example, if the fighter is at 20,000 feet and AIC calls bandit altitude at 30,000 feet at 20 miles, the fighter should ensure that the scan volume indicates that the bars are covering an elevation angle of at least 5 degree high from the following derivation:

- 30,000 feet - 20,000 feet = 10,000 feet of vertical displacement
- 10,000 feet = 20 (NM) x Elevation angle x 100
- 100 = 20 x elevation angle or elevation angle = 5 degree of elevation

Obviously if the fighter is above the bandit, the elevation angle is negative (i.e., depression).

806. INTERCEPT RELATIONSHIPS

Once intercept terms, their relationships and the information on the radar attack display is understood, the fighter should be able to build a mind's eye view of the intercept geometry based on the information presented on the attack display. The fighter aircrew can also interpret the information presented to recognize whether the contact(s) they have is (are) the one(s) being correlated by AIC information.

In Figure 8-6**,** the fighter can determine the following directly from the attack display:

- BH is 190 degrees
- SR is 33 NM
- V_C is 560
- Vertical displacement is 3,000 feet
- Elevation angle is -1 degree
- Bandit altitude is 17 thousand
- Bandit airspeed is 0.5 IMN
- The fighter sees the bandit at an AO of 20L

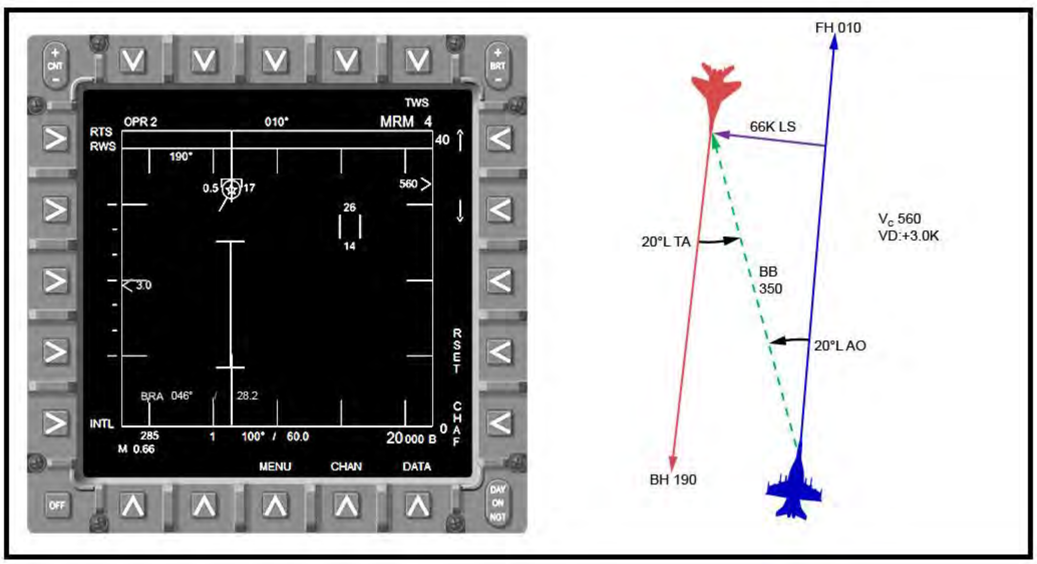

Figure 8-6 Interpretation of Radar Attack Display Information into Mind's Eye View

From this information, the fighter can determine:

- BR is 010 degree
- LS is 66,000 feet (66K)

With this information, the fighter should recognize that FH is on BR, which has a significant impact on future intercept conditions and conduct. The concept of intercept quadrants was touched on in Chapter 5 with the introduction of TA quadrants referenced by AIC. These are shown in Figure 8-7.

807. FIGHTER POSITIONS AND POSITIONAL ADVANTAGE

The concept of intercept quadrants was touched on in Chapter 5 with the introduction of TA quadrants referenced by AIC. These are shown in Figure 8-7: (A) Head-On Quadrant, 0-30 TA "HOT," (B) Forward Quarter, 30-60 TA "Flank" Aspect; (C) 70-110 TA Beam Quarter "Beam" Aspect; (D) Rear Quarter 110+ TA "Drag" Aspect.

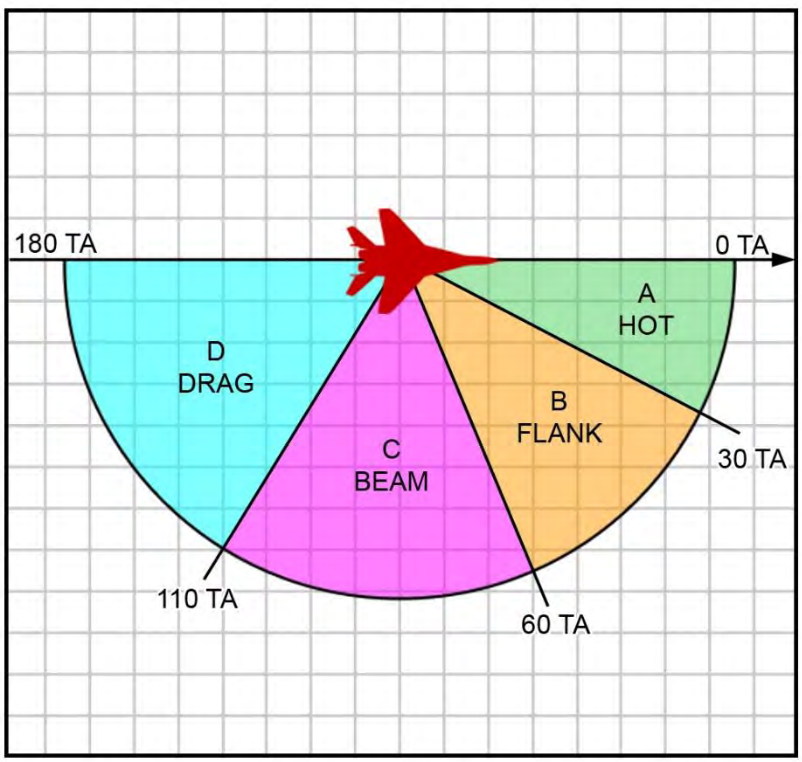

Figure 8-7 Target Aspect

These TA regions also correspond to initial approach quadrants in an intercept and determine whether or not the fighter is beginning the intercept with a positional advantage.

Positional advantage is a relative term used to describe the fighter's ability to attack a bandit or to defend a target in a beyond visual range (BVR) engagement. A fighter with a positional advantage can have an enormous effect on the outcome of the bandit's mission. A fighter beginning with a positional disadvantage will have a difficult time influencing the bandit's actions. In other words, with a positional advantage comes the tactical initiative; without positional advantage, the tactical initiative is not held by the fighter. In Figure 8-8 there is a bandit approaching a friendly ship. Only one of the three fighters has a positional advantage.

Fighter A has a positional advantage since the aircrew can maneuver to place themselves between the bandit and the target. Fighter B is at a positional disadvantage because the distance it must cover to achieve a FQ LAR may mean the bandit has attacked the target and is engaged by the fighter on the egress. Fighter C is in a distinct positional disadvantage because it cannot affect the bandit's actions until bandit egresses.

From this, it should be obvious that the fighter in the head-on or forward quarter, that is hot or flank aspect, has a positional advantage. A fighter in the beam quarter, with beam aspect, is in a neutral or disadvantageous position. A fighter seeing drag aspect is in the rear quarter and is at a positional disadvantage. Recognizing whether or not the fighter has a positional advantage at the beginning of the intercept is possible once the initial geometry is recognized. Once an advantage or disadvantage is recognized, the fighter can take action to change the geometry to create an advantage, mitigate a disadvantage or coordinate with AIC for other assets to engage a group that the fighters are out of position to engage.

In the example above, positional advantage is demonstrated from an AIC or "God's eye" view of the situation with the bandit threatening a near stationary target. However, positional advantage may also include factors like a large vertical displacement, where the fighter has an advantage due to its great altitude differential over the bandit, or the placement of the fighter's planned route or target. Fighter aircrew must recognize the impact of their location, both current and planned, on the tactical situation when evaluating positional advantage and take the appropriate steps to create positional and tactical advantages whenever possible.

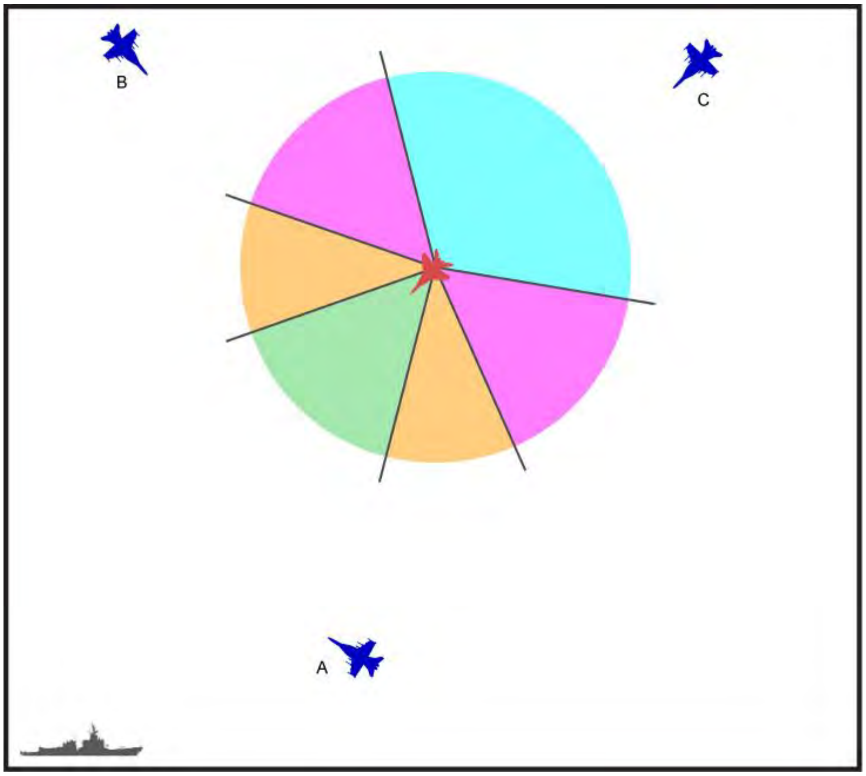

Figure 8-8 Intercept Quadrants and Positional Advantage

Actions used to create or capitalize on a positional advantage include changing heading, altitude, or airspeed or a combination of these. At this stage, with a non-maneuvering, co-speed bandit, geometry changes will be made primarily through heading and speed changes.

808. THE INTERCEPT TRIANGLE

In order for an intercept to take place, the fighter flight path must intersect with the bandit flight path. The intersection point will be the point of intercept. Once aircrew establish the bandit and fighter positions on their respective flight paths, the intercept triangle is formed by the flight paths of the aircraft and the bearing line between aircraft.

The intercept triangle (Figure 8-9) is a useful tool to visualize angles such as TA, AO, HCA and cut. When combined with the fact that the three interior angles a triangle always add up to 180 degrees, a complete spatial picture of the intercept can be obtained. TA and consequently AA can always be calculated if either BB or AO and HCA are known.

Manipulation of fighter and bandit heading, thereby changing AO and TA, respectively, change the geometry of the intercept triangle. Additionally, changes in bandit or fighter airspeed with also change the geometry of the intercept triangle.

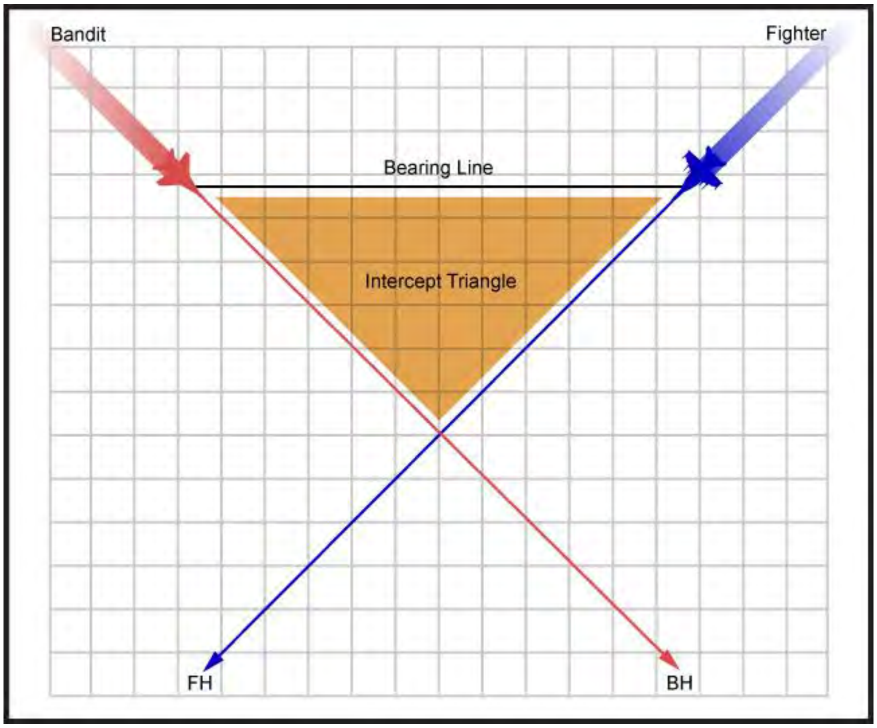

Figure 8-9 Intercept Triangle

809. CONCLUSION

Knowing intercept terminology allows the aircrew to discuss the intercept using a common vocabulary with specific definitions. Fighter aircrew must be well versed in this vocabulary to perform their mission.

The intercept triangle will be explored in much greater detail in the rest of this manual. The recognition that the intercept is a triangle allows the fighter to manipulate the geometry of the intercept to affect a rendezvous to identify and employ weapons on the bandit.

The fighter must use geometry and the intercept triangle to obtain a positional advantage in order to accomplish the briefed mission. An in depth understanding of the relationships between intercept parameters is key in understanding the actions to take to create a positional advantage in any intercept.

CHAPTER NINE
FUNDAMENTALS OF INTERCEPT GEOMETRY II

900. INTRODUCTION

With the information from chapter 8, aircrew can examine the intercept triangle in greater detail to discuss what constitutes optimal intercept geometry in any given situation. For stern conversions, it is assumed that:

- The use of geometry is preferable to burning fuel to affect an intercept. This is not to say a fighter speed advantage will never be used; rather, geometry will be used as the primary means of affecting an intercept.

- The geometry game plan for intercepts should minimize in cockpit calculations.

- The geometry game plan should affect geometry in a logical and predictable manner.

- With these fundamentals in mind, intercept geometry can be discussed in great detail.

901. CONTACT DRIFT

During conduct of an intercept, the contact will move on the radar attack display. This movement is called drift. There are several types of drift and often more than one type is occurring at the same time. Understanding these different types of drift is crucial to understanding what is happening on the attack display and why. The effect of drift will be revisited more than once during the discussion of intercepts at VT-86. If the aircrew knows what kind of drift to expect, then they will be able to detect abnormal conditions, such as bandit maneuvering, much more easily. The types of drift discussed are:

- Turn Drift: Movement of the contact on the radar attack display as a result of fighter maneuvering in heading. Occurs strictly as a result of turning the fighter. To illustrate, if the fighter makes a turn 30° to the right, the target will appear to drift to the left by the same amount and rate as the fighter's turn.

- Intercept Drift: Movement of the contact due to the movement of the fighter and bandit through space. This is the result of changes in geometry during the intercept. For example, as two aircraft approach the merge, the bearing to the other aircraft changes as range decreases. At range, this same effect is seen, but is less pronounced. Controlling intercept drift is a primary goal during any intercept.

- Displayed Drift: The sum of intercept and turn drift, displayed drift is what the aircrew perceive on the radar attack display. It is very important for aircrew to recognize what is causing the resultant displayed drift and what this drift means.

Recognition of the type of drift that is occurring and why is a fundamental fighter aircrew skill.

902. COLLISION COURSE AND THE ISOSCELES INTERCEPT TRIANGLE

An air-to-air intercept is a relative motion problem in which the fighter is constantly striving to control its position in relation to the bandit. Changes in the bandit and fighter's position will result in intercept drift. The ultimate manner of controlling intercept drift is establishing a collision course. On a collision course, the fighter established a constant bearing, decreasing range situation that, if not changed, may result in a midair collision. A contact which is on collision will not drift. A contact which is not on collision must drift and it will always drift away from collision bearing (CB). CB has a direct impact on intercept control.

Recall from Chapter 8 that the intercept triangle is made from the fighter and bandit flight paths and the bearing between the two. A collision course will exist when geometry is such that the bandit remains on a constant bearing with no changes in heading by the fighter. When this occurs, the following conditions will be present:

- AO will be equal in magnitude, but opposite in direction to TA
- The distance to the intercept point for both the fighter and bandit will be equal
- V_C for the intercept will be at a maximum (with both aircraft at the same airspeed)

This is illustrated in Figure 9-1.

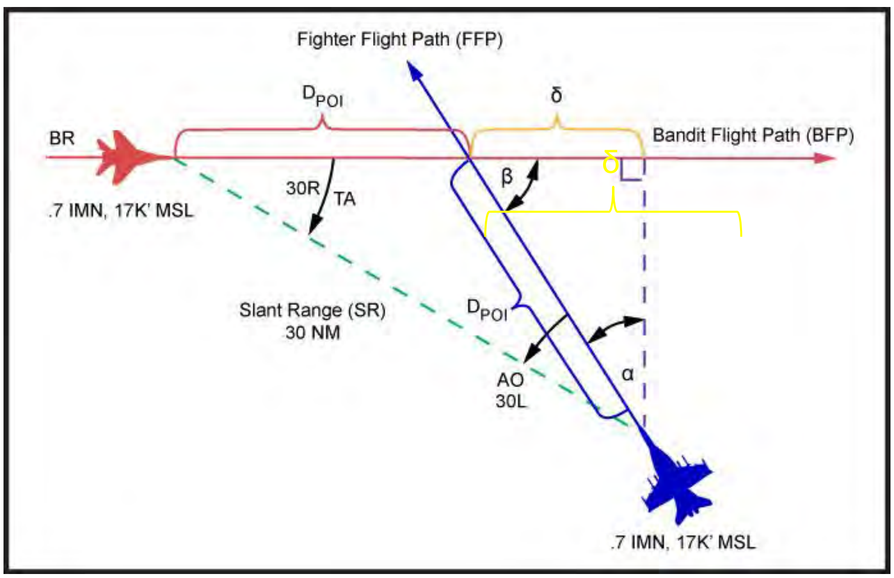

Figure 9-1 Co-Speed Fighter and Bandit On Collision

Using basic trigonometry and knowing TA, AO and SR, one can show that, for the distance the fighter must travel:

- sin TA = LS/SR; therefore LS = SR x sin TA; in this case 0.5 = LS/30 or LS = 15 NM
- Angle α = 180 degrees – 30 degrees - 90 degrees - 30 degrees = 30 degrees
- cos α = LS/$D_{POIFighter}$; therefore $D_{POIFighter}$ = LS/cos α;

Therefore $D_{POIFighter}$ = 15/cos 30 degrees = **17.32 NM**

For the distance the bandit must travel:

- cos TA = ($D_{POIBandit}$ + δ)/SR; therefore $D_{POIBandit}$ + δ = SR x cos TA = 25.981 NM
- tan α = δ/LS; therefore δ = tan 30 degrees x 15NM = 8.660 NM
- $D_{POIBandit}$ = SR x cos TA – tan α x LS = 30 cos 30 degrees - 15 tan 30 degrees = 25.981 NM - 8.660 NM **= 17.32 NM**

To minimize the time-to-kill the fighter should establish a heading that maximizes V_c and minimizes the distance traveled to the intercept point. If a fighter maximizes only V_c by maintaining a pure pursuit path, the distance traveled will be much further than that of establishing a collision course. The mathematical proof of this is too long to discuss in this text, however, it is a logical inference for anyone who has ever played football, soccer or basketball that you don't run AFTER the person with the ball, you position yourself to intercept that person at the place you infer they will be. This is essentially the same fundamental principle used in an intercept, where establishing a collision course is preferable to remaining in pure pursuit. When established on collision:

- TA will not change
- AO will not change
- The contact will not drift

Knowing that TA will always equal AO when a collision intercept has been established in a co-speed situation, the fighter can establish a collision intercept by adjusting its heading to match the AO with the previously calculated TA. Collision course in an effective tool to rapidly close with the bandit. In a co-speed situation, the bandit will not drift when on collision.

903. TA AND AO WITH A BANDIT OFF COLLISION COURSE

If a CB intercept is not established, then one of two things can happen:

- Either the bandit will pass in front of the fighter (a good thing at close range).
- Or the fighter will pass in front of the bandit (a bad thing).

A contact not on a collision course will be subject to intercept drift. This intercept drift will always be away from collision bearing.

For example, if the fighter and bandit are established on opposite headings, that is FH equals BR, and there is LS between their flight paths, then AO and TA will increase with a decrease in range.

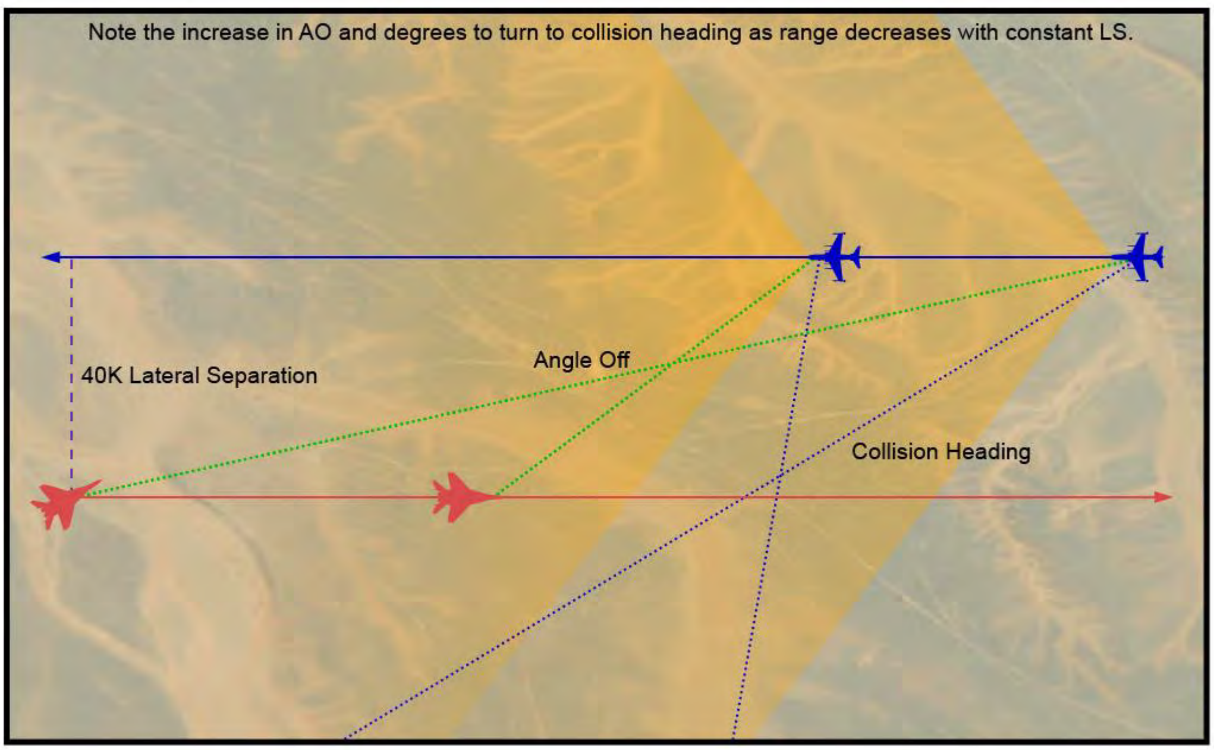

Figure 9-2 Relationship between AO, TA and Slant Range

From Figure 9-2, it is easy to see how TA and AO both increase as slant range decreases. This will occur whenever the bandit is not on a collision course.

904. PREDICTING ANGLE-OFF AND THE CHANGE IN TA

Knowing that the contact will drift when not on collision, and that the drift that occurs will be away from collision bearing, the drift of the contact on the radar attack display becomes very predictable. The most simplistic example of this is when fighter heading is bandit recip (FH=BR). Since TA is also measured from BR to BB, the drift of the contact away from BR represents a change in TA. For every degree the contact drifts, TA increases by one degree. This is shown in Figure 9-3.

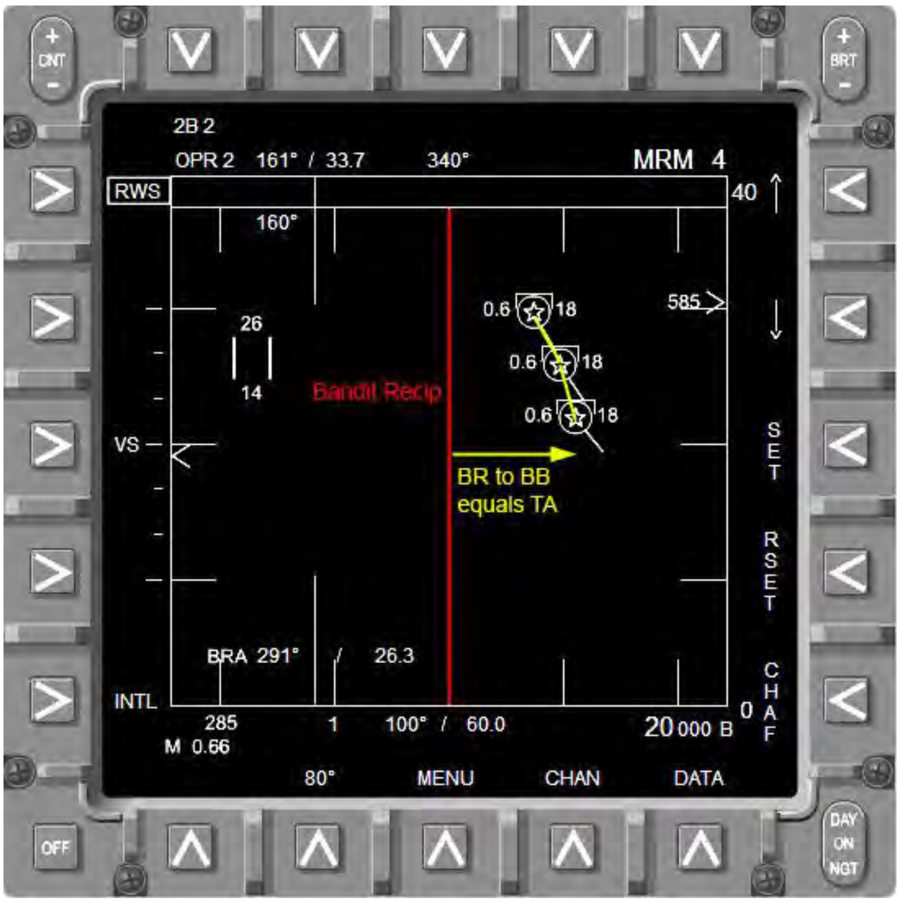

Figure 9-3 AO Drift

Similarly, a contact that is not on collision will drift away from collision. For example, if the fighter turned to place a contact on collision bearing, and had misread the target aspect vector as 30 degrees right when it was actually 40 degrees right, the contact will drift away from the CB, which will be an increase in TA. This is shown in Figure 9-4.

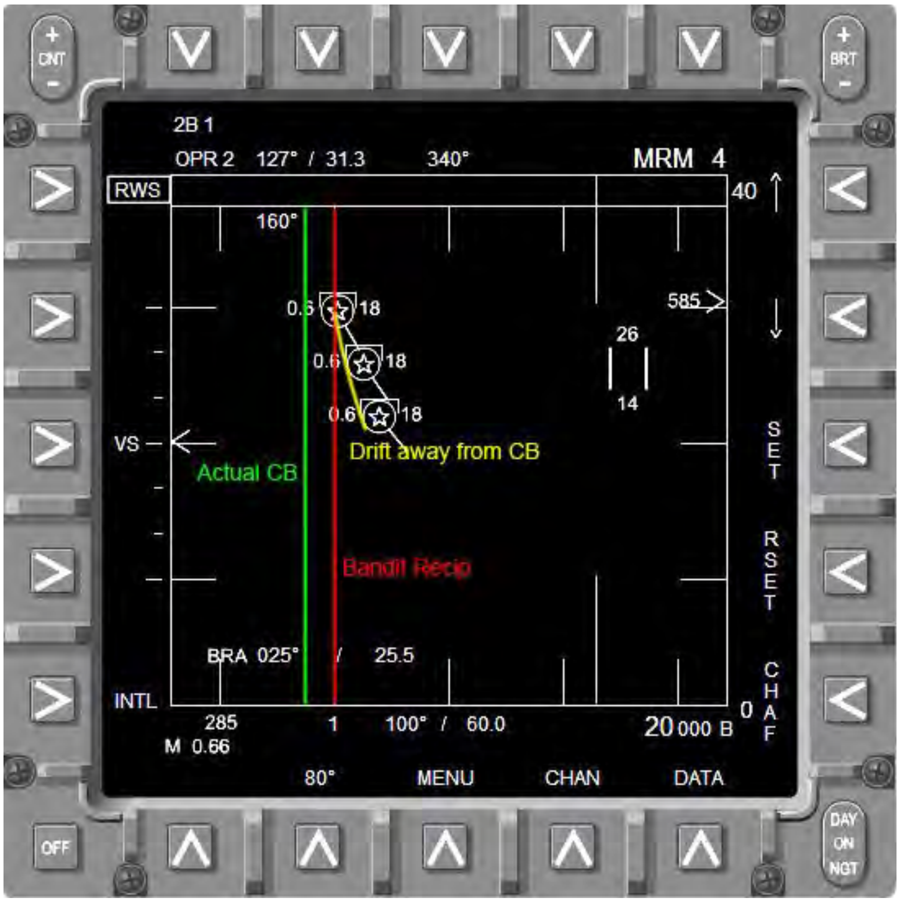

Figure 9-4 Drift with Contact Not on Collision

In another example (Figure 9-5), the fighter turns to try to place the contact on collision and forces a drift that reduces TA. In this case, the contact is placed at 40 degrees right AO with 30 L TA. The result is that the contact will drift to the right, away from the actual CB at 30 R. Since this drift is toward BR, this drift is a decrease in TA. In order to arrest this change in TA, the fighter must make a change in the geometry of the intercept.

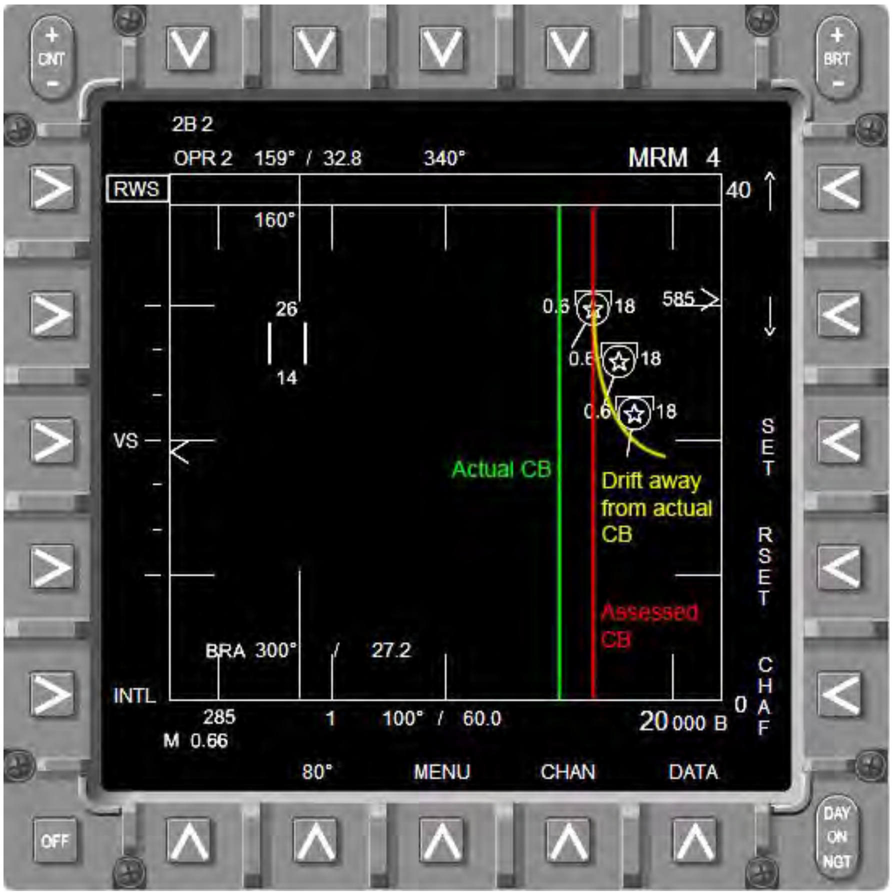

Figure 9-5 Bandit Off Collision

While collision course is useful, there are many occasions where the fighter wants to either increase or decrease TA, and the associated LS, for various reasons. This requires that the fighter understand the geometry created by changing fighter heading, thereby changing the HCA and the associated cut.

When discussing intercepts, cut is used instead of HCA because the cut is easily referenced on the radar attack display. The cut corresponds to BR. Once the fighter has found the bearing on the display that represents BR, the cut is known. This is further aided by the BRA to cursor information being displayed on the radar. Knowing where the cut and BR is lets the fighter immediately determine how TA will change and how the contact will drift.

905. HEADING CROSSING ANGLE, CUT, AO AND LS RELATIONSHIPS

Heading crossing angle (HCA) is the angle between fighter heading and bandit heading the remaining angle between fighter heading and bandit reciprocal heading (BR or “recip”) is called the cut (Figure 9-6). The term “cut” has fallen out of common use in operating forces, but it is a useful learning tool in intercept geometry. Cut is used because the math is easier than using “180 - HCA” every time the relationship is used. A 90 cut is equal to a 90 HCA, as the fighter then has 90 degrees to turn to match bandit heading. Changing the cut changes HCA and vice-versa and can be changed by either fighter or bandit heading changes.

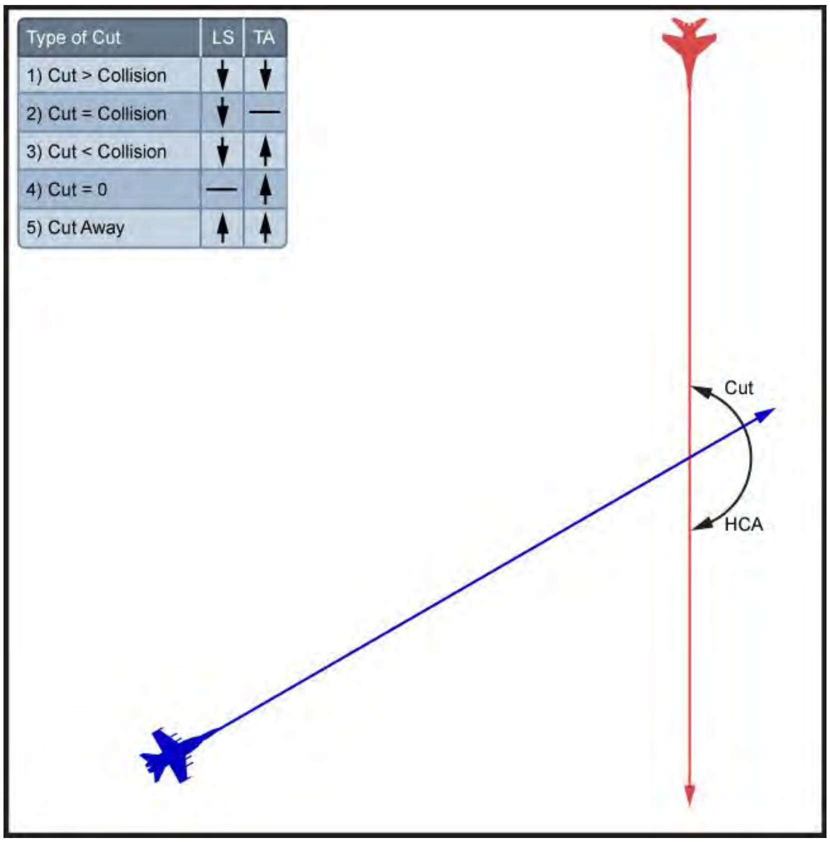

Figure 9-6 Cut and HCA Relationship

There are five types of cuts which fall into three categories. These categories are:

- **Cut into bandit flight path** – an HCA creates a cut into bandit flight path whenever the flight paths of the fighter and bandit cross if neither changes heading. There are three types of cuts into based on how they are related to collision.

- **Cut away from bandit flight path** – an HCA creates a cut away from bandit flight path when the heading places the fighter’s flight path such that the fighter will move away from the bandit’s flight path over time.

- **Cut equal to bandit reciprocal** – this is also called a zero cut.

Each of these types of cuts has specific properties that make it useful in controlling intercept geometry.

1. **Cuts Into Bandit Flight Path**

Cuts into bandit flight path will always reduce lateral separation (LS). However their effect on TA depends on their relation to the cut required for collision. These are detailed below:

a. Cut into equal to collision (Figure 9-7) – Cut into equal to collision places the contact on collision. TA will remain unchanged while LS will decrease. AO will be equal in magnitude and opposite in direction from TA. If co-altitude, the aircraft may collide and will, at a minimum, be in very close proximity at flight path fly through. This cut is a type of lead pursuit and represents the most efficient geometry to close with the bandit.

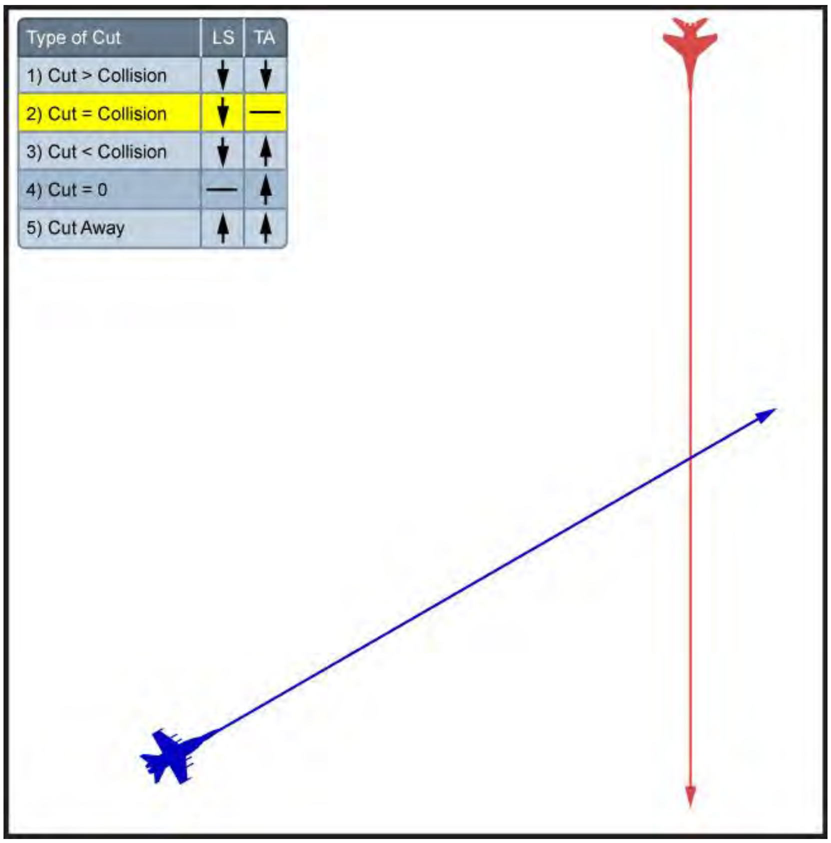

Figure 9-7 Cut Into Equal To Collision

b. Cut into greater than collision (Figure 9-8) – A cut into greater than collision will reduce LS and TA over time. The fighter's flight path is well in front of the bandit with the fighter in a lead pursuit. The fighter can reduce both TA and LS with this type of cut. In fact, this is the ONLY cut which will reduce TA. To see this kind of cut on the radar attack display the fighter needs to see the TA vector pointing across the display with the contact at an AO greater than that required for collision. The contact will drift toward the edge of the display, which will indicate a reduction in TA. Drift will be away from the TA vector.

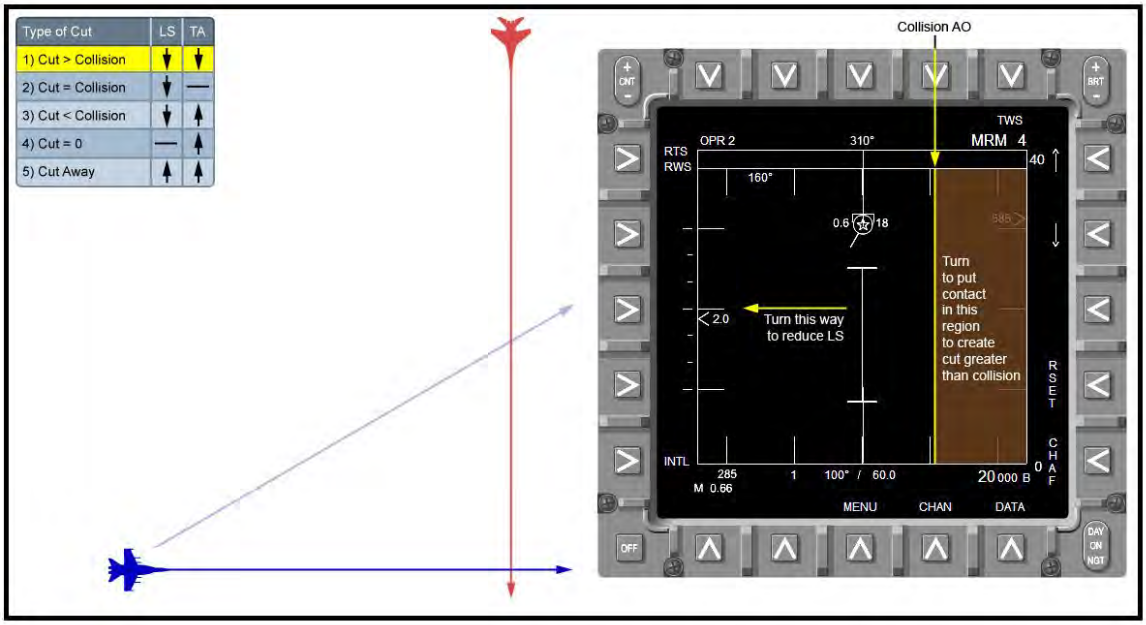

Figure 9-8 Cut Into Greater Than Collision

c. Cut into less than collision (Figure 9-9) – A cut into less than collision places the fighter in either lead, pure or lag pursuit with an HCA less than that required for collision. Pure and lag pursuit are always a cut into less than collision. Fighter headings between pure and collision are lead pursuit with a cut less than collision. This type of cut will reduce LS while allowing TA to increase, which is useful when the bandit is approaching or is within visual range, but unaware of the fighter. On the attack display, the contact's TA vector will be pointed toward the edge of the display with the fighter's nose in pure or behind the contact. If in lead, the contact's TA will be more than the contact's AO and drift will be in the direction of the TA vector.

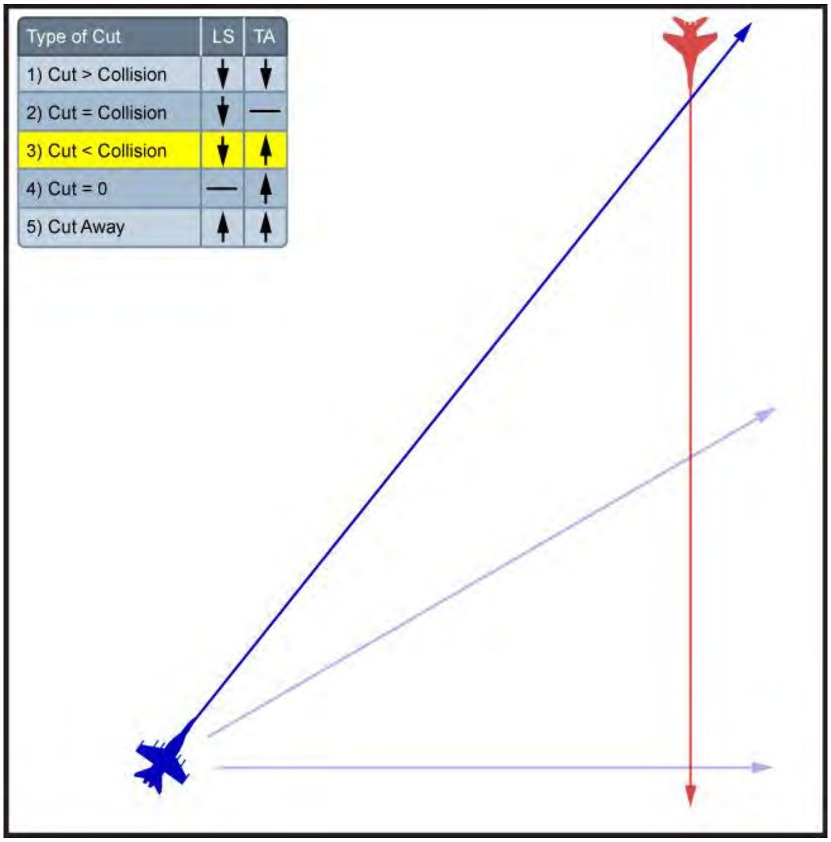

Figure 9-9 Cut Into Less Than Collision

2. **Zero Cut – Fighter Heading On Bandit Recip**

When fighter heading is equal to the reciprocal, the fighter is on a zero cut (Figure 9-10). HCA is 180 and the fighter has 180 degrees to turn to bandit heading. With 0 TA, the bandit is on collision will merge in close proximity with fighter nose-on if they do not collide, when range reaches zero. With TA>0, the fighter is on a parallel, opposite direction, flight path. TA will double as range halves. For example, on a zero cut with 15 TA at 30 NM, there will be 30 TA at 15 NM. This is the only cut that does not change LS, TA will grow. Since no LS is being removed, this is not a type of pursuit.

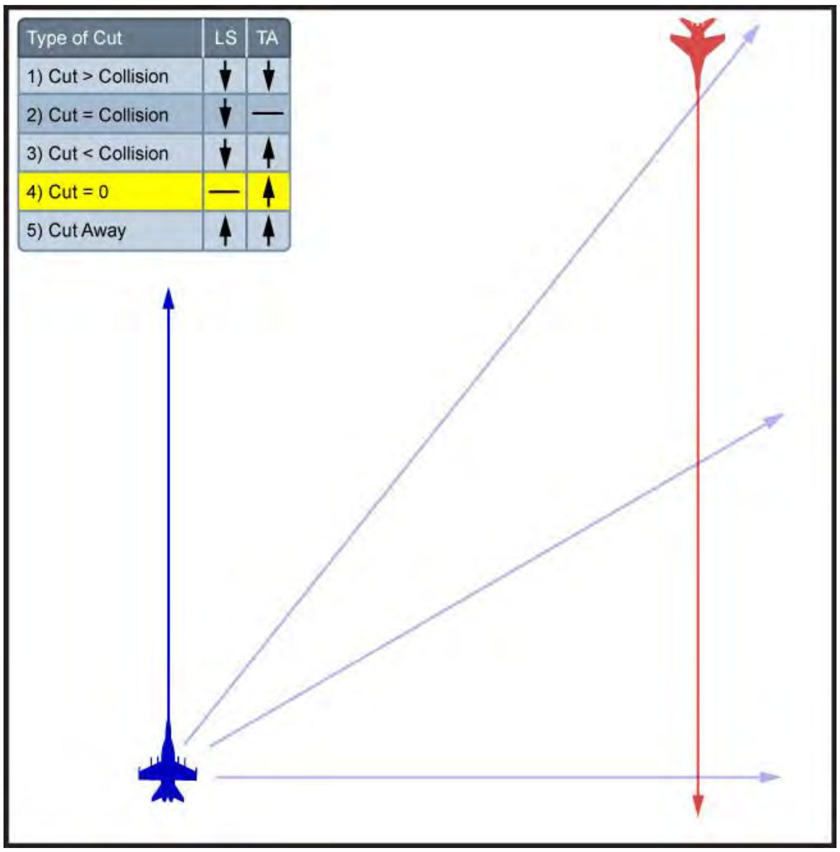

Figure 9-10 Zero Cut

These properties of a zero cut are very important in that this is the only cut which preserves the current LS.

3. Cut Away from Bandit Flight Path

A cut away is the only way to increase LS (Figure 9-11). At high TA, a cut away will mean the contact is off the attack display, while a cut away for low TA may keep the contact on the radar attack display. A cut away will be used by the fighter any time LS needs to be increased. Since LS is being generated, it is not a type of pursuit.

Understanding the five types of cuts will allow the fighter to manipulate intercept geometry to accomplish whatever goal is required.

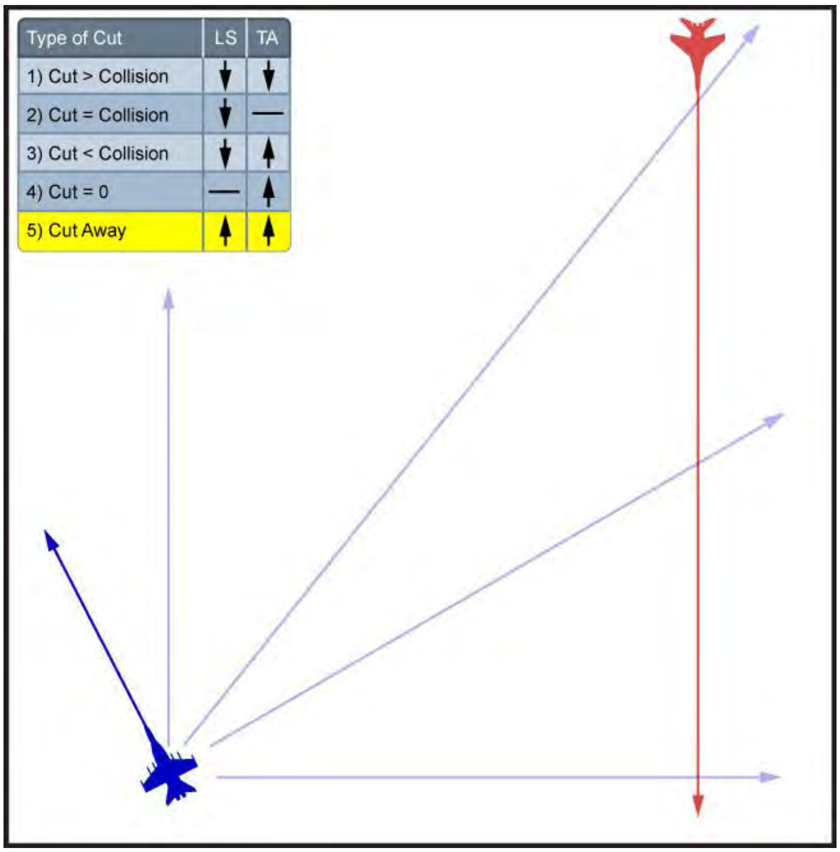

Figure 9-11 Cut Away from Bandit Flight Path

906. MAXIMIZING LS/TA CHANGES IN THE CO-SPEED INTERCEPT

The effect of HCA on intercept geometry should be readily apparent. While an instantaneous snapshot of the intercept can be made by evaluating TA, AO and slant range and determining LS, it is the cut that determines how this geometry will change over time. With a non-maneuvering contact, the fighter's changes in heading will create or remove lateral separation and build or remove TA over time. How the fighter can manipulate intercept geometry is the focus of stern conversion intercepts.

In a co-speed intercept with a non-maneuvering bandit, the fighter has control over LS and TA. The limiting factor for the ability to impact these is the range at which the intercept begins. A couple of examples that help highlight this:

1. **Maximum LS Generation from a 0 TA, 0 LS Start**

Assuming a 0 TA, 0 LS start against a co-speed, non-maneuvering contact, the fighter can immediately turn to a 90 cut (90 HCA) to build the maximum amount of LS in the minimum amount of time. Assuming 20 NM start 300 KGS (approximately 0.5 IMN), or 5 NM per minute, and that the fighter must turn hard as possible to turn to a zero cut when LS equals 40,000 feet (desired turning room in stern conversions) or nose-on when SR reaches 10 NM (nominal visual range) the following can be demonstrated:

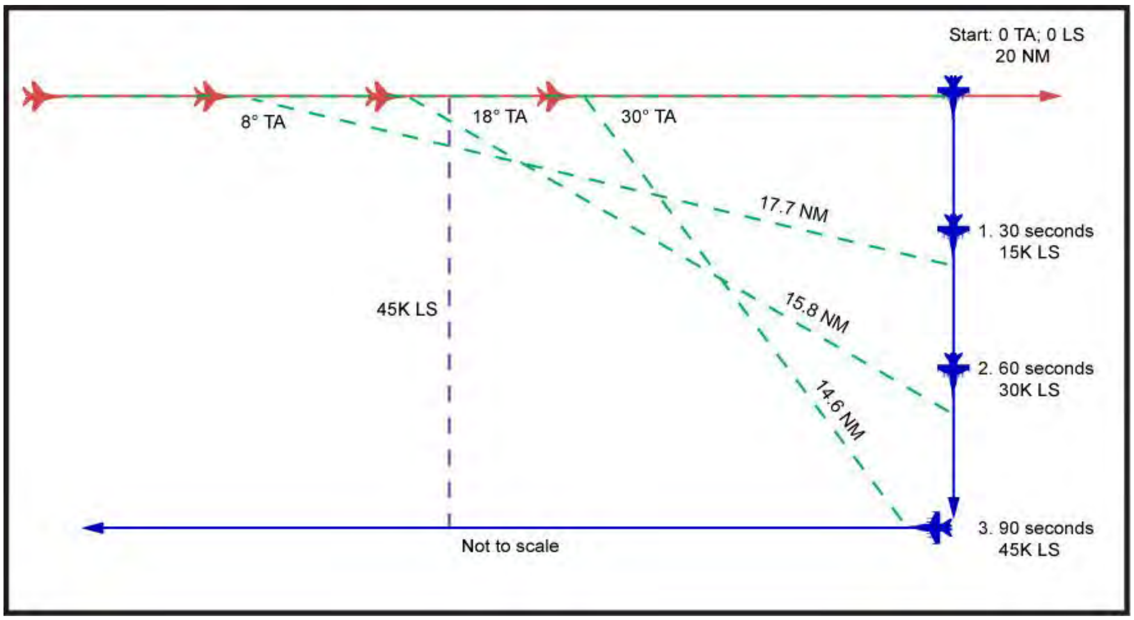

Figure 9-12 Fighter using 90 Cut to Generate Turning Room

From Figure 9-12:

a. After thirty seconds, the fighter has generated 2.5 NM, or 15,000 feet of LS

i. SR has decreased from 20 NM to 17.7 NM

ii. TA has increased to 8.1 degrees (8.1 * 17.7 = 14,390 feet LS per the formula)

b. After one minute, the fighter has generated 5 NM, or 30,000 feet LS

i. SR is now 15.8 NM

ii. TA is now 18.1 degrees (LS formula yields 28,662 feet LS)

c. At ninety seconds into the intercept, the fighter has generated 7.5 NM or 45,000 feet of LS

i. SR is 14.6 NM

ii. TA is 29.5 degrees (LS formula yields 42,980 feet LS)

At this point the fighter should turn hard as possible to BR to capture and hold 40K of LS. When the fighter turns to a zero cut, the bandit will be about 30 AO at a slant range of about 14 NM. TA will continue to grow and, if no further heading changes are made, the fighter and bandit will pass with 45K LS about one minute later. The fighter would not have radar contact to the bandit until the turn to a zero cut. Once on the zero cut, the contact will be at 30 degrees right AO and will drift toward the edge of the radar attack display as TA increases.

2. **Maximum LS Removal Example**

A 90 cut into can be used to remove the maximum amount of TA and can be used to remove the maximum amount of LS. If the fighter began with 30 TA start at 20 NM slant range (120,000 feet), the fighter would begin with 60,000 feet LS (60,000 feet LS by the formula as well). In this example, the goal of the fighter is to establish a position as close to the bandit's flight path as possible, but the fighter must be nose-on at 10 NM. The fighter would expect to see the following:

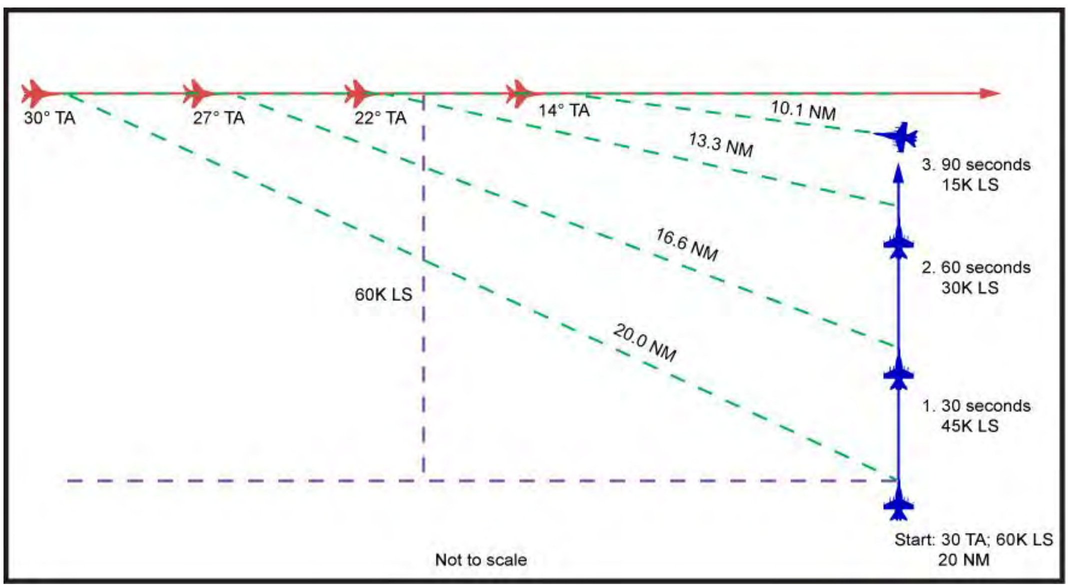

Figure 9-13 LS Removal Example

From Figure 9-13:

a. Initially, the fighter has 60K LS

i. TA is 30 degrees on the left

ii. AO is 60 degrees on the left

b. At 30 seconds, the fighter has removed 15K of LS

i. TA has been reduced to 26.8 degrees

ii. SR is 16.6 NM

iii. AO is 63.2 degrees on the left

c. At 60 seconds, the fighter has removed 30K LS

i. TA is reduced to 22.1 degrees

ii. SR is 13.3 NM

iii. AO is 67.9 degrees (recall that radar attack display limitation is 70 degrees left or right in azimuth)

d. At 90 seconds, the fighter has removed 45K LS

i. TA has been reduced to 14.3 degrees

ii. SR is 10.1 NM

iii. AO is 75.8 degrees

What is important to note here is that although the change in LS from this example is the same as in the previous example, the removal of LS changes TA more slowly. The reason for this is that if the rate of change of TA increases the further off collision bearing the contact is. In other words, the further a contact is from collision bearing, the faster the contact will drift. This drift will always be away from collision bearing.

Also note that the drift away from the fighter's nose with the cut into greater than collision will be in the opposite direction of the contact's TA vector. ANY time a contact drifts the opposite direction from the aspect vector, the fighter is removing LS.

Additionally, when using a 90 cut away to create LS, the contact was not on the attack display. This is not preferable. Likewise, using a 90 cut into remove LS made the contact drift off the radar attack display. This is also not preferable.

907. HOT AND COLD ON THE ATTACK DISPLAY

Based on TA, AO, and fighter heading (which determines the HCA and, therefore, the cut), the fighter can identify the "hot" and "cold" sides of the display (Figure 9-14). These are defined as follows:

- The hot side of the display is the portion of the attack display where the fighter should place the contact to increase the rate at which LS is being removed. This represents a turn toward bandit flight path.

- The cold side is the direction the fighter should turn to place the contact to slow down, stop or reverse the removal of LS. In other words, this is a turn away from bandit flight path.

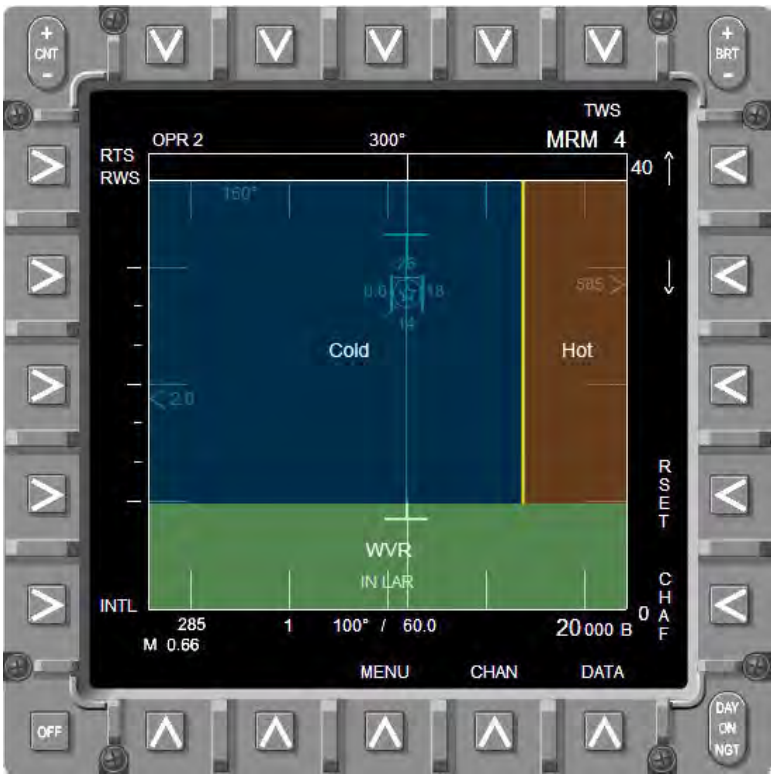

Figure 9-14 Hot and Cold Sides of the Attack Display

The dividing line between the hot and cold sides of the display is the ideal intercept curve. That is, the curve corresponding to 40K of LS to 10 NM.

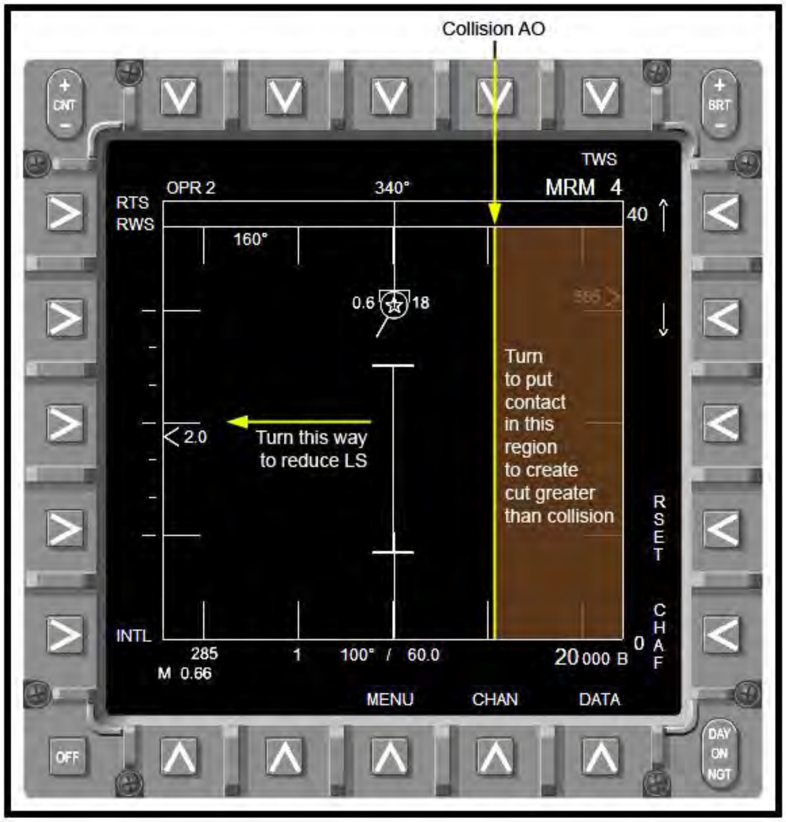

Figure 9-15 Hot Side of Attack Display

Because a TA vector is used instead of a heading vector on the L&S symbology, where it points can be used to denote to the fighter where hot and cold are on the attack display. Simply put, the TA vector stick always points in the direction to turn to move the contact toward the hot side of the attack display (Figure 9-15). Turning toward the aspect vector will heat up the intercept. Turning away will cool off the intercept. Although interpretation of the TA vector may not seem intuitive, having a TA vector provides better SA to the positional relationship between aircraft than a heading vector does. The dividing line between hot and cold on the contact is collision bearing (CB). As TA changes the amount of turn to place a contact hot or cold will change with the corresponding change in CB. The SNFO should continue to assess TA to identify collision bearing and the subsequent hot/cold sides of the attack display.

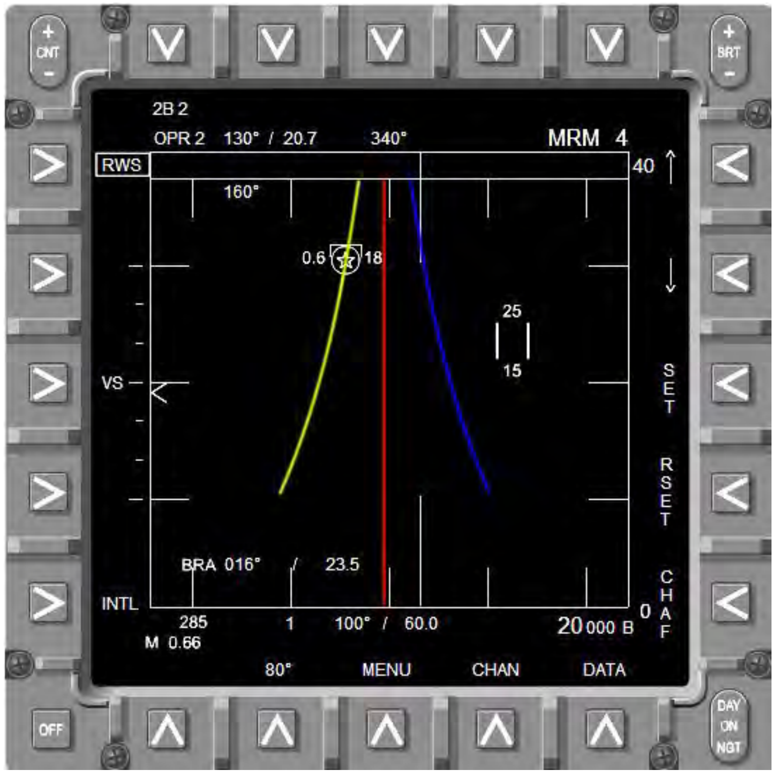

Figure 9-16 Change in Collision AO and TA on a Zero Cut

In the example above, the red line represents BR. The fighter is on a zero cut which will maintain LS with an increase in TA. The yellow line equates to a 40K LS. The blue line is collision bearing. From a zero cut, turning to place contact right of collision bearing at any range (the blue line) will create a cut into greater than collision. TA and LS will decrease.

Turning to place the contact left of 0 AO will be a cut away. LS and TA will increase and may need to be reduced later. To capture TA, the fighter must turn to place the contact on the blue line (AO equal and opposite to TA) and then hold that heading. LS will decrease, but TA will remain constant.

Intercept geometry can be changed by either fighter or bandit changes in heading. Contact drift is predictable in theses intercepts. Fighter aircrew must understand how and why the contact will drift and the relationship that drift has to TA, AO and LS. In the next chapter, methods of using different types of cuts and fighter heading changes to manage LS and TA will be explored.

908. INTERCEPT FORMULA QUICK REFERENCE

The following formulas are used for quick reference in the cockpit and should be committed to memory:

- Aspect Angle (AA) = 180 - Target Aspect (TA) - AA = 180 - TA (same direction as TA)
- Cut = Fighter Heading (FH) to Bandit Reciprocal (BR) - Cut = FH to BR
- Target Aspect (TA) = Bandit Reciprocal to BB - TA = BR to BB
- Collision Bearing (CB) = ½ Cut - CB = ½ Cut
- CB = Collision Antenna Train Angle (CATA) - CB = CATA
- Lateral Separation = Target Aspect x Slant Range x 100 - LAT SEP = TA x SR x 100
- Altitude Differential = Elevation Angle x Slant Range x 100 - ALT DIFF = Elev x SR x 100
- Angle-off (AO) = Antenna Train Angle - AO = ATA
- Degrees to Go (DTG) = Fighter Heading to Bandit Heading

  i. DTG = FH to BH

  ii. DTG = 180 - Cut

CHAPTER TEN
TARGET ASPECT CONTROL

1000. INTRODUCTION

The stern conversion intercept is the introductory intercept at VT-86. Stern conversions teach introductory air-to-air radar employment skills, intercept geometry and timeline awareness. Stern conversion intercept procedures used to join other friendly aircraft or arrive in an offensive position on non-friendly aircraft. It is a critical skill needed by fighter aircrew to achieve mission success. This chapter will describe aircrew actions from the commencement of the intercept at beyond visual range (BVR) to the transition to within visual range (WVR) at 10 NM.

1001. TARGET ASPECT VISUALIZATION

During an intercept, the fighter must accomplish the following tasks:

- Pre-commit sanitization and picture building
- Correlate the picture with AIC information
- Get declaration on all groups
- Commit to the highest priority group
- Correlate the group's position
- Set intercept geometry to affect the bandit
- Employ weapons
- Transition to visual range
- Perform a stern conversion counterturn to arrive in the bandit's rear quarter

In a co-speed intercept with the fighter and bandit at 0.5 IMN, the V_C for a head on aspect will be in the vicinity of 600 KTS (Figure 10-1). This means that the fighter and bandit will close with each other at 10 NM per minute. At this speed a 30 NM intercept will take 3 minutes from commit to the merge. This rate translates to 30 seconds every five miles. Based on this, most intercept timeline tasks will be allowed 30 seconds to complete.

This allows the fighter to build a timeline on which intercept tasks are placed. The intercept timeline should be committed to memory to ensure that no matter what the range, the fighters can step into the timeline and execute proper intercept mechanics.

Figure 10-1 Time to Accomplish Actions with 600 KTS V_C

The timeline is a guide. All ranges on the timeline are no later than (NLT) ranges. The fighter must be able to enter the timeline and execute tasks from that point forward; however, the first task will always be correlation and declaration. The timeline is normally briefed line by line to address formation management, sensor employment/usage, communication format with examples and crew coordination. This helps ensure completeness in brief for each important range or task on the timeline.

In the stern conversion intercept, the fighter will accomplish the following tasks outside of 10 NM:

- Commit, correlate and declare the single group
- Determine target aspect and LS of the contact
- Set intercept geometry to achieve/maintain 40K LS by 10 NM

This chapter focuses on the fighter's actions to 10 NM.

1002. PRE-COMMIT, COMMIT AND CORRELATION

Once established in the area and ready to begin the intercept, the fighter will start the flight with a "fight's on" call. After the "fight's on" call has been echoed by all players, the fighter will call AIC for the picture. AIC will respond with the picture in tactical control in a BRAA format.

1. Group Definition

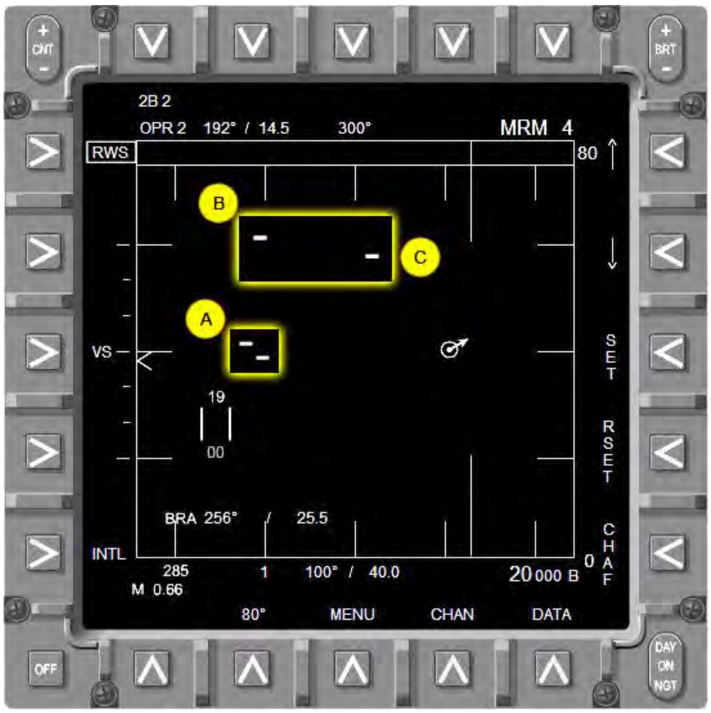

Figure 10-2 Group Definition

A group by definition in VT-86, is assumed to be two aircraft within 5 NM and 5,000 feet of altitude. Thus, in Figure 10-2, the two contacts in group A area group while the single contacts in group B and C are two separate groups. Scenarios with multiple group or groups with more than one aircraft will be addressed in Section Radar Attacks and beyond. In stern conversion intercepts, pictures will be single groups will consist of single contacts only.

2. Correlation

The fighter can correlate the location of the group in bearing, range and altitude using the BRA information on the attack display. If no contacts are detected on the attack display, the fighter should place the acquisition cursor (called the cursor hereafter in this manual) at the location of the BRA called by AIC, and then adjust the elevation of the scan volume to bracket AICs called altitude, if given. If AIC does not pass altitude information, the fighter should manually adjust the scan volume only after two complete frames. Recall from radar theory that the bar scan of the radar means the antenna will move in elevation, as evidenced by the movement of the elevation caret. If in a 6-bar scan, the radar operator should ensure that any elevation adjustments made occur after sanitization of the complete frame at that elevation setting. Once the contact is detected, the fighter should place the cursor over the contact and reference the displayed altitude and BRA to cursor position. Correlation is accomplished with a declaration call to AIC:

a. Lead SNFO (PRI) "*SABRE, Hammer-11, contact BRA 177, 28, 22 thousand, declare*"

AIC will repeat the call to correlate the group and provide the declaration.

b. AIC (PRI): "*Hammer- 11, single group BRA 177, 27, 22 thousand, hot, hostile*"

The fighter can then begin to prosecute the intercept.

3. **Commit**

The first fighter action on the timeline is commit. When the fighters commit, they are leaving their assigned CAP or route to prosecute an intercept to a logical conclusion on a group that triggered the commit. Fighters commit to a picture, not an individual group. In future stages, options after the commit will be discussed in more detail. In stern conversions, the commit is tied directly to the detection and correlation of the single group but no later than 30nm of range.

The fighter will commit on any contact that has less than 60 TA or a range of 30 NM or less. Radar contact with the group that triggers commit is not required. Thus, the fighter may commit once AIC has called a group within 30 NM or with hot aspect rapidly approaching 30 NM.

Due to geometry of the training areas at VT-86, the fighter should expect 25-30 NM setups for stern conversions.

1003. TARGET RADAR INTERPRETATION

Once the fighter has correlated the contact the fighter should turn to place the contact on the nose to "point and assess" the geometry of the intercept. The fighter can expect to see 0-45 TA on either side during this stage. Once intercept geometry has been assessed, the fighter will turn to execute the game plan presented in this chapter to create, preserve or maintain 40K of LS.

1. **Target Aspect and the TA Vector**

The TA vector on the attack display shows the current computed TA (Figure 10-3).

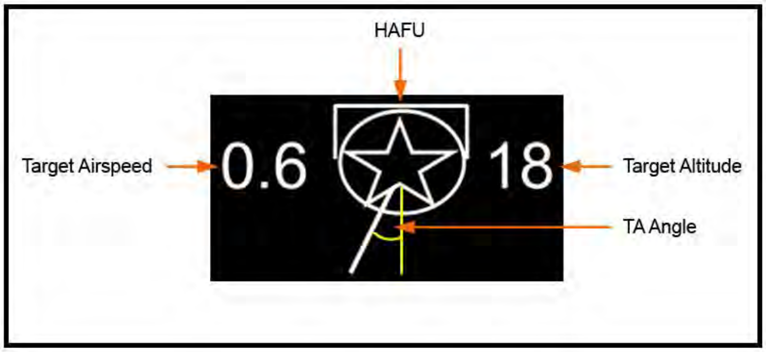

Figure 10-3 TA Vector on the Trackfile Symbology

SNFOs at VT-86 are expected to interpret TA to the nearest 10 degrees. However, TA is whatever the SNFO calls it. Proper execution of the correct game plan against the stated TA, TA management and control of the intercept are more important than precise TA interpretation. The SNFO should make a logical and supportable TA assessment based on the information presentation by AIC and on the radar attack display. That being said, the information is present on the display, and in this manual, to interpret TA to the nearest degree.

2. **Low TA**

Low TA (Figure 10-4) setups are those with TA less than 20 degrees and are characterized by initial rates of closure equal to the sum of the fighter and the contact's airspeeds. For example, at 0 TA, with both aircraft doing 0.5 IMN, the aircrew should expect to see closure rates around 600 KTS.

TA of 10 or less is considered very low. V_C will be near 600 KTS and LS at the beginning of the intercept will be very small.

With TA between 10 and 20, the fighter is beginning the intercept with close to the 40K goal. For a 30 NM setup, the 40K goal is met with 13.333 degrees TA. Since this is an unrealistic and irrelevant level of precision, it should be specifically noted that 15 degrees TA at 30 NM is 45,000 feet of LS.

Figure 10-4 Low TA

3. **Medium TA**

Medium TA (Figure 10-5) setups are those where the TA is between 20 and 35. These intercepts are characterized by initial V_C in the region of 450-500 KTS.

Figure 10-5 Medium TA

In an intercept that begins with 30 NM of separation and medium TA, the fighter has between 75,000 and 105,000 feet of LS. The fighter will need to reduce LS by 10 NM to meet the 40K at 10 NM.

4. **High TA**

High TA (Figure 10-6) intercepts begin with TA of 40 degrees or greater. In these intercepts, the fighter has at least 120,000 feet of LS. The fighter has to remove a large amount of lateral separation prior to 10 NM. Typical V_C for high TA intercepts is around 480 KTS.

With very high TA, defined as more than 45 degrees, the fighter will have to change the geometry at a greater rate than is available in a co-speed intercept. These intercepts will be discussed in a later chapter dedicated to speed variations.

Figure 10-6 High TA

5. **TA Interpretation**

Interpretation of target aspect is an important skill (Figure 10-7). However, there are some indications that should make TA interpretation much easier.

a. At 0 TA the vector points at the bottom of the display.

b. At 10 TA, the aspect vector is just off of vertical.

c. At 20 TA, the aspect vector is noticeably off of vertical, but not to the point of the L&S star.

d. At 30 TA, the aspect vector is just below the lower point of the L&S star.

e. At 36 TA, the aspect vector is lined up with the point on the L&S star.

f. Around 45 TA, the aspect vector is just past the bottom point of the star.

g. At 60 TA, the aspect vector is well beyond the point of the star.

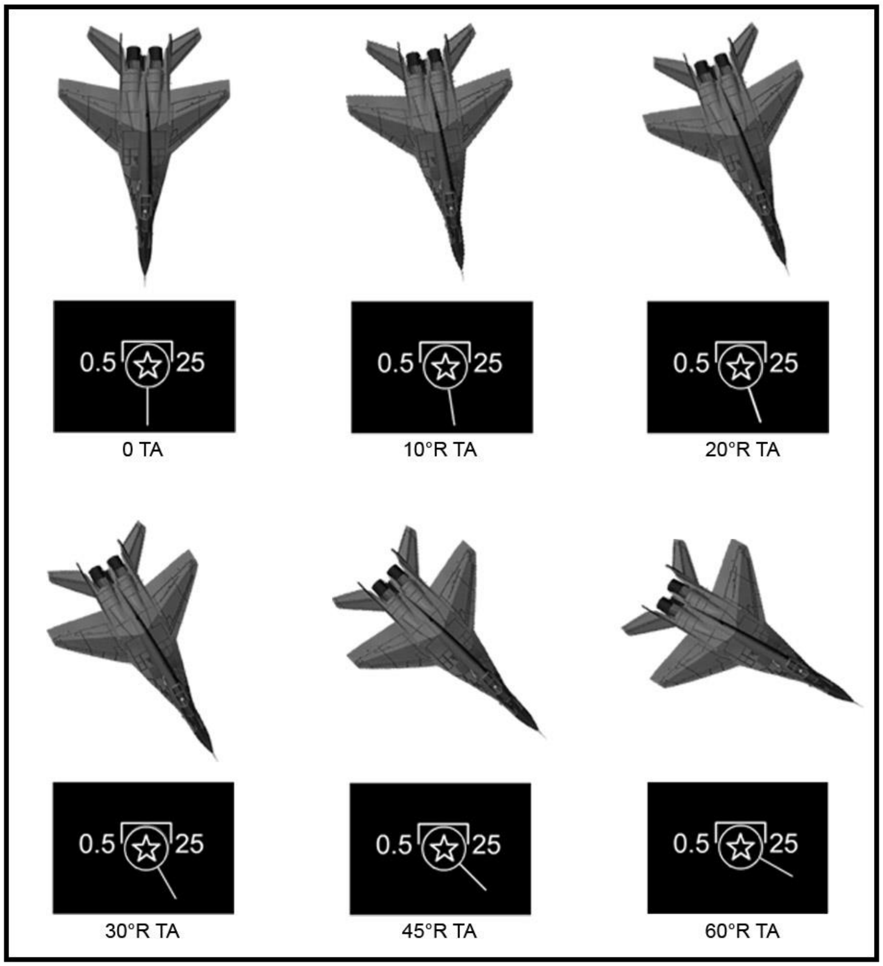

Figure 10-7 TA and Associated Symbology

If these reference points are too hard to see, recall that at 90 degrees the TA vector will point directly into the airspeed or altitude numbers of the L&S symbology.

1004. THE 40K LATERAL SEPARATION GOAL

Arriving IN LAR in the rear quarter is dependent on the aircrew's ability to manage LS outside of 10 NM. This is the same technique used to rendezvous on a tanker or friendly formation.

The 40K of LS is not an arbitrary number. Lateral separation equates to turning room (Figure 10-8). With 40K of LS the fighter has enough turning room to turn nose-on at 10 NM, maintain pure pursuit and rollout in a rear quarter (RQ) LAR for an SRM. The lateral separation (LS) goal in this stage of intercepts is 40,000 feet (40K) at 10 NM. At 10 NM, the fighter will bring the contact to the nose to perform a stern conversion. LS in the radar environment equates to turning room in the visual arena. The fighter needs to be able to determine the amount of LS at any point in the intercept and recognize increasing or decreasing LS trends. With too little LS the fighter may have to make an energy depleting break turn to roll out in the bandit's rear quarter. This deceleration will result in a fuel critical fighter arriving in the rear quarter, but at an longer range than desired. This distance must also be closed by accelerating. In fuel critical fighters, burning extra fuel due to poor geometry management is not acceptable.

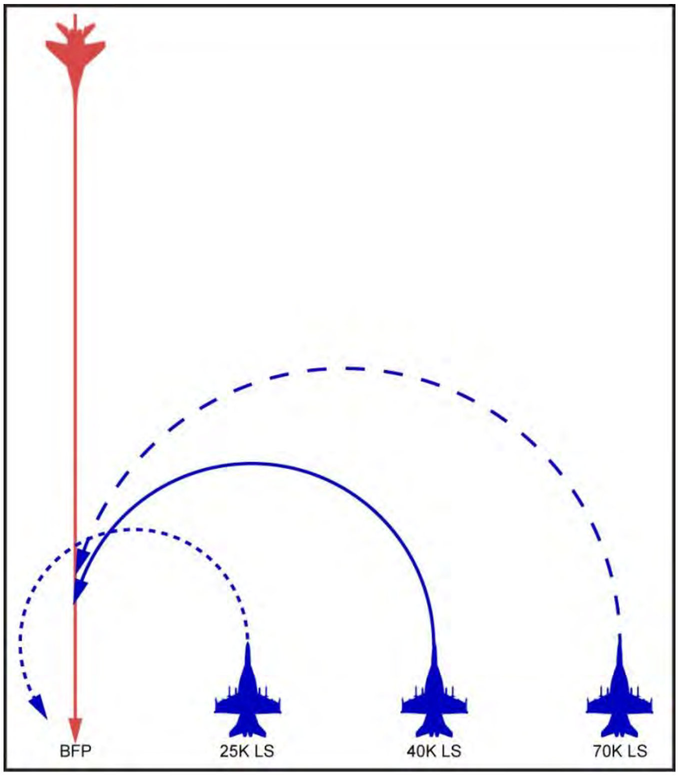

Figure 10-8 40K LS and Turning Room

1005. LS GATES AND THE 40K GOAL

In order to meet this goal, the fighter will have to do one of the following:

- Turn to create LS.
- Turn to preserve LS.
- Turn to remove LS.

To do this, the fighter must have a fundamental understanding of the calculation of LS and how fighter heading changes geometry to affect LS. Recall the LS equation:

$$LS = TA \times SR \times 100$$

40 NM		LS
TA	10	40,000
	20	80,000
	30	120,000
	40	160,000
	50	200,000
	60	240,000

30 NM		LS
TA	10	30,000
	20	60,000
	30	90,000
	40	120,000
	50	150,000
	60	180,000

25 NM		LS
TA	10	25,000
	20	50,000
	30	75,000
	40	100,000
	50	125,000
	60	150,000

20 NM		LS
TA	10	20,000
	20	40,000
	30	60,000
	40	80,000
	50	100,000
	60	120,000

15 NM		LS
TA	10	15,000
	20	30,000
	30	45,000
	40	60,000
	50	75,000
	60	90,000

10 NM		LS
TA	10	10,000
	20	20,000
	30	30,000
	40	40,000
	50	50,000
	60	60,000

Figure 10-9 LS Computation

Using the LS equation, it is easy to generate a LS table in Figure 10-9 and find corresponding TA/Range combinations that correspond to 40K LS. From the formula and Figure 10-9, it is easy to see that at 30 NM, 15TA equates to 45K of LS. At 20 NM, 20 TA is 40K of LS. Thus, key relationships to commit to memory are

- 15 TA at 30 NM
- 20 TA at 20 NM
- 30 TA at 15 NM

Each of these mean the LS goal has been reached.

The fighter's goal is 40K LS, but air-to-air intercepts are as much art as they are science. Given the dynamic nature of the intercept environment any LS determination made by the fighter will be a snapshot in time. The fighter aircrew should not focus on the details of precise calculation of LS, but rather the aircrew need to focus on trends and correcting those trends back toward the goal.

So while it is important to know what LS is at any point in the intercept, this is only the first piece of information the fighter needs to control the intercept. A thorough understanding of intercept geometry and how geometry will be used to create, remove or preserve LS is required.

1006. CAPTURING 40K LS BY 10 NM

In order to have 40K LS at 10 NM the fighter has two choices. First, the fighter can turn to the bandit reciprocal with 40K of LS and maintain this to 10 NM. Second, the fighter can capture 40 TA and place this on collision to 10 NM. From Figure 10-10, it is easy to see that once the fighter maneuvers to 40K LS, to maintain this, fighter heading must equal bandit reciprocal. Recalling from Chapter 9 that a fighter heading equal to bandit recip creates a 180 degree HCA, or a zero cut, and that on a zero cut LS does not change, the importance of identifying bandit recip becomes readily apparent.

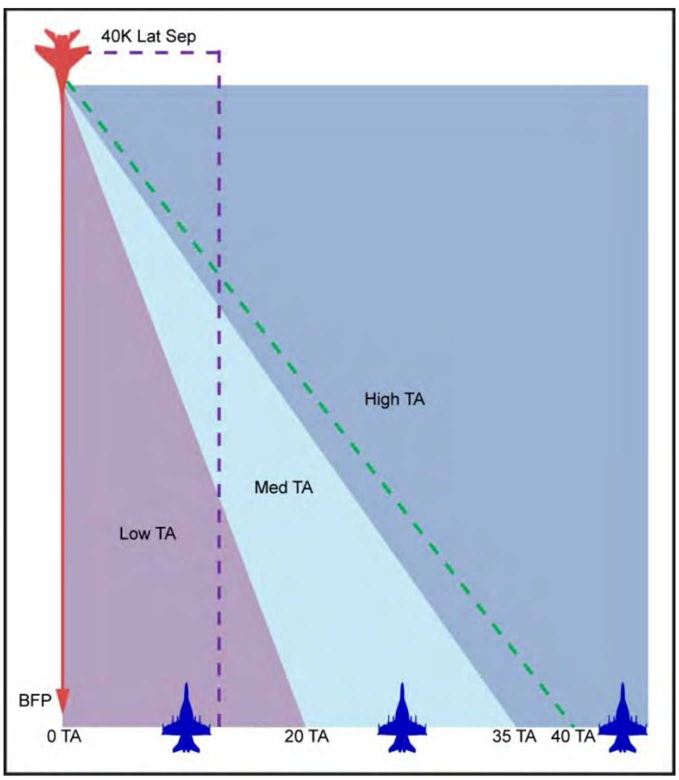

Figure 10-10 Potential Fighter Starting Positions

1. **Identifying Bandit Recip**

As previously discussed, when the fighter's heading is on bandit recip, LS remains unchanged as range decreases and TA increases. If the fighter turns to a zero cut, the current lat sep is captured and will not change. It is very important to be able to rapidly identify bandit recip. There are three techniques to do this. The first is to simply memorize the recip table in Figure 10-10. The second is to look at the HSI. The third is to compute it via the "plus two, minus two method." In this technique, for headings from 020 degrees to 180 degrees adding 2 to the hundreds and subtracting 2 from the tens provides the reciprocal. For headings greater than 190 degrees, subtracting 2 from the hundreds and adding 2 to the tens provides the recip. The recip of 300 degrees is 120 degrees; the recip of 020 degrees is 200 degrees. This works for all headings except 190 degrees and 010 degrees, which are reciprocals of each other.

Hdg → Recip Recip ← Hdg	
360	180
010	190
020	200
030	210
040	220
050	230
060	240
070	250
080	260
090	270
100	280
110	290
120	300
130	310
140	320
150	330
160	340
170	350

Figure 10-11 Recip Headings

Once bandit recip is computed, the fighter can turn to the bandit's recip to preserve the current LS.

2. **Turning to Collision with 40 TA**

Recalling that the bandit is on collision when TA is equal in magnitude but opposite in direction from AO, it is self-evident that to capture 40 L/R TA the contact must be placed at 40 R/L AO.

Recognition of 40 TA can be achieved by the previously discussed interpretation of the TA vector or the distance from BR to AO when BR is computed.

SNFOs are expected to use the TA vector and interpret this to within 10 degrees. However, BR to AO is a direct and exact measurement of TA and is especially easy when the fighter is on a zero cut.

1007. STERN CONVERSION INTERCEPT TIMELINE

Based on the 600 KTS V_C worst case scenario, the fighter can establish timeline to accomplish the required intercept tasks to reach a 40K LS goal by 10 NM. With this goal in mind, the fighter can create a visual representation of the timeline that depicts the expected actions, formation and geometry management highlights, sensor employment considerations and intercept communication formats/examples.

The stern conversion intercept timeline is shown below in Figure 10-12. Note: (prior to VID, at CT checkpoint 2.5nm, include to comm "Standby (group name)".

Range	Action	Form/Geometry	Sensor	Comm
	Pre-Commit	Cap – Alt As briefed/250KIAS	MRM/RWS/80NM/140/6B	*"Rage-11, Tapes on, Fights on"* PRI BDCT - BRA
30	Commit	Point and assess		Tactical – BRAA *"Rage-11 Commit"* PRI *"Check tapes M/A"* AUX
		Set Geometry – K&B, BR, Collision, 50AO	STT	*"AIC, Rage 11, contact BRA XXX/YY, ZZ thousand declare"* PRI
25	Assess Geometry	Climb/Descend 1K below Set A/S match IMN		
20	20 TA Gate			
15	30 TA Gate			
10	Employ – Hostile	Nose-on/CT begins		*"Rage-11 Fox-3"* PRI
5	Timeout Fox-3	60 TA/450 Vc	STT/SRM WACQ /SRM - clean	*"Rage-11 timeout, single group, ZZ thousand"* PRI
2.5	CT Check Point	90 TA/300 Vc		
1.0	VID Employ –Hostile	Trail – 1K Look up		*"Shoot, Shoot, Fulcrum"* or *"Friendlies, Friendlies, skip it"* PRI *"Rage-11 Fox-2"* PRI *"Rage-11 Kill, ZZ thousand"* PRI
	Post Engagement - KIO			***"KIO, KIO, Fighters KIO"*** PRI ***Bandits KIO"*** PRI ***"AIC, KIO"*** PRI
	Separation	Swap Caps		*"Rage-12 flowing east as bandit, 1.5"* AUX *"Rage-11 flowing west as the fighter, 1.4"* AUX

Figure 10-12 Stern Conversion Timeline

The timeline begins with pre-commit setup with CAP at 250 KIAS and the radar RWS/140/80NM/6B range with MRM selected. Target aging should be added for VMTS flights with that option set to longer than frame time (normally 16 seconds for these parameters). Communications are separated into examples and control/format changes. The depiction then walks through each event during the intercept and actions to take.

This format makes the brief easier to talk to because all of the required actions are on the board. The fighter aircrew can address each action item and expand where needed.

The timeline for each stage of training should be committed to memory.

1008. TARGET ASPECT CONTROL PROCEDURE

On the initial turn in, the fighter should stop the turn when the AIC called bandit bearing is on the nose. This allows the fighter to point its nose at the bandit while assessing what steps to take next. This is called a "point and assess" strategy (as opposed to blindly setting geometry based on AIC information). The point and assess strategy allows the fighter to do the following:

- Place the expected contact location in the center of the radar's scan volume, thereby increasing the probability of detection
- Ensures that the fighter is closing with the contact while sanitization is taking place
- Keeps the fight in front of the fighter to make geometry more apparent

Once the fighter has detected the contact, the fighter should use the BRA information on the attack display to correlate the contact with AIC information. As previously discussed, AIC will provide a declaration on the group. Once the declaration is obtained, the fighter must make an assessment of target aspect to and execute the target aspect management. The procedure for the intercept will therefore be:

- Detect and correlate the contact; command STT upon correlation
- Identify TA and LS (point and asses)
- Determine if current LS is greater or less than the 40K goal
- Depending on TA:
    - i. Turn to generate required LS; OR
    - ii. Turn to a zero cut to preserve LS; OR
    - iii. Turn to collision to remove unwanted LS
- Capture 40K LS or 40 TA

Depending on the initial target aspect, the fighter may execute more than one turn to manage geometry; however, the goal will always be to reach 40 TA and hold that on collision to 10 NM or turn to BR with 40K LS and hold that to 10 NM.

1009. TARGET ASPECT MANAGEMENT PLANS

There are three possible situations the fighter can be in at the beginning of the intercept. These are:

- Low TA without enough LS
- Medium TA with enough LS (20-40 deg TA)
- High TA (TA > 40)

How these scenarios are handled is discussed below.

1. Low TA Management; Kick and Build

With TA at 0, the fighter must build LS to meet the 40K requirement. Because of the range, the fighter will reach a 40K LS gate before reaching 40 TA. This can be done rapidly at range by placing the contact at 50 AO cold which is also called the "kick and build" game plan (Figure 10-13).

With the bandit at 50 degrees AO cold, the fighter rapidly creates LS while maintaining radar contact with a low possibility of gimbaling the contact. Due to intercept drift, the contact will drift away from the fighter's nose toward the edge of the attack display. The fighter will be on a cut away to build LS and TA. If at any time during the creation of LS, gimbaling becomes a possibility due to contact drift, this can be corrected by turning 10 degrees toward the contact to return it to 50 AO cold.

When the 40K LS goal is met, the fighter captures this LS by turning to BR and maintaining this heading until 10 NM. TA will increase to 40 at 10 NM. The fighter must recognize the 20 NM, 20 TA goal, or be ready to turn to BR at 15 NM with around 30 TA.

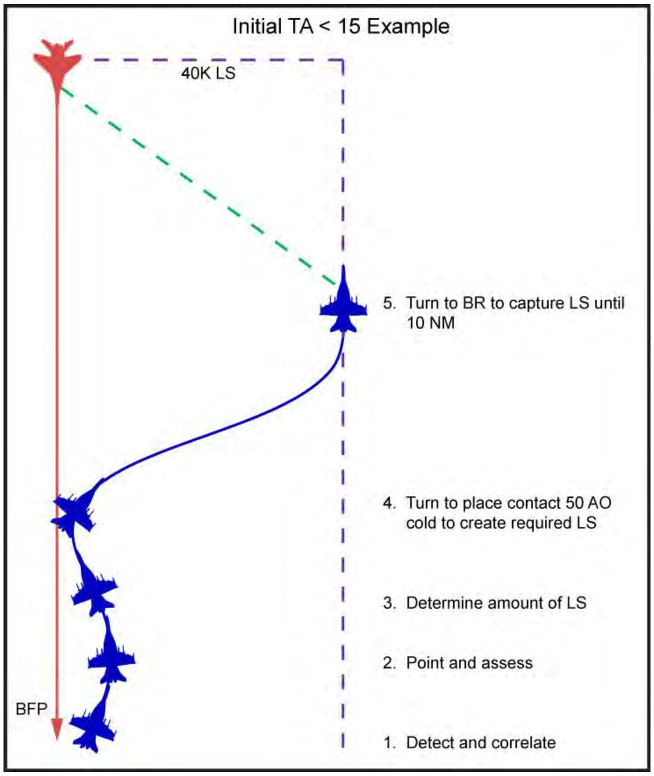

Figure 10-13 Kick and Build Game Plan

For example: The fighter has correlated and has turned to point and assess. Bandit heading is 220 degrees, BR is 040 degrees.

The fighter assesses TA = 5 degrees R and LS about 15,000 feet on the right. The fighter must generate LS. The fighter turns left hard as possible to place the contact 50 AO cold for a fighter heading of 350 degrees. The contact will drift out, so the fighter will have to make 10 degree turns into the contact to maintain contact. As TA and LS build, the fighter holds the contact at 50 AO hot until 40K LS is achieved as indicated by 30 degrees R TA at about 15 NM. At this point, the fighter turns to BR to capture 40K LS.

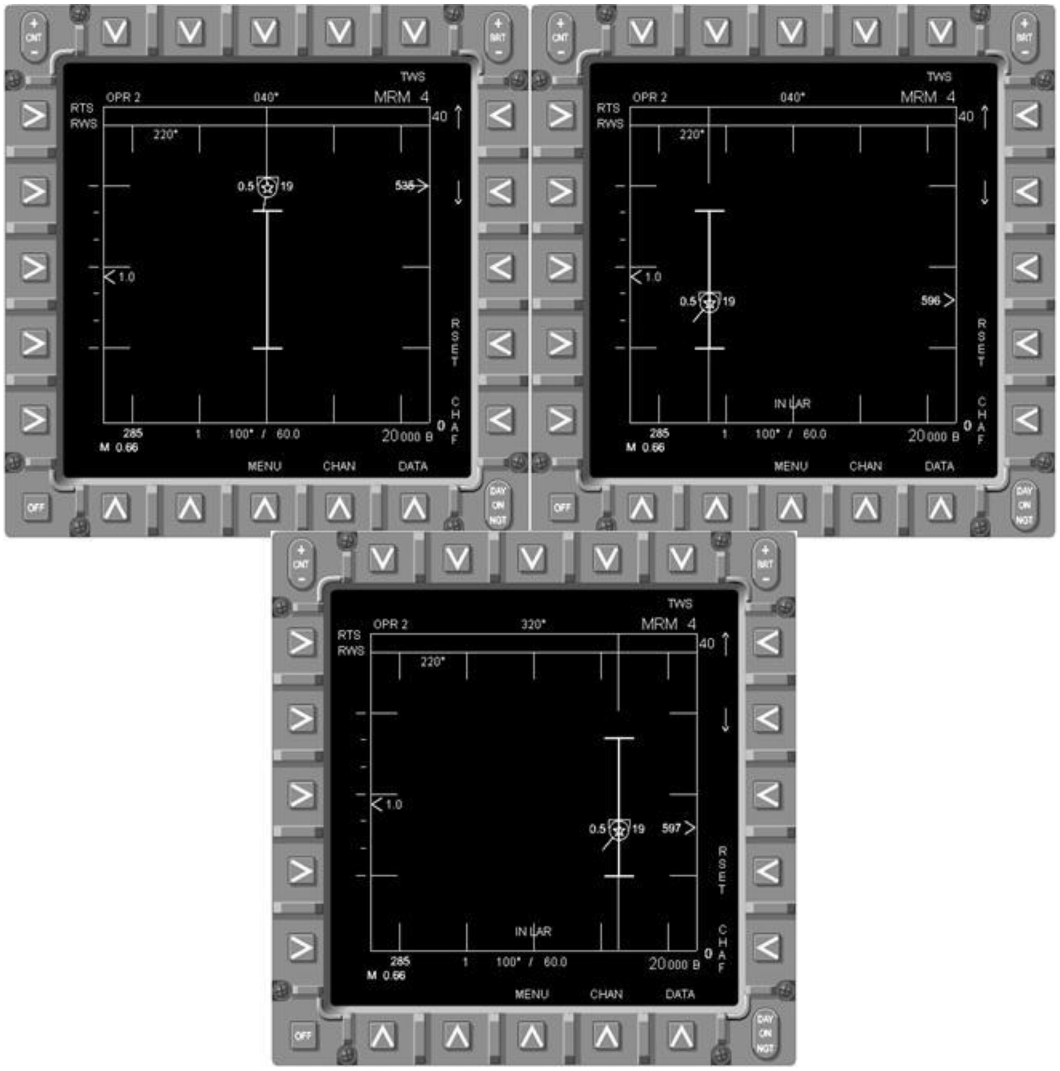

Figure 10-14 Expected Drift Patterns during Phases of Intercept

For example, at point and assess, the fighter is on BR and shows about 15L TA. Since the fighter has 45K of LS, the fighter remains on a zero cut to preserve this amount of LS while TA builds.

When on a zero cut, AO = TA. When the contact drifts to 40 L AO, the fighter turns to collision at 40 R AO. This captures 40 L TA. This turn will be 80 degrees to the left for a fighter heading of 320 degrees.

After the fighter turns to place 40 L TA on collision at 40 R TA, LS will initially be about 45K. However, once on collision, LS will decrease while TA remains constant to meet the 40K LS goal at 10 NM (Figure 10-15).

2. **Medium TA (20 < TA <35) Management**

Medium TA is from 20 TA to 35 TA. From the LS equation, it is easy to determine that initial setups at 30 NM will result in between 60K and 105K of LS. Therefore, the fighter must remove between 20K and 65K of LS.

Once correlated, the fighter brings the contact to the nose to assess TA and LS. With a TA between 20 and 35 at 30 NM, the fighter has more than enough LS. Rather than chase the 40K LS goal, the fighter will turn to bandit recip and let TA build to 40. Once TA = 40, the fighter turns to capture 40 TA to 10 NM. The turn to capture 40 TA should be 80 degrees and should be started when the contact is at 36 AO, which corresponds to 36 TA.

The turn to collision will occur at a much greater range than that for 15-20 TA even though the procedure is identical. The difference on the radar is that the initial position of the contact will be further from the nose.

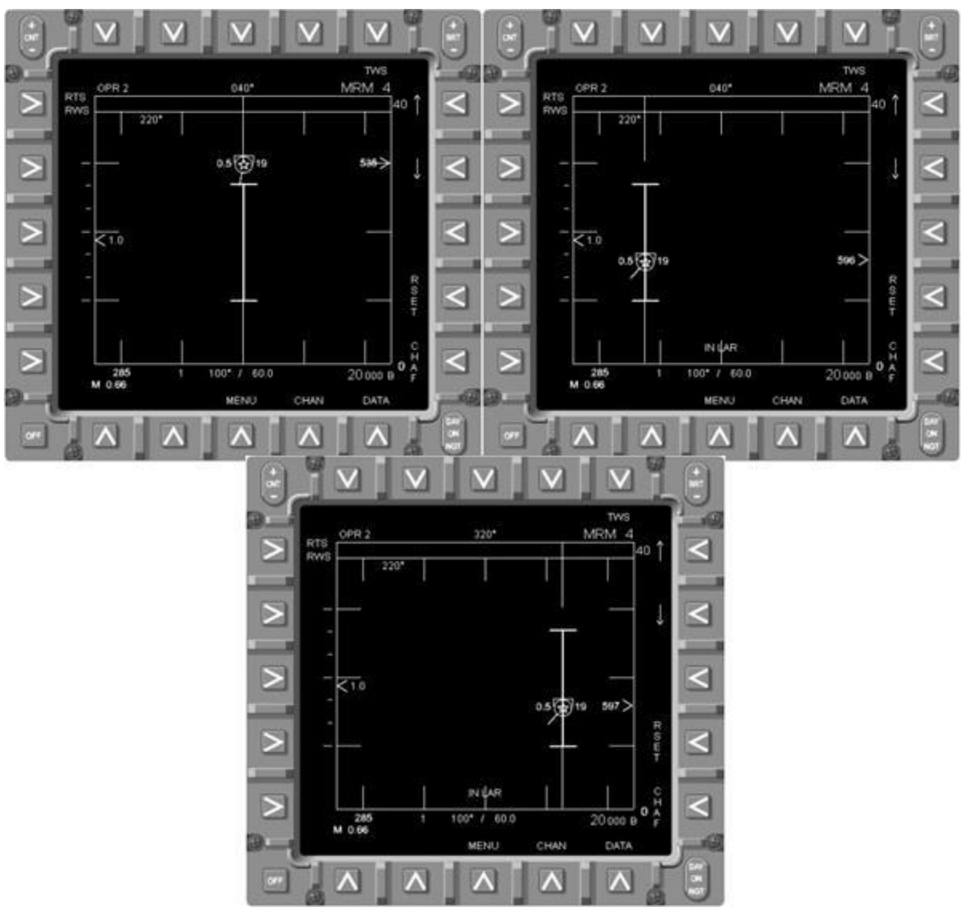

Figure 10-15 Medium TA Drift

For example: The fighter has correlated and has turned to point and assess. Bandit heading is 220 degrees, BR is 040 degrees.

The fighter assesses TA = 30 degrees L and LS about 90K on the left. Rather than chase the 40K LS goal, the fighter turns to a zero cut to allow TA to build to 40L. Once 40L TA is recognized (by the fact that AO=TA on a zero cut) the fighter turns to place 40L TA on collision at 40R AO and holds this geometry to 10 NM.

The turn to place the contact on collision will be 80 degrees since the fighter must turn 40 degrees left to bring the contact to the nose and another 40 degrees to place the contact 40R AO. The turn should begin when the contact is around 36L AO to allow for drift in the turn. This is shown in Figure 10-16.

3. **High TA (35 < TA < 45)**

40 TA Setup - With a setup that has 40 TA, immediately turn to place this on collision bearing at 40 degrees L/R AO as appropriate and keep the contact there until 10 NM. The SNFO should attempt to assess and act on this situation as rapidly as possible.

The contact should be placed on collision at 40 AO and kept there until 10 NM. As this is the simplest scenario, the SNFO must be able to accurately and rapidly detect the 40 TA situation (Figure 10-16).

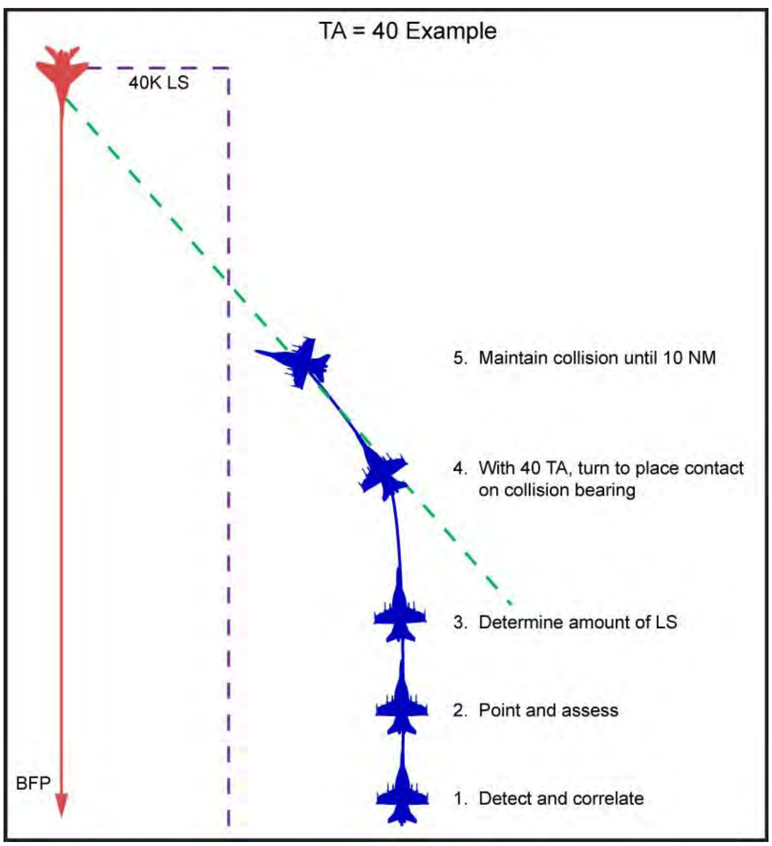

Figure 10-16 Execution with a 40 TA Start

4. **High TA (TA > 45)**

With TA greater than 45 the contact should be placed at 50 AO hot. For any aspect less than 50, this will reduce both LS and TA. If the fighter assesses that 40 TA has been reached, turn immediately to capture 40 TA on collision and continue to 10 NM (Figure 10-17).

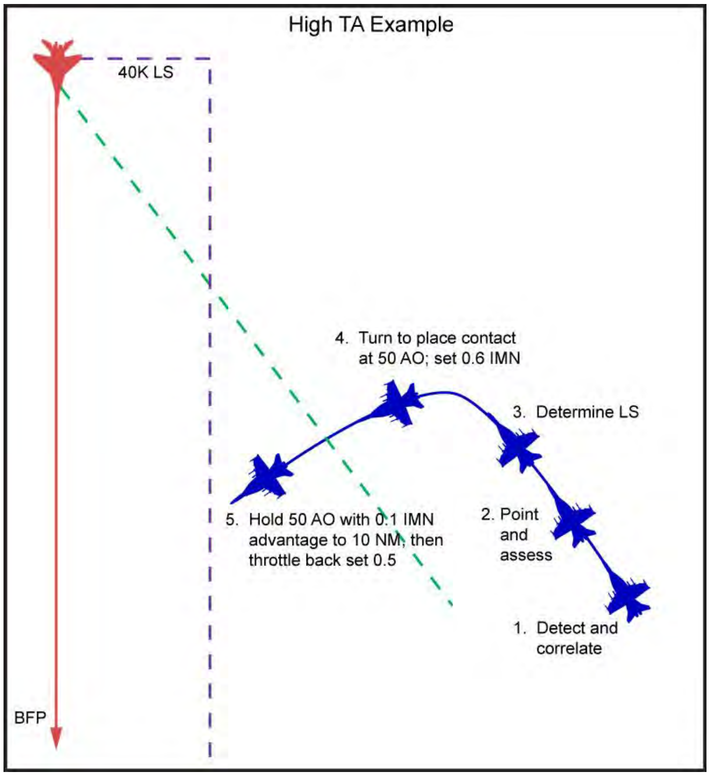

Figure 10-17 High TA Example

With TA greater than 50, the fighter is close to losing positional advantage. To maintain a positional advantage the fighter must go beyond the normal isosceles, co-speed intercept triangle (Figure 10-18). Using geometry, it can be shown that the distances A, B, C, and D are:

a. A = 30 NM x sin 60 degrees = 25.98 ≈ 26

b. B = 30 NM x sin 55 degrees = 24.57 ≈ 24.6

c. C = A/sin 80 degrees = 26.4 NM

d. D = B/sin 80 degrees = 24.98 NM

Since C > D, the fighter must cover a greater distance than the bandit in order to arrive at the intercept point at the same time. To achieve this, the fighter must increase its airspeed to cover more distance in the same amount of time.

Recall that at 300 KGS, the bandit will cover the 25 NM to the intercept point in 5 minutes. At 360 KGS, the fighter can cover the 26.4 NM in 4.4 minutes (4 minutes 24 seconds). This means the fighter, has re-established a positional advantage while maintaining the contact at 50 AO. This can be achieved by the fighter adding a 0.1 IMN speed advantage.

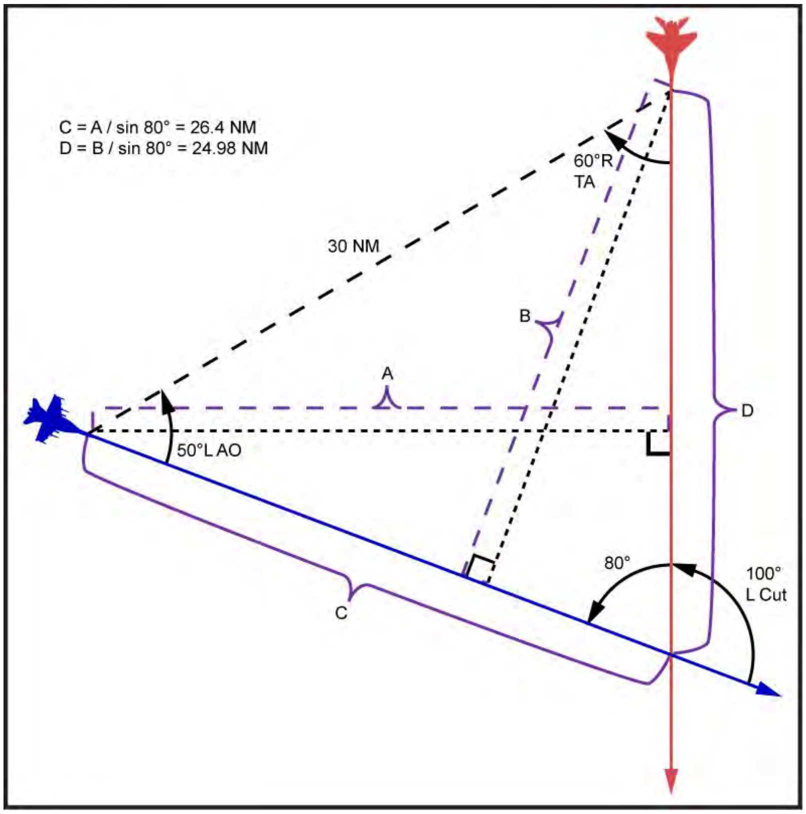

Figure 10-15 Intercept Triangle Geometry for Intercepts with TA >50

The SNFO should command "*Set point 6*" to instruct the pilot to increase airspeed.

No later than 10 NM, the SNFO should direct "*Throttle back, set point 5"* to return to 0.5 IMN. This applies to all contacts with TA of 50 or greater. The effect of a fighter 0.1 IMN speed advantage is to move collision bearing toward the fighter's nose by 5 degrees. The fighter can then use a predictable geometry to manage LS, and even reduce it toward the 40K goal. Since the speed advantage will move collision bearing in by 5 degrees, a contact with 50 TA at 50 AO with a speed advantage will slowly drift away from the nose, reducing target aspect.

When faced with a non-isosceles intercept, the fighter is not likely to reach a 40K LS situation. However, anytime the fighter has the bandit on collision, TA will not change. Procedures for addressing too much LS at 10 NM will be covered in the next chapter.

1010. TA MANAGEMENT SUMMARY

The TA management plan at range is summarized in Figure 10-19.

TA Assessment at 30 NM	Initial LS	First Turn	Second Turn	Third Turn
0 – 10	0 – 30K	50 AO Cold	Bandit Recip	Collision at 40 AO Hot
20	60K	Bandit Recip	Collision at 40 AO Hot	Nose-on at 10 NM
30	90K	Bandit Recip	Collision at 40 AO Hot	Nose-on at 10 NM
40	120K	Collision at 40 AO Hot	Nose-on at 10 NM	
>=45	135K+	50 AO Hot with 0.1 IMN speed advantage	Nose-on at 10 NM	

Figure 10-19 TA Management Summary

Evaluate TA and LS, then turn to place the contact to meet the 40K LS at 10 NM. In all cases, the fighter will turn nose-on at 10 NM.

CHAPTER ELEVEN
DISPLACEMENT TURN FUNDAMENTALS

1100. INTRODUCTION

In the event the fighter arrives at 10 NM with significantly less than 40K of LS, a maneuver must be made to create turning room while maintaining radar contact with the bandit or other aircraft being joined on. This turn is called the displacement turn.

Although during an intercept the displacement turn is only executed if the fighter has arrived at 10 NM with less than the desired amount of turning room, the principle applies when joining on a formation of aircraft or on an aircraft on a predictable flight path, like a tanker.

1101. THE NEED TO CREATE TURNING ROOM

As previously identified, lateral displacement in the BVR arena translates to turning room in the visual arena. Recall that AWI intercept procedures are designed to be just that, an all-weather procedure, meaning that the fighter can execute these procedures and arrive in a rear quarter LAR without ever obtaining a tally on the intercepted aircraft. Thus, the fighter should be comfortable with the concept that once the pilot achieves a tally, likely with the assistance of AREO calls from the SNFO, the intercept will proceed visually. However, if conditions are such that a tally is not made, the SNFO should prosecute the intercept.

The displacement turn, or DT, is essentially a contingency scenario in that, if the fighter has executed intercept procedures correctly and achieved 40K of LS at 10 NM, no DT is required. It is addressed here because there are many various reasons that the fighter may find itself at 10 NM with significantly less than 40K and the DT procedures will apply, even beyond stern conversion intercepts.

Often when a fighter arrives at 10 NM with 0 TA, uninformed crews will see two solutions to the turning room problem. The first is to accept that no turning room exists and set up for high aspect BFM entry.

The problem with this is that at 10 NM and 0 TA, there is a high likelihood that the bandit is aware of the fighter’s presence. 10 NM is outside SRM employment range, and the fighter is then spending almost one third of the intercept managing a head on charge at the bandit. In IMC or poor visibility, there is a significant chance that the fighter will not see the bandit and will be unable to engage or make an ID if one is required. This effectively means the fighter has failed in its mission to engage the bandit or ID the unknown aircraft and the bandit can blow through the merge to continue on its mission. Obviously, this is not desirable.

The second action aircrew often perform is to place the contact at the maximum available AO in an attempt to rapidly build TA and LS. The problem with this is that at short ranges, any bandit maneuver will result in a rapid line of sight, or AO change. If the bandit is at greater than 60 AO and maneuvers away from the fighter even slightly, contact will be lost as the bandit drifts rapidly off the edge of the fighter’s attack display. Once contact is lost inside of 10 NM, the fighter must rely on AIC information and lost contact procedures to reacquire the bandit. Again, this is not desirable.

The fighter must execute a planned turn to create LS in a controlled fashion. This is what the DT aims to achieve.

1102. OBJECTIVES OF THE DISPLACEMENT TURN

The DT is required only when the fighter arrives at 10 NM with 20K of LS or less. This situation could arise from improper execution of the target aspect management plan or bandit maneuvers. This chapter will focus on the former, with reactions to bandit maneuvers covered in advanced 1v1 intercepts.

There are three goals of a displacement turn

- To create close to 40K of LS to allow the fighter to execute a standard counter turn
- To ensure that the fighter maintains radar contact on the bandit through the maneuver in preparation for the counterturn (CT) and VID/SRM employment
- To ensure that the fighter remains in control of bandit TA and the intercept.

In previous versions of intercept training displacement was an integral part of the intercept. With the advent of better radars and more realistic training scenarios, the DT has become a secondary training objective, but is still a skill that fighter aircrew need to understand.

1103. ACCOMPLISHING THE DT OBJECTIVES: THE RULE OF 50

The fundamental rule for displacement is the Rule of 50. This rule states that the proper displacement point for a contact at 10 NM is 50 AO cold minus the current TA. From this, a quick table can be built to illustrate proper displacement points (Figure 11-1).

Target Aspect	LS @ 10 NM (in feet)	Displacement AO (50 AO Cold - TA)
0	0K	50 AO, either side
10 L/R	10K	40 AO L/R
20 L/R	20K	30 AO L/R
30 L/R	30K	20 AO L/R
40 L/R	40K	10 AO L/R
50 L/R	50K	0 AO

Figure 11-1 Displacement Chart

It should be noted that intercept procedures will state the contact should be on the nose at 10 NM with 40K LS. From the table, the displacement point for 40 TA is 10 AO and 50 TA would be on the nose. For the intent of stern conversions, 10 AO is “on the nose.”

It should also be noted that with 30 TA, the fighter has 30K of LS, rather than displace this to 20 AO on the opposite side; this situation is manageable through the counterturn and will be discussed in the section of that chapter about cooling off a hot counterturn, which is a counterturn that is faster or closer than desired.

However, for TA 20 or less, the fighter will apply the rule of 50 to displace the contact to the proper displacement point and begin the counter turn.

The displacement turn is complete once the contact has been displaced to the displacement point. Any maneuvering after displacement is counter turn management.

1104. HOW MUCH LS CAN A DT GENERATE?

Based on the requirement to maintain radar contact to the bandit, the SNFO can expect to generate approximately 25,000 feet of LS from a 0 TA start and coming nose-on at 5 NM. The fighter should prepare for a hot counterturn.

1105. MINIMUM DISPLACEMENT

The SNFO should announce the intent to turn for displacement by stating:

SNFO (ICS) - “*Left Hard for displacement*”

Ten degrees prior the SNFO should announce

SNFO (ICS) - “*Ten to go*”

At the proper displacement heading the SNFO should command:

SNFO (ICS) - “*Steady Up*”

The turn to displacement is not based on a specific heading, but the desired displacement AO as assessed at 10 NM by the SNFO. The purpose of these calls is to ensure the pilot understands what the intent of the SNFO is and that the SNFO is thinking about the geometry of the intercept. The SNFO should recall that the ST will always be a cut away, or place the contact on the cold side of the attack display. That is, the turn is AWAY from the TA vector.

1106. REVIEW OF DT PRINCIPLES

Simply put, a displacement turn is only required if less than 20 TA exists at 10 NM. If this is the case, place turn to place the contact to 50 AO for 0 TA, 40 AO for 10 TA or 30 AO for 20 TA. Once the contact has been displaced, the counterturn begins.

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CHAPTER TWELVE
COUNTERTURN FUNDAMENTALS

1200. INTRODUCTION

The stern conversion intercept gets its name from the position the fighter arrives in at the conclusion of the intercept, i.e., the bandit's stern. The stern conversion means that the fighter converts front hemisphere target aspect into the stern, or rear quarter, aspect.

The 40K LS goal sets up the fighter for this stern conversion turn. Due to the rapidly changing geometry at this stage of the intercept, the fighter must perform a counterturn in order to compensate for intercept drift, maintain radar contact and arrive within SRM parameters in the rear quarter. This chapter discusses the stern conversion counterturn.

1201. DRIFT

Previously, the concepts of intercept and turn drift were discussed as they applied at relatively long BVR. Although the CT begins within visual range (WVR), the same concepts of intercept and turn drift apply. In fact, the effects of both are magnified by the short range and high line of sight rate changes that occur.

The drift management goal of the fighter in the CT is to use turn drift, adjusted by varying the fighter turn rate, to counter intercept drift to keep the bandit on the fighter's nose from 10 NM until SRM parameters are satisfied.

1202. COUNTERTURN OBJECTIVES

The goal of the rear quarter counterturn (CT) is to arrive in the rear quarter within SRM parameters. It counters outward drift from the contact. Ideally, the CT will begin at 10 NM with 40K feet of lateral separation. Just like in the BVR portion of the intercept, the WVR portion of the intercept has range and TA gates to assist with geometry.

1203. NORMAL COUNTERTURN FROM 40K LS AT 10 NM

The counterturn is a dynamic environment in that without the fighter maintaining a continuous turn to keep the contact on the inside gimbal limits of the radar, the contact would rapidly drift off of the attack display. If the fighter has achieved the goal of 40K LS at 10 NM and brought the contact to the nose on timeline, then the counterturn is pretty easily accomplished.

1. **10 NM Gate**

At 10 NM the fighter should have 40K LS with 40 TA and about 530 V_C. The fighter should go pure. With 40K LS, the fighter has the proper amount of turning room to keep the contact on the nose and roll out within SRM range (0.5-2.0 NM) at the contact's six o'clock position. If the fighter comes nose-on at 10 NM and maintains a wings level position, the contact will drift in the direction of the TA vector toward the edge of the attack display. The fighter should counter this intercept drift by entering a series of harder turn rates until in the rear quarter LAR. The initial turn rate will be easy and will increase to a standard by 7 NM.

2. **5 NM 70 TA Gate**

As the fighter remains nose-on, TA will continue to increase as range decreases. At 5 NM, the fighter should see 70 TA and approximately 450 V_C. The fighter should maintain pure pursuit. The fighter will be in a hard turn.

3. **2.5 NM 90 TA, 90 DTG Gate**

At 2.5 NM, the fighter should see 90 TA. The fighter will have 90 DTG to bandit heading and V_C should be 300. The fighter should be in pure pursuit in a hard turn.

4. **1.5 NM 150 TA Gate**

If the fighter has remained nose-on, at 1.5 NM the fighter should be IN LAR for an SRM. If a valid shot exists and the contact is hostile, then the fighter should employ. The fighter should begin to roll out of a hard turn toward wings level.

5. **Wings Level, 1NM 180 TA**

If the CT has been executed correctly, the fighter will roll out wings level at the bandit's six o'clock, on bandit heading with 1 NM of separation and 1,000 feet of lookup. This represents the culmination point of an ideal intercept.

1204. CORRECTING THE COUNTERTURN

For any number of reasons, the fighter may not arrive at 40K at 10 NM or may deviate from the ideal gates listed in Figure 12-1. The fighter must have a good understanding of the relationship between range, TA and V_C during the CT. These relationships are shown below and should be committed to memory.

Essentially, the CT assessment can be boiled down to:

- Assess range and TA during the CT and compare to checkpoints.

- Compare TA to range and check V_C.

- If TA is lower than called for at range, the CT is hot.
- If TA is higher than checkpoint at range, the CT is cold.
- Example: TA is 80 at beyond 5 NM, the CT is COLD.

  i. The corrective action is to pull 10-20 degrees of lead

  ii. "*Harde*r" to pilot

  iii. Conversely, if approaching 5 NM and TA is less than 60, the CT is HOT; "*Ease*" to cool off.

Range	TA (Ideal)	V_C (Approximate)
10	40	530
7	50	490
5	60	450
4	70	400
3	80	350
2.5	90	300
1.5	150 (Fox-2)	150
1.0	180 (Ideal)	0

Figure 12-1 Counterturn Checkpoints

As the fighter maintains a nose-on position, the SNFO should evaluate the range, TA and V_C against the table to determine if the CT is on track or needs correcting. A fighter that sees 500+ V_C at 5 NM is hot and needs to cool the CT off. Likewise a fighter than sees 400 V_C outside 4 NM is cold and needs to heat up the CT.

1. **Heating Up**

To heat up a CT, the fighter must increase its turn rate to place the contact no more than 20 degrees AO hot. This is, in fact, placing the fighter in lead pursuit to close with the bandit's flight path.

Once the fighter recognizes the intercept has returned to the desired pattern, the turn rate should be eased to allow the contact to drift to the nose. Once on the nose, the turn rate should be increased again to hold pure pursuit into the rear quarter.

2. **Cooling Off**

If the fighter recognizes TA is too low and V_C too high for the current range, the fighter is hot and needs to cool off the CT. In this case, the fighter eases the turn rate to allow the bandit to drift no further than 20 degrees AO cold, placing the fighter's nose in lag pursuit. The fighter does not want to lag by more than 20 degrees. Once the fighter recognizes the correct gate is reached, the turn rate should be increased to return to pure pursuit. If the fighter has let the contact drift greater than 20 degrees, a hard turn may not generate a turn rate sufficient to get the fighter's nose out of lag.

Counterturns that start with between 25 and 40 TA at 10 NM will begin hot and need to be cooled off. These counterturns should be manageable and on the ideal curve by 5 NM.

3. **The 2.5 NM, 90 DTG Gate**

The 2 NM, 90 DTG, 300 V_C gate is important for the following reasons:

a. Meeting this window means the fighter will roll out IN LAR for SRM.

b. 300 V_C check will help remind aircrew to remove speed advantage.

c. This is the last time for fighter to go to lead; past this point the fighter cannot generate an energy sustaining turn rate sufficient to pull lead.

d. This is the final opportunity to use geometry to solve range and V_C issues; after this point, the intercept is a tail chase

The fighter should never ease the turn rate at 2.5 NM and 90 DTG or a hot overshoot will be induced. The 2.5 NM gate is the only "must make" gate (Figure 12-2).

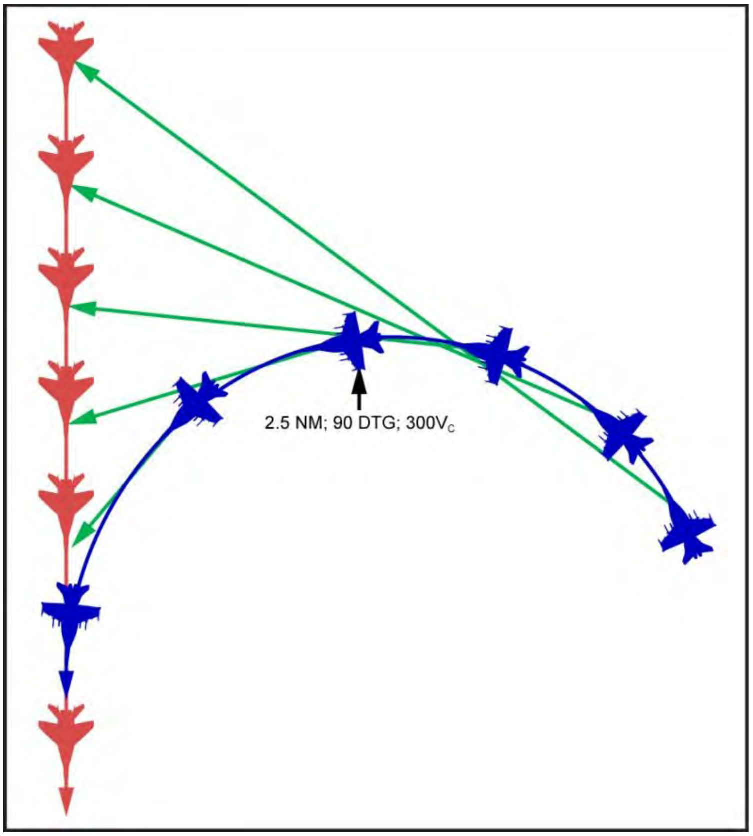

Figure 12-2 Counterturn

1205. RECOGNIZING AND COUNTERING THE HOT OVERSHOOT

The fighter will induce a hot overshoot by easing at 2.5 NM or by not cooling off a hot CT. A hot overshoot is characterized by:

- Fighter is unable to keep bandit on the nose in a hard turn
- Bandit line of sight rate increases as L&S drifts rapidly toward the edge of the display

To counter a hot overshoot:

- Never ease the turn, this will exacerbate the overshoot
- Maintain a hard turn

If radar contact is lost:

- With no tally call "*Rage 11 clean single group*"
- Select WACQ /SRM
- Turn HAP 30 degrees past bandit heading (if known)
- After 5 seconds, turn to bandit heading in a standard turn; if AIC provides a BRA to the contact, place that bearing on the nose

This procedure will isolate the bandit on one side of the fighter. It is possible that the fighter may maintain radar contact through a hot overshoot. In this case, the fighter should maintain the hard as possible turn until the bandit is on the nose.

1. **Fighter Induced Deviations – CT After Displacement**

SNFOs should recognize that if the fighter begins the CT from a position other than 40K LS, the CT gates here, specifically those from 5 NM in, can be used as a gauge to control the CT and intercept into the rear quarter. Procedurally, the fighter is starting from a hot position and should cool the intercept by going to lag until the CT gates are being met.

2. **The Phantom 60 Knots of Closure**

SNFOs should also note that if 0.1 IMN speed advantage was applied earlier in the intercept to convert TA and not removed, an extra 60 KTS V_C will be seen in the counterturn. The speed advantage should be removed at 10 NM.

1206. COUNTERTURN COMMUNICATIONS

The SNFO should use standard turn management terminology to manage the counterturn. AREO calls should continue until the pilot calls tally. Directive communications should be prioritized over descriptive commentary.

1207. MEDIUM TARGET ASPECT

The SRM will be employed in AWIs from the rear quarter. In the OFT, an audible tone is used to simulate the feedback from an AIM-9 that is tracking a target and radar indication of IN LAR.

In the aircraft, radar indications of IN LAR are visual when the target meets parameters, but there is no audible tone.

Once in the rear quarter of the contact, the aircrew will seek to meet SRM requirements.

- STT (Bandit locked)

- Visual shots within BFM parameters are considered un-assessable

- b. Range 0.5 to 1.5 NM

- c. "IN LAR" cue displayed.

- Hostile declaration by AIC; OR aircraft visually identified as a hostile type

Against a contact declared hostile, the fighter may shoot in CT as soon as IN LAR is displayed. Once in IN LAR, employ and call *"Rage 11, Fox-2*" on PRI. The SNFO should minimize Time-to-Kill (TTK); do not wait for RQ and fuselage alignment.

1208. COUNTERTURN SUMMARY

The counterturn can be summarized as follows:

- At 10 NM, evaluate LS

- If 40 TA at 10 NM, fly normal CT honoring the gates from the table

- If 25 < TA < 40 at 10 NM, initiate CT and monitor checkpoints; cool off as required to meet 2 NM gate.

- If TA < 20, displace to 50 AO cold and begin CT when outward drift occurs, monitoring checkpoints to meet 2.5 NM gate.

- At 2.5 NM be at 90 DTG with 300 V_C in STT with SRM selected; prepare to employ/VID

- Make the VID as early as possible; do not wait to rollout to employ the SRM against a hostile contact.

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CHAPTER THIRTEEN
INTERCEPT PROGRESSION

1300. INTRODUCTION

The previous chapters discussed identifying the spatial relationships at the beginning of the intercept, target aspect management, pursuit curves, and proper drift control from the initial setting of geometry through the counterturn and into the bandit's rear quarter. This chapter addresses the stern conversion intercept as distinct phases, giving the aircrew a logical framework from which to approach all intercepts.

The stern conversion is the basic radar intercept procedure used to join other aircraft. It is a critical skill needed by fighter aircrew to achieve mission success. This lesson will describe how aircrew manage intercept geometry beyond visual range (BVR) and transition to within visual range (WVR) to execute an expeditious rendezvous for a SRM or VID. These procedures will ensure aircrew success not only at VT-86, but also in the FRS and fleet.

1301. INITIAL INTERCEPT CONDITIONS AND ACTIONS

The initial conditions presented in an intercept determine what the fighter's course of action should be. The fighter needs to analyze initial geometry to determine TA, LS and what actions need to take place to manage the change in LS. The fighter is given information from AIC which defines the location of the bandit. From this information, the fighter can obtain radar contact and analyze the situation.

The fighter must perform the following actions in this order before setting geometry:

- Turn to place the contact call on the nose (point and assess).
- Sanitize airspace to detect the group (sanitization).
- Correlate the detected group with AIC information.
- Obtain a declaration.

1. **Communication Formats**

In this stage, AIC will be using tactical control in the BRA format to aid the fighter in acquiring the contact. Tactical control can be either anchored to bullseye or given in BRA (bearing, range, altitude) format. BRA format always references the fighter's nose. Recall from Chapter 5 that broadcast control does not reference bandit aspect in its calls, where tactical control does. Initial picture calls for stern conversions will be in the tactical BRA format.

2. **Sanitization**

The fighter should ensure that airspace in the current scan volume is "clean" prior to adjusting the scan volume. Initially, the fighter should center the scan altitude volume at the called altitude with the cursor at 25 NM to ensure the called altitude at 30 NM is in the scan volume. If the contact does not appear, the fighter can place the cursor at the AIC called BRA and center the elevation scan coverage. Again, the fighter should be patient as a RWS/140 degrees/6B frame takes approximately 13 seconds to complete.

3. **Commit Criteria**

The following two requirements are the commit criteria for stern conversions at VT-86:

TA < 60 degrees

Range ≈ 30 NM (NLT)

Once the fighter determines that the AIC information meets these two criteria, the fighter will commit with the following call:

SNFO (PRI) - "*Showtime, Commit*"

SNFO (AUX) - *"Check tapes, master arm"*

The bullseye card assists the aircrew's understanding of intercept geometry, geographic threat location and threat relevance of the called contact, with respect to the fighter, defended position, route, commit line, etc.

4. **Point and Assess**

The point and assess game plan involves the fighter pointing their own aircraft towards threat sector and obtaining radar contact, then using radar information to assist with the intercept geometry decisions. As shown in Figure 13-1, the point and assess plan allows the fighter to make informed commit and geometry decisions. Following the commit, the fighter will point at the bandit to assess the initial intercept conditions.

a. Advantages:

i. More detailed contact information from radar contribution to fighter aircrew (L&S or STT).

ii. Own aircraft weapon system is directed at the contact in the event of a Hostile declaration.

b. Disadvantages:

i. Compresses the range between fighter element and contact element

ii. Allows contact element to gain SA that they are targeted when radar energy is detected from fighter element

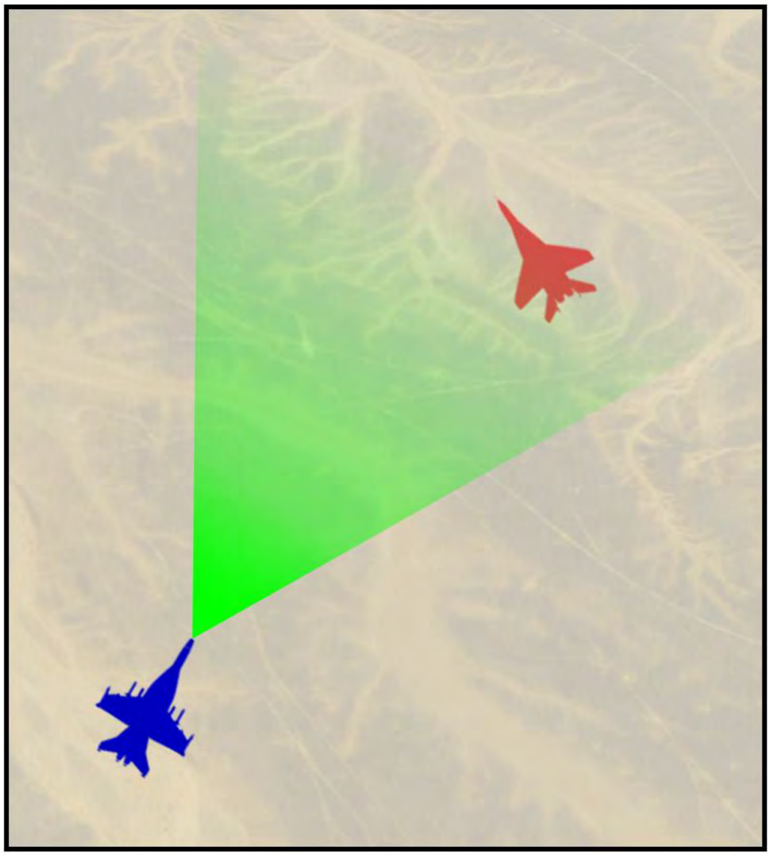


Figure 13-1 Point and Assess Plan

5. **Correlation and Declaration**

Once radar contact occurs, the SNFO will make a declaration call to the AIC controller to correlate the radar contact to the AIC called group. An example of the communication format is as follows:

SNFO (PRI) - *"SABRE, Showtime 11, contact BRA XXX, YY, ZZ thousand, declare."*

AIC will respond with a correlated contact and declaration:

AIC ("SABRE") - *"Showtime 11, SABRE, single group BRA XXX, YY, ZZ, Hot, Hostile."*

Communication for the declaration call is in the tactical control format. AIC response will label and name the picture/group "single group." The aircrew must remember the AIC called declaration in order to not violate ROE by employing weapons without authorization. If there is any confusion with the declaration, another declaration call should be made.

The fighter needs to analyze initial geometry to determine TA, LS and what actions need to take place to manage the change in LS. The fighter is given information from AIC which defines the location of the bandit. From this information, the fighter can obtain radar contact and analyze the situation.

6. TA and LS Analysis

The BVR geometry goal of the stern conversion at VT-86 is to achieve 40K LS by 10 NM. Lateral separation is the distance between the fighter and projected bandit flight path (Figure 13-2).

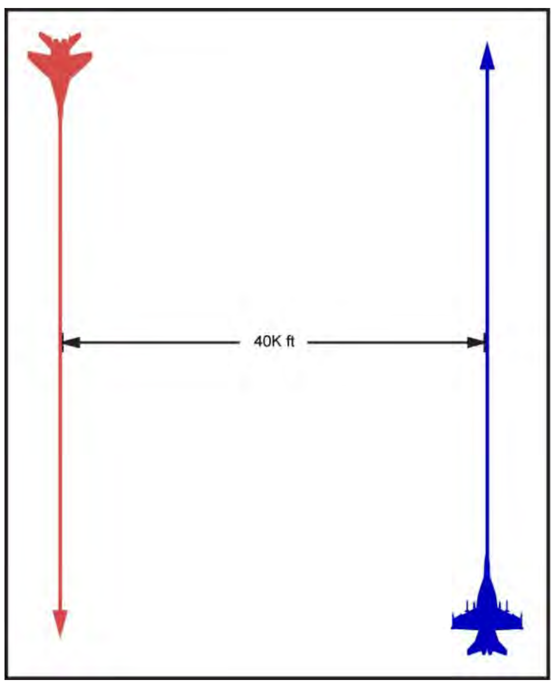


Figure 13-2 40K Lat Sep Goal

The formula for LS is:

$$LS = TA \times Range \times 100$$

To calculate LS, the SNFO is expected to identify TA to the nearest 10 degrees and act based on that determination. Once the initial geometry is understood, the intercept's initial phase is over.

1302. INTERCEPT MID-PHASE; TA MANAGEMENT PLAN EXECUTION

Initial conditions for Stern Conversion AWIs will be 0-45 TA at approximately 30 NM. However, SNFOs should understand geometry management to at least 55 TA since slow recognition of initial conditions or wrong application of a game plan may allow TA to build to 50 or greater. The SNFO should apply geometry and a speed advantage to stop the growth of TA out to 60 TA with timely application of the correct game plan and good headwork.

Once the initial situation is recognized, the fighter will apply the game plan for a low, medium or high TA contact.

1. Summary of Starting Positions

Figure 13-3 shows the fighter's potential starting positions and how they relate to the 40K LS goal.

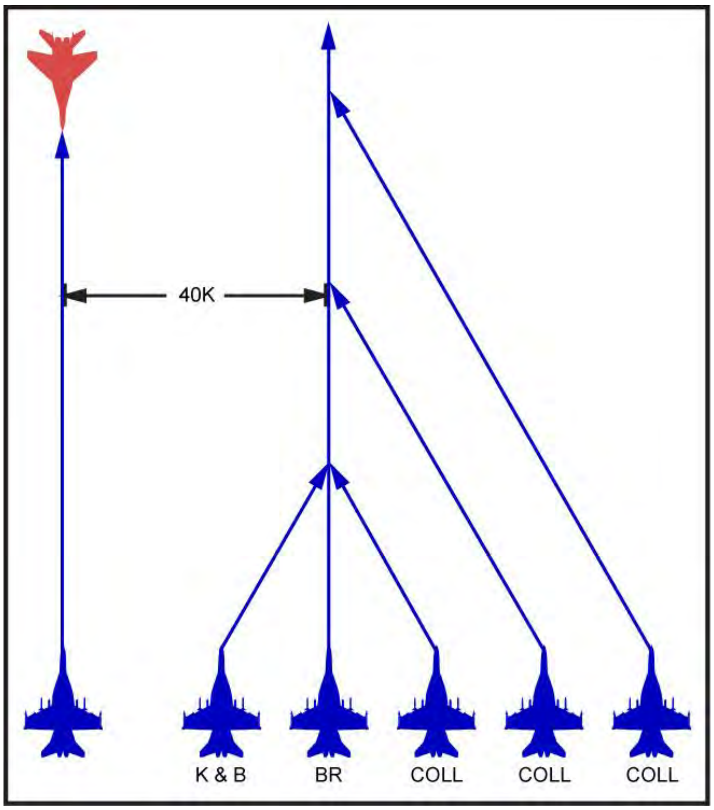


Figure 13-3 Summary of Starting Positions

Figure 13-4 provides radar display examples for various TAs. These TA checkpoints, used in combination with the Lat Sep Gates, assist aircrew in recognizing when 40K LS is achieved.

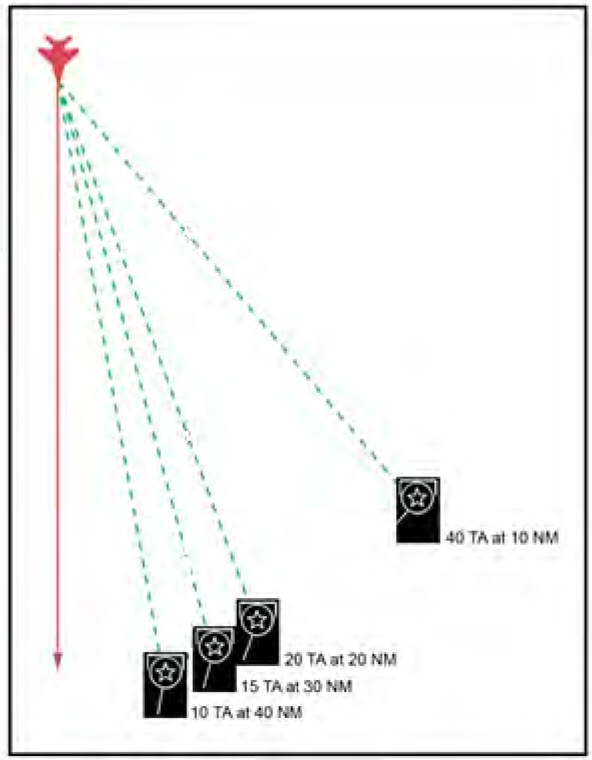


Figure 13-4 Radar TA and Intercept Starting Points

1303. RECOGNIZING AND CAPTURING THE 40K LS GOAL

1. Recognizing 40K TA

The fighter must recognize when the 40 LS goal has been reached. The table in Figure 13-5 shows the relation between TA and range for 40K of LS.

Target Aspect	Range
10	40
15	30 (45K LS)
20	20
30	15 (45K LS)
40	10

Figure 13-5 TA vs. Range for 40K LS

These gates shall be committed to memory for effective intercept execution.

In Figure 13-6, the red line is bandit reciprocal (BR, or a zero cut), the blue line represents the AO to place the contact for collision, and the yellow line shows the growth of TA, as measured from BR to BB. This is the expected drift pattern for a zero cut execution that starts at about 12 TA at 30 NM. As the contact drifts left on the display, TA is increasing, but LS is remaining constant at 40K.

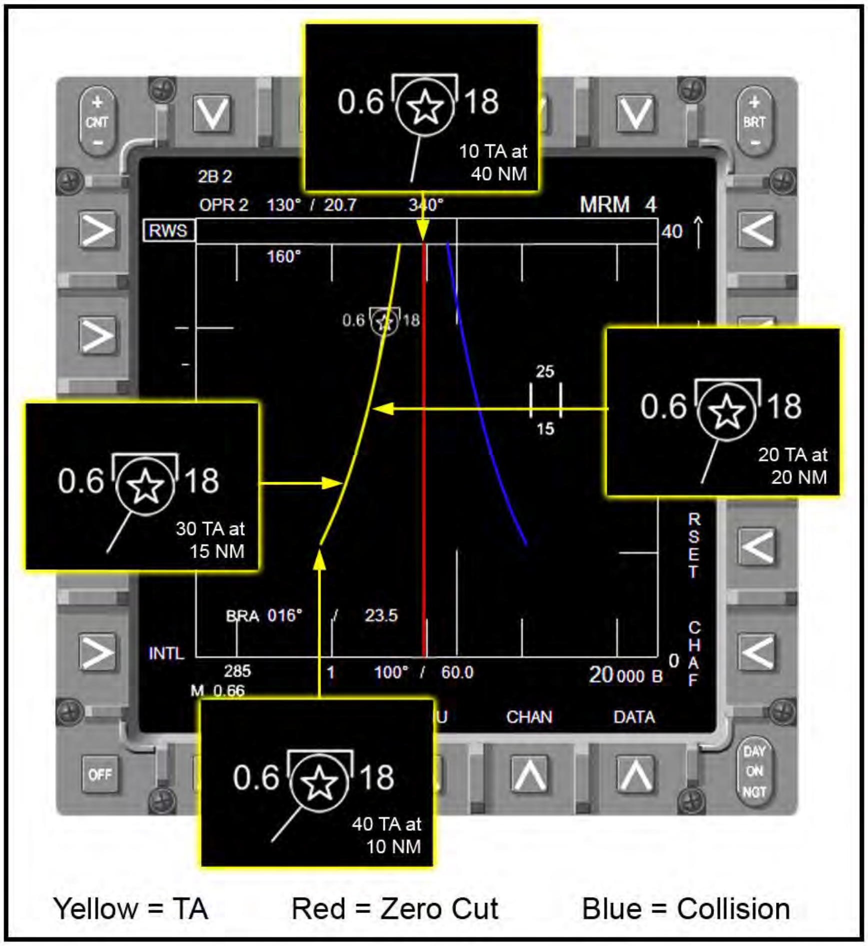


Figure 13-6 Attack Display Showing 40K LS Goal

The overlap between game plan execution and TA is shown below in Figure 13-7.

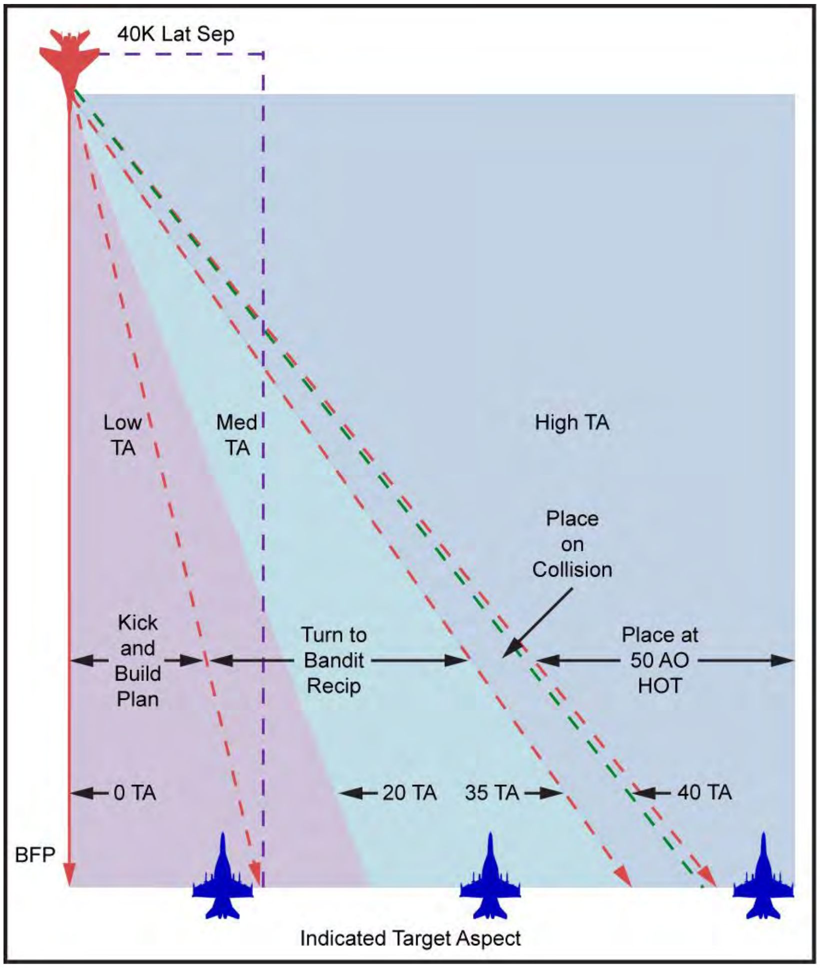


Figure 13-7 TA Regions in Relation 40K Goal

2. **Capturing**

Capturing 40K LS will occur one of three ways:

a. The fighter will turn to collision after building 40 TA

b. The fighter will turn to BR and maintain 40K LS to 10 NM

c. The fighter will continue to reduce LS to 40K by placing the bandit on collision with 40 TA until 10 NM

The key is for the fighter to recognize which of these scenarios applies.

a. Example 1 - 10 TA start: With 10 TA at 30 NM, the fighter has 30K LS. The "kick and build" plan applies. The fighter should place the contact at 50 AO cold and monitor TA gates. The most likely checkpoint for 40K recognition will be 20 TA at 20 NM. Turning to a zero cut at 25 NM with 15 TA equates to 37.5K of LS, which does not meet the LS goal.

b. Example 2 - 45 TA start: With 45 TA at 30 NM, the fighter has 135K of LS. The fighter must work immediately to reduce LS. The fighter should turn to place the bandit 50 AO hot and add a 0.1 IMN speed advantage. By 20 NM, the fighter may have reduced TA to 40, at which time the fighter could turn to place the bandit on collision at 40 AO hot and remove the speed advantage.

c. Example 3 - 20 TA start: With 20 TA at 30 NM the fighter has 60K of LS and needs to stop TA from building. To preserve LS, the fighter should turn to a zero cut, and let the contact drift to 36 AO. Then the fighter should turn into the bandit 80 degrees to place the contact on collision with 40 TA.

These three game plan execution examples show the logic the SNFO should use approaching the geometry management phase of the intercept.

3. **Correcting TA Management**

TA and LS should be continually assessed. The SNFO should ask, "What is happening to LS and TA with this geometry? Is the current gameplan I am executing producing the desired results?" If the answer is no to the second question, the SNFO should act, considering the following:

a. Immediately assess TA

b. Compute LS for the current TA

c. Apply the gameplan that is appropriate for the current LS

The SNFO should be proactive and work the current problem, not try to fix the previous problem that was not done correctly.

4. **Actions at 10 NM**

At 10 NM, the fighter should turn to place the bandit on the nose and perform another TA assessment. The fighter should then determine for a final time if 40K LS has been achieved and update intercept geometry as required.

The fighter should also commence AREO calls to talk the pilot's eyes onto the bandit.

1304. STERN CONVERSION TURN

If 40K of LS has been achieved, the fighter begins the counterturn (CT). When performed correctly, this will result in the fighter arriving in the rear quarter with:

- 1,000 feet of look up
- 0.5 to 1.5 NM of range
- STT
- Tally (preferred)

The goal of the rear quarter counterturn (CT) is to arrive in the rear quarter within SRM parameters. It counters outward drift from the contact. Ideally, the CT will begin at 10 NM with 40K of lateral separation and the fighter will remain in **pure pursuit** all the way to SRM parameters.

1305. DISPLACEMENT TURN CONTINGENCY

If the fighter encounters a situation where there is little to no LS at 10 NM, a displacement turn will be required (Figure 13-8). The goal of the displacement turn is to create LS for the counterturn. The DT will not be necessary if the conversion game plan discussed in this lesson is executed. This is a tool to use in the event of a quick geometric decision due to compressed range between the fighter and contact or low SA.

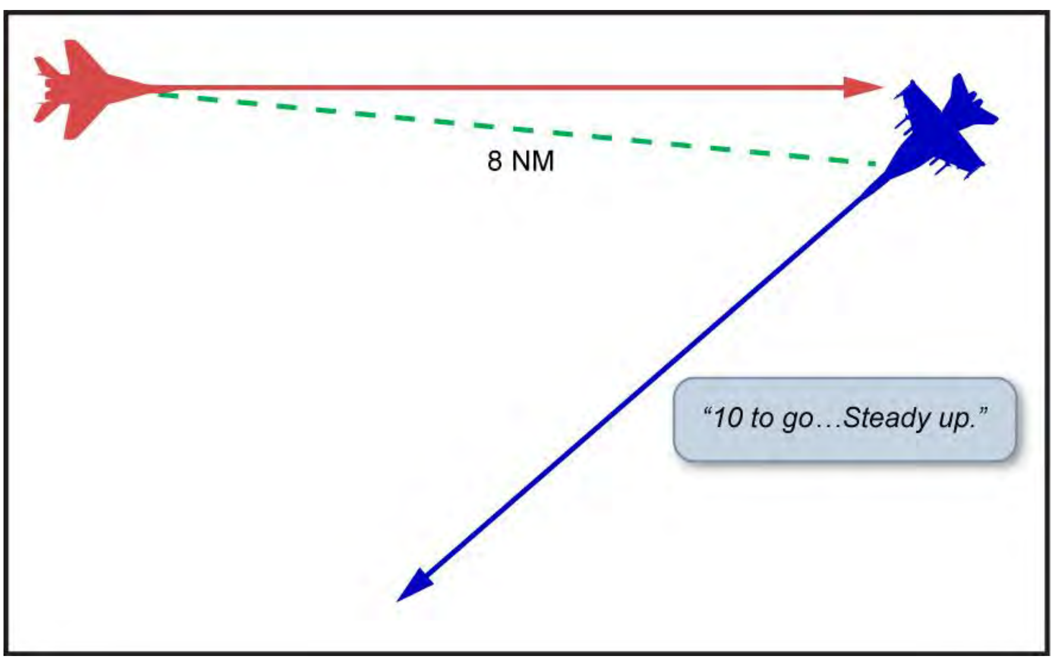


Figure 13-8 Displacement Turn

The two objectives of the displacement turn (DT) are:

- To orient the fighter's flight path (heading) so as to gain lateral separation as required.

- Achieve an intercept geometry that ensures that the drift rate in the counterturn is controlled and that the counterturn does not require high AOB and G-Load (especially important at night or on NVGs to avoid disorientation).

Five steps are used to accomplish the DT:

- Determine TA.

- Determine distance from displacement range (10 NM).

- Determine the displacement point (AO), left or right of the fighter's nose from the previous TA assessment.

- Direct the pilot to turn in the direction necessary to place the contact on the displacement point with "*Left/Right Hard for Displacement*." Once within 10 degrees of the displacement point, describe "*10 to go.*" Lastly, at the displacement point, direct "*Steady Up*."

- Once the contact is displaced to the correct AO and you see outward drift, direct the counterturn (usually a directive turn in the opposite direction of the displacement turn) and give AREO calls to the pilot. Once the pilot is tally, they will execute the remainder of the counterturn visually.

The displacement point chart below, Figure 13-9, assists aircrew with the proper displacement points.

Target Aspect	Displacement Point
0	50° L/R
10	40
20	30
30	20
40	Go Pure
50+	20 Lead

Figure 13-9 Displacement Points

Once again, the DT is a contingency procedure that is not required if the TA management game plan is properly executed. However, these procedures should be used to correct for little or no LS at close range (< 10NM) on a stern conversion.

1306. SRM EMPLOYMENT CRITERIA

Once the fighter has a tally on the bandit, the fighter should maneuver as required to achieve an SRM employment opportunity. Aircrew should always strive for a radar lock. Radar lock greatly improves the ability of the aircraft's weapons systems to acquire the target. However, A/A gun and SRM employment does not require a radar lock.

In the aircraft, radar indications of IN LAR will be visible when the target meets launch parameters, but there is no audible tone (Figure 13-10). Any shot taken with an IN LAR cue is considered valid, so with a radar lock, use the displayed LAR. In the OFT, an audible tone is provided to simulate the feedback from an SRM that is tracking a target along with a radar indication of IN LAR. When employing the SRM, the SNFO will transmit "*Showtime 11, Fox-2.*"

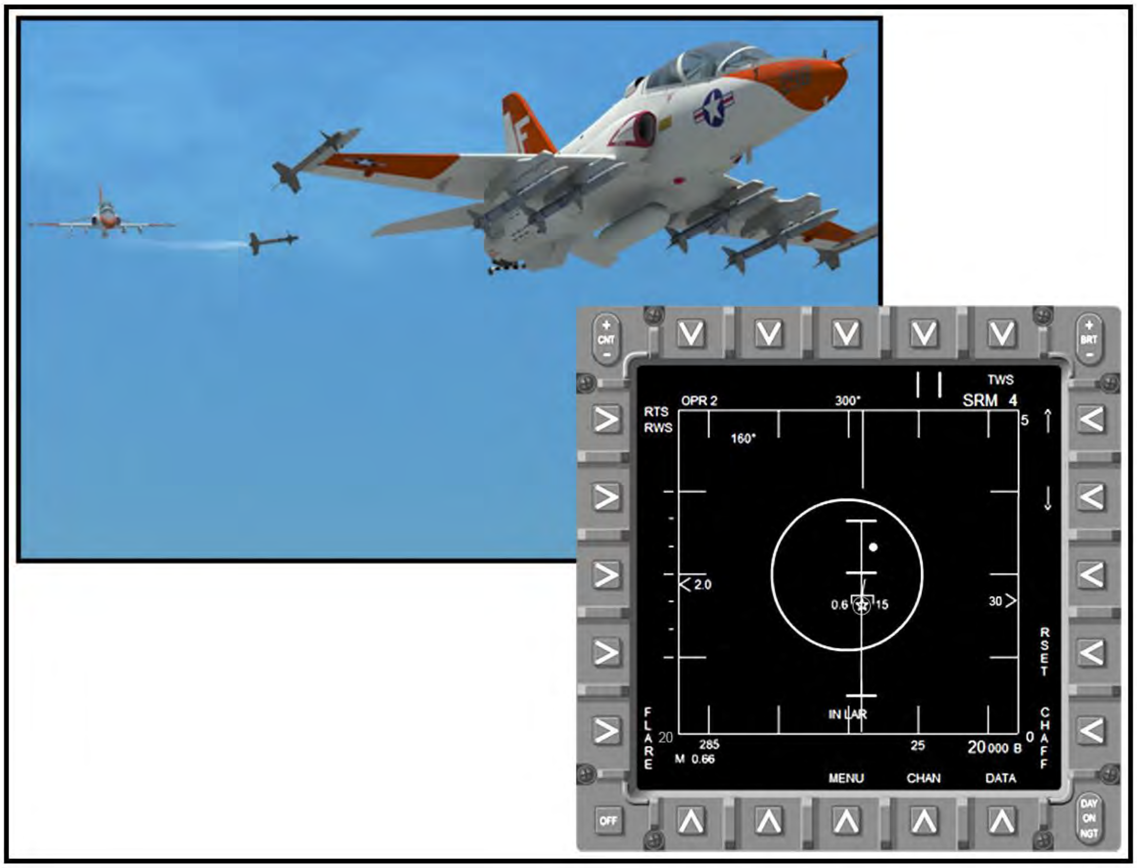


Figure 13-10 RQ SRM with a Radar Lock

With no radar lock, the SNFO should continue to attempt to acquire a radar lock in WACQ. However, with a tally, the SNFO should direct maneuvering to the valid RQ SRM LAR used in BFM training. For AWI purposes, visual shots (SRM without radar lock) are considered "not assessable."

1. Visual Identification

Prior to reaching visual identification ranges (typically inside of 5nm) broadcast on AIC frequency "C/S, standby (group name)" to clear the frequency.

Aircraft identification should be communicated to AIC using the UNCLASS NATO reporting name, such as: "*Shoot, shoot, Fulcrum.*" Aircrew should be well prepared for threat and friendly aircraft ID and the ROE for weapons employment. The event brief should include the type of aircraft expected. Appendix B includes aircraft presented in the OFT. The SNFO is responsible for correct visual identification and terminology.

1307. CONCLUSION

Stern conversions are a critical skill required for tactical aircraft employment. Formation, radar, and communication are the critical skills for success in the air-to-air environment. Most missions will require a rendezvous on a Flight Lead, airborne tanker, or visual identification of an unknown aircraft. The information and procedures in this chapter will be utilized throughout the training at VT-86 and the fleet.

CHAPTER FOURTEEN
AIR-TO-AIR MISSILES

1400. INTRODUCTION

As with most industries, technological innovation played a critical role in making today's air-to-air missiles extremely lethal. The technological evolution spans from unguided rockets to missiles with internal radar systems and guidance in the current combat environment. It is imperative strike fighter aircrew understand the capabilities of modern air-to-air weapons and how to employ them. Understanding the enemy's capabilities is also critical and those capabilities are highlighted in Chapter 4. This chapter will focus on the history and components of the U.S. air-to-air missiles; the AIM-9, AIM-7, and AIM-120.

1401. AIR-TO-AIR MISSILE HISTORY

The end of WWII and its aftermath marked a period of furious innovation in air-to-air missile development. The AIM-9 missile project was initiated in the early 1950s and the production models entered operational service in 1956. The Sparrow project began in 1946, with the first test firing of a missile in 1952. The missiles became operational in 1956 aboard F3H Demons and F7U Cutlass aircraft. The late 1960's witnessed the innovation of active missiles with the advent of the AIM-54 Phoenix missile and subsequently the AIM-120 AMRAAM, carried on today's U.S. tactical Strike Fighters.

The first guided missile kill occurred in September 1958 when employed by the Chinese Nationalists (Taiwan) against the Communist Chinese during the Formosa Straits conflict. It was also during this conflict that an unexploded AIM-9 was recovered by the Communists, and eventually turned over to the Soviets, who exploited the technology to develop the AA-2 Atoll.

The AIM-9 utilized Infrared (IR) guidance. IR guidance seeks the infrared emissions from a target in the electromagnetic spectrum. Missiles with these passive guidance systems are commonly referred to as "heat seekers."

The AIM-7 Sparrow variants have been utilized as air-to-air and surface-to-air weapons since the missile's inception in 1946. The weapon utilized semi-active radar guidance. Once the strike fighter has illuminated the target with a radar lock, the Sparrow guides on the reflected energy of the target by using a forward-looking planar-array antenna.

During the 1960s, the growing Soviet bomber threat required a missile that utilized look-down/shoot-down capability with either conventional or nuclear warhead systems. In response, the U.S. Department of Defense initiated a program that would evolve into the AIM-54 Phoenix missile supported by the AWG-9 weapon system. This was a revolutionary technological advance in modern air-to-air weapons because it was the first "active" missile. Active missiles have the capability of guiding themselves with radar systems within the missile. No longer did the missile require radar support from the strike fighter until detonation. A critical added benefit to this technological break-through was the new ability to shoot multiple missiles. Now that a missile could support itself in flight, the strike fighter aircrew could locate another target and shoot again! This capability was precisely what the U.S. DoD needed to counter the Soviet threat.

1402. AIM-9 SIDEWINDER HISTORY

The AIM-9 Sidewinder is a short-range, all-aspect, heat-seeking missile. The Sidewinder has proven itself to be the weapon of choice because of its simplicity, reliability, and high probability of kill. Since the missiles inception in the early 1950s, the Sidewinder has seen vast improvements in its basic design.

The early Sidewinders suffered from poor seeker head discrimination (i.e., could not distinguish one heat source from another) and a very limited firing envelope. During the Vietnam War, the Sidewinder received improved seeker head capabilities with Sidewinder Expanded Acquisition Mode (SEAM), which enabled the missile to have a wider field of view for acquiring targets.

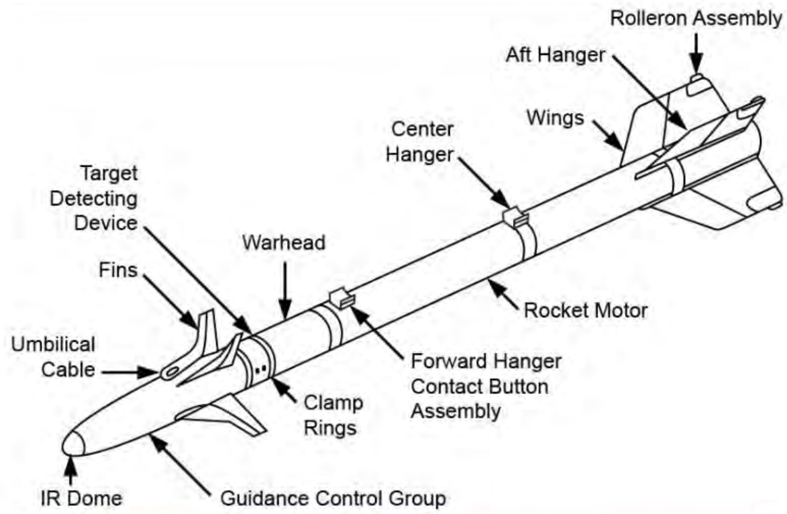
During the 1970s, the Sidewinder received a new seeker head, fuse, and warhead combination that gave it all-aspect capability. Since then, additional improvements include better turn performance, flare rejection, helmet-mounted sight integration, and smokeless motors. The AIM-9X is the latest version of the Sidewinder family. This extremely capable weapon will be introduced in later training at the FRS.

1403. AIM-9 DESIGN

The AIM-9 is a small, lightweight, low-cost missile. Although it still carries a price tag of $100,000, this is relatively economical when compared to its radar-guided big brothers. The Sidewinder has four major sections: guidance, fuse, warhead, and rocket motor.

1. Physical Characteristics

Refer to Figure 14-1 for physical characteristics.



AIM-9 Physical Characteristics			
Fusing	Contact/Prox	Diameter	5 in
Minimum Range	1000 ft	Weight	185 lbs
Gyro Tracking	24° per sec	Length	9' 5"
Thrust	2880 lbs	Turning	45 G
Warhead	ABF	Gimbal Limit	±40°
Velocity	MACH 2+	Seeker FOV	3.5°

Figure 14-1 AIM-9 Sidewinder

2. **Guidance and Control**

The guidance and control section consists primarily of an IR seeker head that is cooled by compressed nitrogen and contains indium antimonide (InSb), which makes it very sensitive to IR emissions. A thermal battery provides power for 60 seconds time of flight.

Target acquisition is indicated by a sharp tone in the pilot's headset. The tone increases in intensity as the target approaches the center of the seeker head field of view. The missile is guided by the deflection of the 4 forward fins that are pneumatically controlled by a gas generator ignited at launch.

3. **Fuse**

The AIM-9 utilizes two types of fusing mechanisms, contact and proximity. The contact fuse feeds a firing pulse to the warhead upon missile impact. The proximity fuse is a laser-optical system that detects when the missile is within a lethal range, sending a firing pulse to the warhead.

The Sidewinder employs a safe and arm device that senses missile launch and will not allow the warhead to arm until the missile is safely ahead of the firing aircraft.

4. **Warhead**

The AIM-9L/M has an annular blast fragmentation (ABF) warhead consisting of a high explosive encased by titanium rods and a zirconium disk. The titanium rods penetrate an aircraft's skin and the zirconium disk fragments will set fire to any combustible material.

5. **Rocket Motor**

The Mk-36 rocket motor produces 2,880 pounds of thrust for a 5.0 second burn time that accelerates the AIM-9 to approximately 2.0 Mach above the launch aircraft's airspeed. The "smokeless" motor is actually 95% smoke free, leaving only a thin wisp of smoke in its trail, which would be imperceptible to the enemy.

1404. AIM-7 SPARROW HISTORY

The AIM-7 Sparrow is a medium range, all-aspect, all-weather, semi-active radar guided missile. Unlike many of its predecessors, the current Sparrow (AIM-7M) is a reliable and highly lethal weapon. In the late 1950s and 1960s, the AIM-7 evolved into versions using semi-active radar, or SAR, homing guidance. In this method, the missile “homes in” on the reflected energy provided by the launching aircraft, which is “illuminating” the target with its radar. The missile could then fly to an intercept point along the target’s flight path. In 1963, production switched to the AIM-7E version. It used a new propulsion system, a solid-fueled rocket motor. The new motor significantly increased range and performance of the missile. Effective range of course depended greatly on firing parameters like launch speed, altitude, and relative velocity of the target.

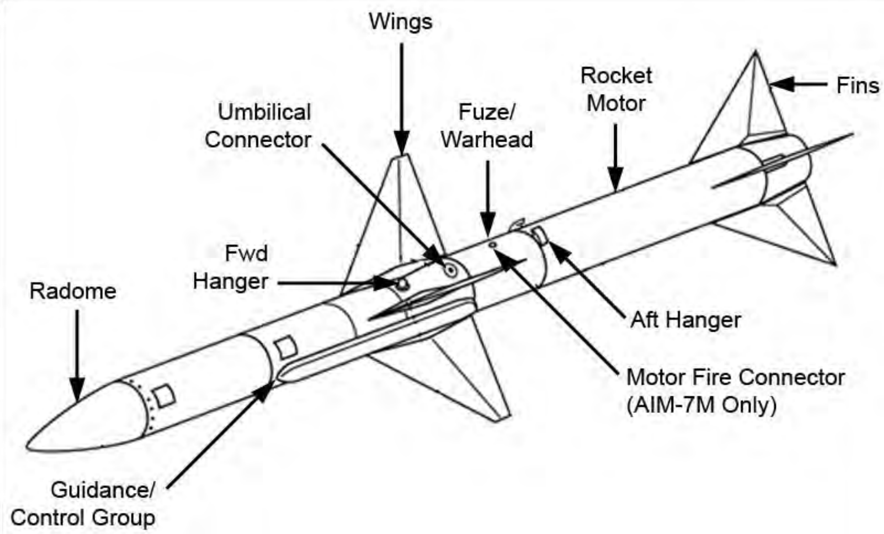
Although a great improvement over beam riding, SAR still required the launching aircraft to provide radar illumination, via STT, until weapon impact. This limited the strike fighters’ maneuverability, required the strike fighter to engage one target until it was destroyed, and often guaranteed a within visual range (WVR) encounter with the target’s wingman. Development continued on semi-active seekers and the Sparrow III was deployed very widely with U.S. and allied forces.

1405. AIM-7 DESIGN

The AIM-7 is a 12 foot long, 500 pound missile. Although it is not a launch and leave missile like the Sidewinder, the high reliability and performance level of the Sparrow make it a viable weapon. Like the Sidewinder, the Sparrow can be broken down into four major sections: guidance, fuse, warhead, and rocket motor.

1. **Physical Characteristics**

Refer to Figure 14-2 for physical characteristics.



AIM-7 Physical Characteristics			
Length	12 ft	Diameter	8 in
Wingspan	40 in	Weight	510 lbs
Motor Burn Time	3.5/12.5 sec	Warhead	85 lbs
Kill Radius	40 ft	Turning	25 G
Minimum Range	1000 ft	Velocity	2.5 MACH
Maximum Target Altitude	89,000 ft	Launch Time	1.5 sec

Figure 14-2 AIM-7 Sparrow

2. **Guidance and Control**

Once the strike fighter has illuminated the target with a radar lock (STT), the Sparrow guides based on the reflected energy from the target using a forward-looking planar-array antenna. The missile receives guidance information from the strike fighter's own radar via a rear facing antenna on the end of the missile. The forward wings are controlled by an open-loop hydraulic system that is pressurized upon trigger squeeze. Once the hydraulic fluid is used, it is vented out of the missile. When the fluid has been exhausted, the missile can no longer maneuver.

3. **Fuse**

The AIM-7 has a safe and arm device that delays arming of the missile until it has traveled a safe distance in front of the launch aircraft. The Sparrow has both a contact fuse and a proximity fuse, which will detonate the missile at the closest point of approach to the target.

4. **Warhead**

The AIM-7M employs an 85 pound annular blast fragmentation warhead that explodes into thousands of steel fragments. The hot gases that propel these fragments also serve to ignite all combustible materials.

5. **Rocket Motor**

The Sparrow has a Mk-56 boost-sustained, solid propellant rocket motor. The initial boost lasts for 3.5 seconds and propels the missile to its cruising speed of 2.5 Mach over the launch aircraft's speed. The motor then sustains the thrust for an additional 12.5 seconds to allow the missile to maintain its speed over a much greater range.

1406. AIM-120 AMRAAM HISTORY

The Advanced Medium-Range Air-to-Air Missile (AMRAAM) is the high priority replacement for the aging AIM-7 Sparrow and retired AIM-54 Phoenix missiles. Currently a joint program for the Navy and Air Force, the AMRAAM is designed to have higher performance and lethality, at a lower cost.

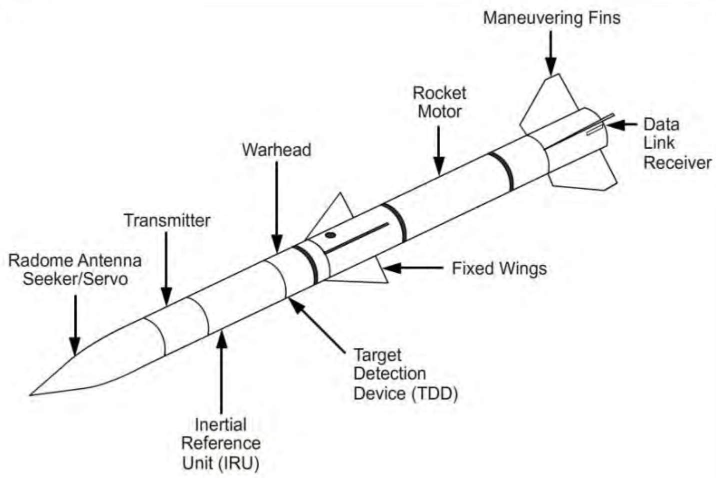
The AMRAAM program began in 1975 as a joint Air Force/Navy program. In 1981, Hughes was awarded a full scale development contract after a fly-off against Raytheon. After eight years of testing, the AIM-120 became operational in 1991. It was first used in combat in December of 1992 when a USAF F-16 used an AMRAAM to down an Iraqi MiG-25 Foxbat during a confrontation over Southern Iraq.

1407. AIM-120 DESIGN

The AMRAAM is slightly smaller in size and weight in comparison with the AIM-7, with many of the same features as the AIM-54. The AMRAAM has four major sections: guidance, fuse, warhead, and rocket motor. Its appearance is similar to that of an AIM-7 Sparrow.

1. **Physical Characteristics**

Refer to Figure 14-3 for physical characteristics.



AIM-120 Physical Characteristics			
Length	12 ft	Velocity	MACH 4+
Diameter	7 in	Weight	326 lbs
Max Range	> 35 NM	Warhead	50 lbs
Kill Radius	50 ft	Warhead	ABF

Figure 14-3 AIM-120 AMRAAM

2. **Guidance and Control**

At medium to short ranges, the strike fighter is not required to illuminate the target with a radar lock because the AMRAAM can guide via a Track While Scan system similar to the AIM-54. These advanced tracking techniques allow any fighter carrying the AMRAAM to have multi-target capability without a multi-target radar system.

3. **Fuse**

Like all previously mentioned missiles, the AIM-120 also has a safe and arm mechanism that delays arming of the missile for the safety of the firing aircraft. The AMRAAM also uses a laser scanning device to verify external shape, and thus confirm aircraft type, in its fusing mechanism.

4. **Warhead**

The AIM-120 employs a 50 pound annular blast fragmentation (ABF) warhead that explodes into thousands of tiny fragments. Although one third smaller than the warhead of the AIM-7M, the AMRAAM utilizes higher density gases to propel fragments more explosively than the Sparrow.

5. **Rocket Motor**

The AMRAAM has a high-impulse motor giving rapid acceleration to a Mach number higher than 4.0 above aircraft airspeed. The rocket motor is designed to produce very little smoke to aid in reducing the launch signature.

1408. CONCLUSION

This chapter provided a historical perspective of the development of air-to-air missiles, as well as, an in-depth analysis of the designs of the AIM-9, AIM-7, and AIM-120. All these missiles possess the same basic design of guidance, fusing, warhead, and rocket motor. Strike fighter aircrew must know the characteristics of their own air-to-air weapons and their enemies. The studying continues as technology evolves in the world wide air-to-air missile inventory.

CHAPTER FIFTEEN
MRM EMPLOYMENT

1500. INTRODUCTION

This chapter discusses the purpose of Beyond Visual Range (BVR) employment training, the characteristics and display of the Launch Acceptability Region (LAR), the factors affecting successful BVR employment, the MRM radar modes, and the missile firing range display information (Max Range, Ropt, Rne). The last segment of the chapter will focus on some rules of thumb and terminology used in BVR communication. Overall, the MRM employment in the OFT and VMTS provide an excellent initial training environment to prepare the student for follow AIM-120 AMRAAM training in the F/A-18F Super Hornet.

1501. MRM TRAINING

The purpose of MRM training is to provide the SNFO with introductory BVR employment simulation. Any engagement that takes place beyond the normal range for visual acquisition of the bandit (generally accepted to be 10 NM) is considered to be BVR. To employ BVR weapons with precision, the student must utilize the standard aviation skills of aviating, navigating, and communicating, as well as weapons systems knowledge, radar display interpretation, tactical crew coordination, and tactical communication. This training is extremely challenging and requires extensive study, simulation training, flight preparation and debriefing. A key point to understand during this segment of training is that the SNFO is learning *skills*, not tactics. Tactics will be taught at the FRS. Specific tactics related to the AMRAAM are evolving and beyond the attack display of entry level training. The training goal is to produce functional system operators, not tactically proficient aviators.

1502. LAUNCH ACCEPTABILITY REGION

The launch acceptability region, or LAR, is a three dimensional volume of space around a hostile aircraft into which the fighter must fly in order to have a chance to successfully employ its weapons. LARs are often depicted in a 2-dimentional (Figure 15-1), top down view that is only valid at the stated altitude and airspeeds.

The fighter will maneuver in altitude, airspeed, and heading in order to achieve the best weapon solution for his opponent. The LAR is largest (i.e., longest R_{MAX}) with 0 TA, at high airspeed and high altitude and is smallest (i.e., shortest R_{MAX}) in the rear quarter at low altitude and low airspeed. Missiles like altitude, airspeed, and closure to achieve maximum kinematics.

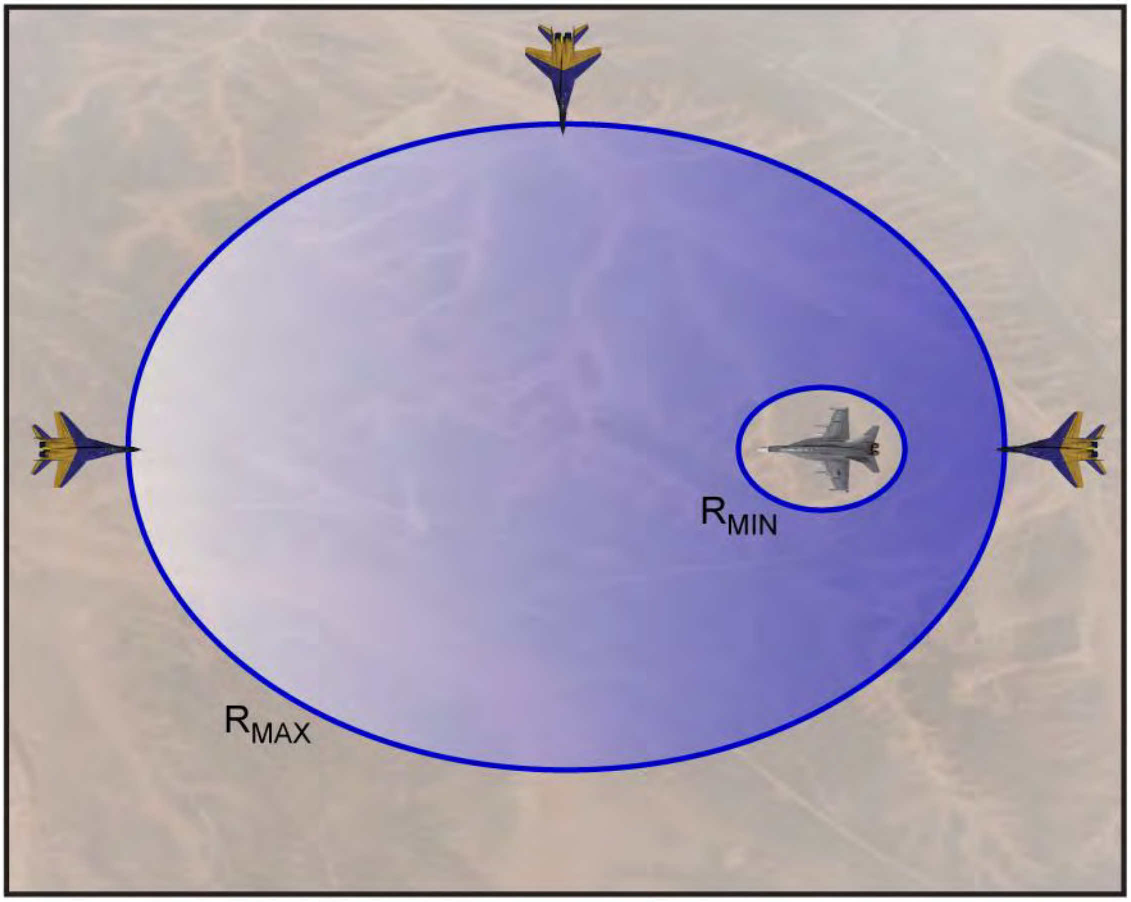


Figure 15-1 Two-Dimensional LAR Representation.

1. **Additional BVR Terminology and Definitions**

a. R_{MAX}: Maximum range of an air-to-air missile. The maximum range from which an A/A missile can be fired and reach its target given the current target and fighter conditions (Vc, aspect, altitude, etc.).

b. R_{NE}: No escape range. The range at which a launched missile will have the energy and maneuverability to intercept the target regardless of the target's post launch maneuvering.

c. R_{MIN}: Minimum range. The shortest range a missile can be launched, acquire the target, receive post launch guidance, and fuse its warhead to intercept its target.

d. WEZ: Weapon Engagement Zone. The three-dimensional volume of airspace around a fighter into which the hostile aircraft must fly to employ weapons.

e. ASE circle: The allowable steering error, or ASE, circle and steering dot represent deviation from optimal heading for collision course and deviation from optimal heading and elevation to have the missile on collision course at launch.

f. Steering dot: The steering dot, used in conjunction with the ASE circle, is a “fly to” cue, meaning you should turn toward the dot to center it in the ASE circle to have the missile on collision course at launch.

2. **LAR vs. WEZ**

The strike fighter’s LAR is dynamic based on parameters of airspeed, altitude, aspect and closure. The bandit’s WEZ (Figure 15-2) expands and contracts, just like the Strike Fighter LAR, based on changing flight parameters. As one can see, the understanding of the enemy’s weapons capability and how the various parameters affect the WEZ is critical for survival.

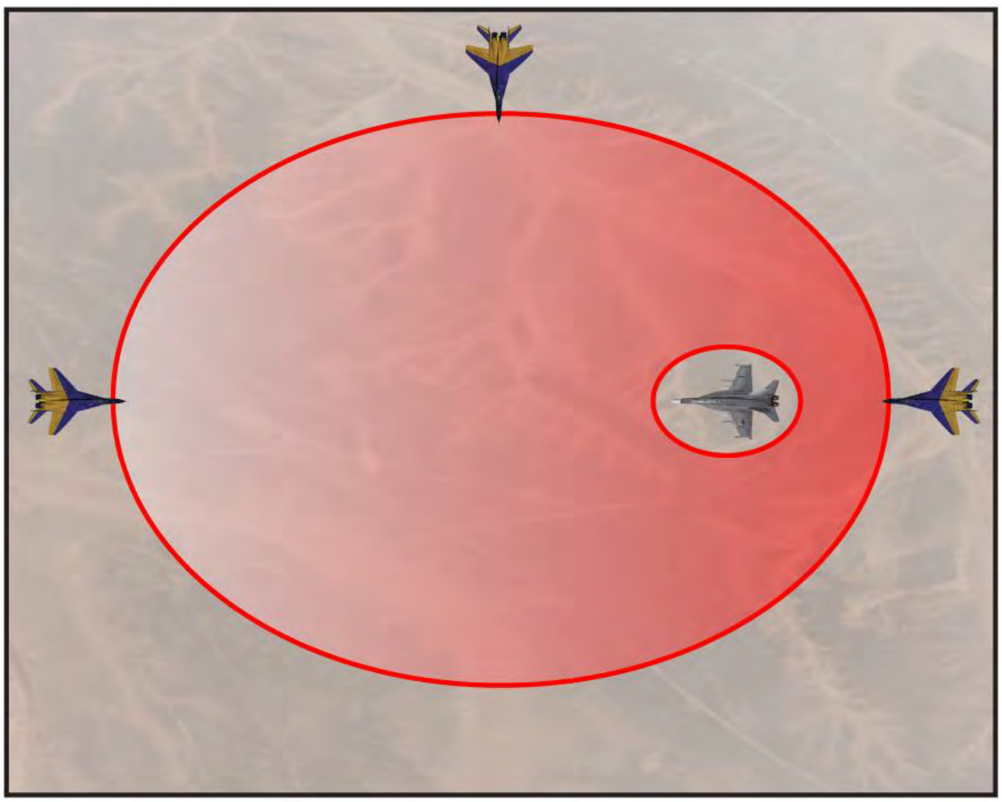


Figure 15-2 Representation of Bandit WEZ

1503. LAR DISPLAYS

The displayed LARs in the OFT and VMTS provide aircrew situational awareness for missile launch decisions. Maximum range for both systems is highlighted in Figure 15-3.

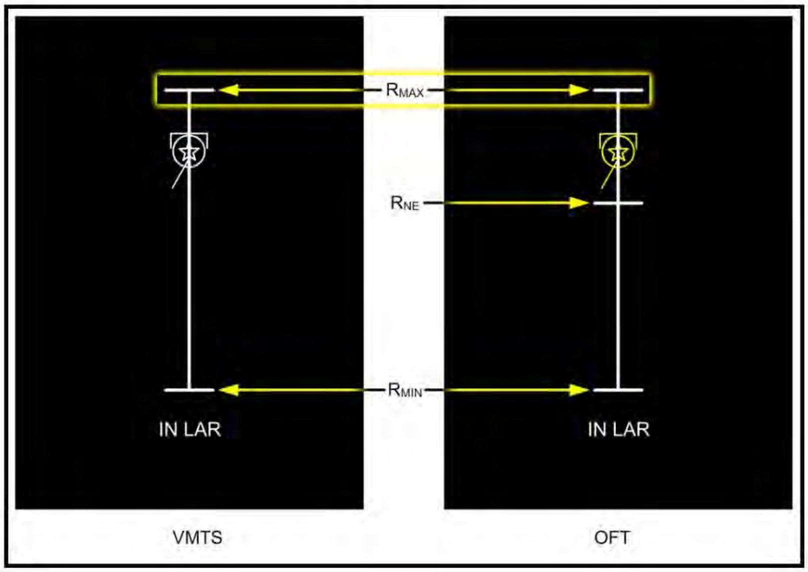


Figure 15-3 Maximum Range or R_{MAX}

No escape range is important because launching at a bandit at or inside R_{NE} guarantees the missile will have the kinematic energy to reach the bandit, regardless of maneuvers. R_{NE} is displayed in the OFT but not displayed in VMTS (Figure 15-4).

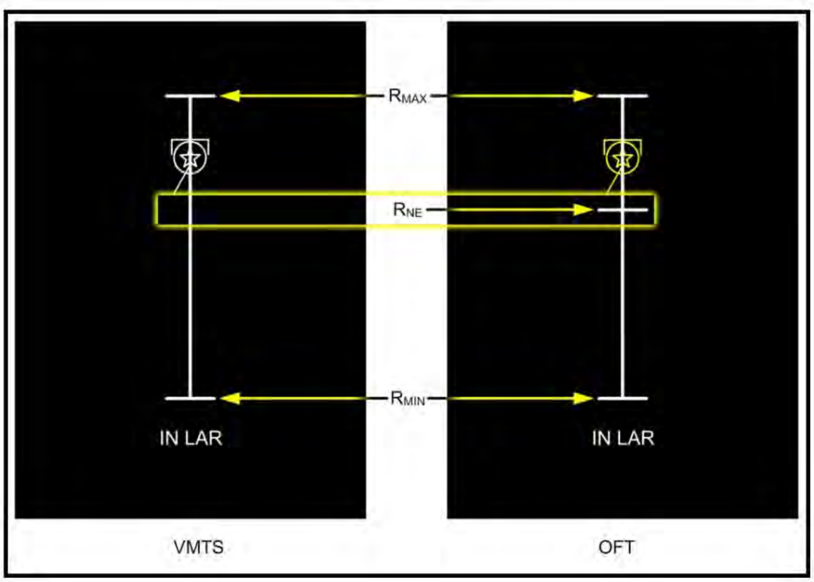


Figure 15-4 No Escape Range is Only Displayed in the OFT

Minimum range, the shortest range to the bandit a missile can be launched and fuse properly, is generally smaller for IR missiles than for radar missiles (Figure 15-5). This is due to IR missiles requiring less information from the host aircraft than radar missiles. The same symbology is used for MRM and SRM.

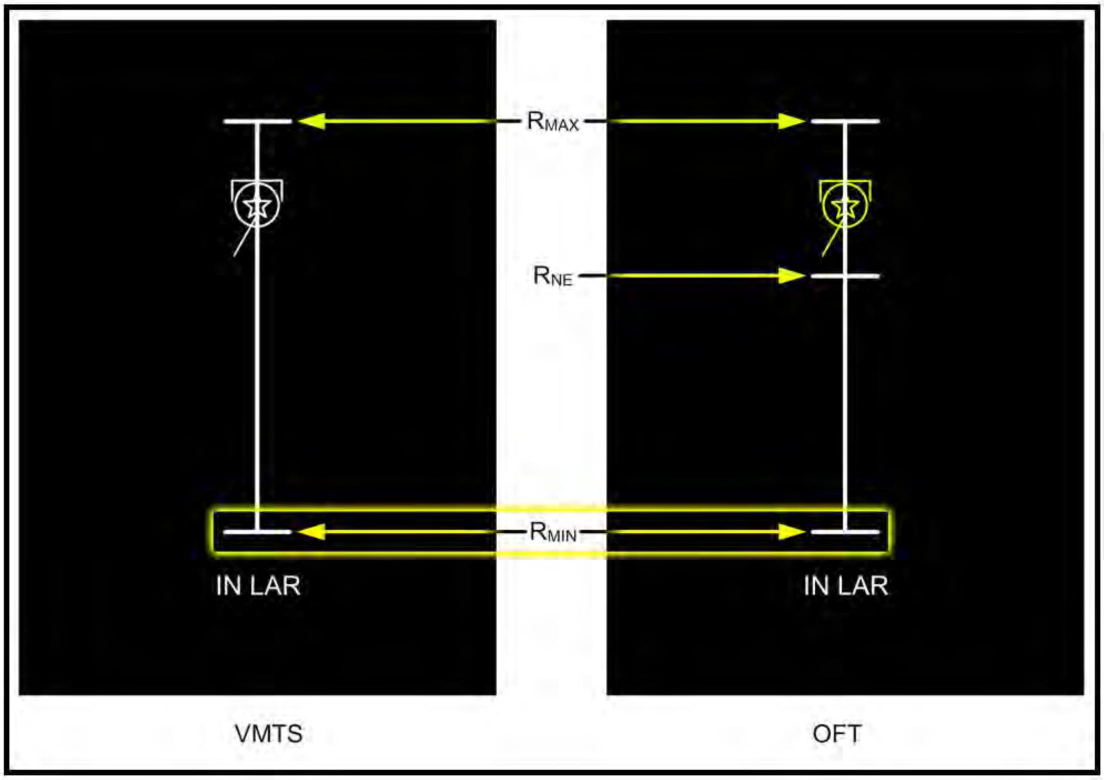


Figure 15-5 Minimum Range

The ASE circle and steering dot appear inside 1.2 R_{MAX} providing the optimal elevation and azimuth to shoot the MRM (Figure 15-6). This provides the missile with the best chance of reaching the bandit in the current situation. In the figure below, the bandit is in LAR with the steering cue (or "dot") inside the ASE circle. These cues are only displayed in the OFT.

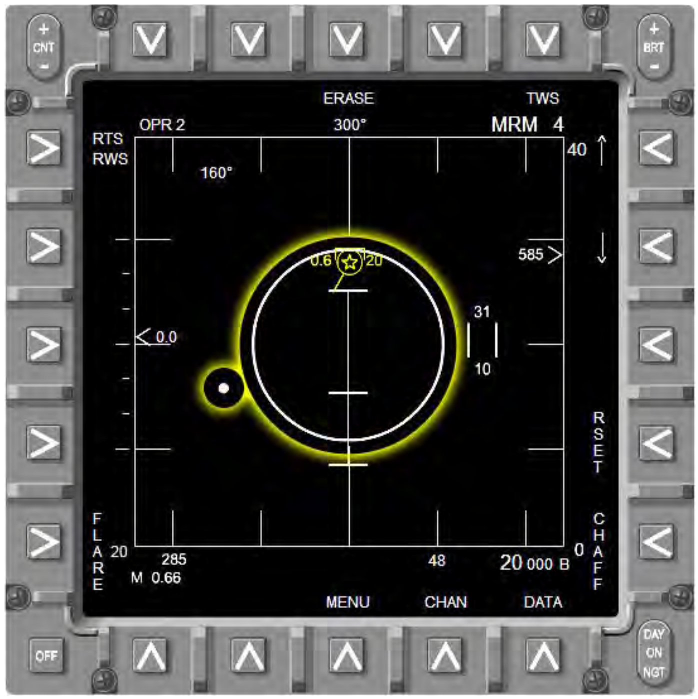


Figure 15-6 Allowable Steering Error Circle and Steering Dot

1504. CONTROLLABLE EMPLOYMENT FACTORS

There are many factors that can affect the true probability of kill (P_k) for a missile in any given situation. The strike fighter can control the following conditions in an intercept:

- Employment range: The range a strike fighter employs weapons can have a significant effect on the success of the missile. At long range, the bandit has the time to recognize he is being shot at and maneuver to defeat the missile. It is for this reason the R_{NE} is an important range to understand. Any shots taken at less than maximum range improve the missile's chance of success.

- Radar mode: MRM employment requires the radar mode to be STT, TWS, or TWS EXP (OFT only). STT provides the most accurate bandit information and smallest uncertainty volume. If a mode other than STT is used, there is a greater uncertainty to the bandit's actual location. Additionally, if radar modes are changed during flyout, for example from STT to TWS, then uncertainty about the bandit's location will grow accordingly.

- Track quality: Closely associated with the concepts of radar mode effects on P_k are those related to the quality of the trackfile just prior to, and after launch. If a trackfile is consistently in and out of a MEM condition, then the quality of that trackfile is suspect. Weapons employment should be delayed until the trackfile quality improves, or an STT can be commanded on that track.

- Strike fighter conditions at launch: The strike fighter can have an impact on the success of a missile throughout its time of flight by establishing favorable flight parameters prior to launch. Generally, the faster and higher a fighter is, the larger the available LAR for any given bandit. This is because the missile can accelerate from an already higher airspeed in thinner air and use gravity to assist in end game maneuverability.

- Bandit AO at launch (Lead): The missile is much faster than the fighter. If the missile was considered to be twice as fast as the fighter, in order to place the missile on collision at launch, AO would have to be reduced by half. In other words, the correct lead AO for a missile is ½ collision AO based on TA. With newer, faster missiles, better fire control systems and better radars, lead AO control has become unnecessary. Rather these computations are taken into account with the IN LAR symbology. Always shoot with IN LAR displayed.

1505. FACTORS CONTROLLED BY THE BANDIT

The bandit is able to control its flight parameters to challenge the P_k of the strike fighter's missiles. The bandit may also use electronic counter measures (ECM) to deny the strike fighters radar system from attaining a reliable radar track.

If a bandit is aware that it is being engaged, it will most likely take steps to defend itself. These steps may include chaff, active ECM (jamming), aggressive maneuvering, or a combination of these. If an enemy pilot can get the strike fighter's radar to stop looking at his aircraft for only a short period of time, there is a high likelihood that the fighter's missile will be decoyed, especially at long ranges.

1. **Max Range and P_k Enhancing Shot Considerations**

Once a missile has been employed and is being supported through its TOF, the strike fighter must decide whether follow-on BVR employment is desired or required. If the strike fighter shoots at maximum range and bandit maneuvers aggressively, the missile is likely defeated. Another BVR LAR will likely present itself to the strike fighter when the bandit tries to reacquire the fighter by pointing its nose at the strike fighter. This follow-on employment will likely be inside of R_{NE} and have a high probability of success. The strike fighter may employ additional weapon(s) against a bandit prior to time out of the first weapon if dictated by the tactical situation. This second employment would be called a "P_K enhancing" shot (Figure 15-7).

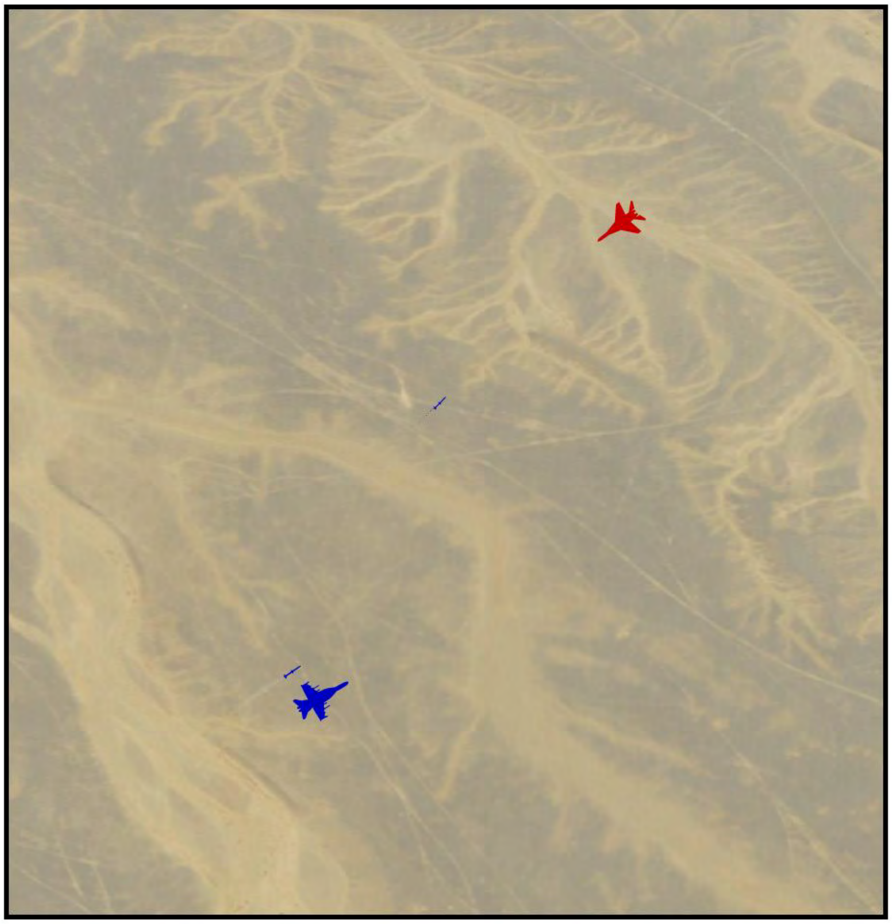


Figure 15-7 Probability of Kill (P_K)

2. **Maximum Range vs. R_{OPT}**

Employing from maximum range has the potential benefit of the missile impacting the bandit before the strike fighter enters the bandit's WEZ. It also allows more time in the intercept to employ a P_k enhancing second missile shot. The drawback is the bandit can defend against the missile with relative ease due to the missile losing end-game energy. This is referred to as a "kinematic defeat" of the missile. Additionally, the strike fighter may not have a second missile to utilize for a second shot.

As a result of the drawbacks of a maximum range shot, tactics (which will be taught at the FRS and fleet level) often associate an optimal range for shooting, called $R_{OPT.}$ R_{OPT} is generally a compromise between having enough shot range to not be defensive to the bandit, while also shooting close enough to have ample end-game energy for the missile.

3. **Valid Shot Criteria for MRM Employment**

The following criteria must be met for an MRM valid shot. Notice the differences between the OFT and VMTS.

a. Radar mode was STT or TWS.

b. IN LAR was displayed (Dot in the ASE circle is not required if IN LAR is displayed).

c. Mode was STT, TWS throughout missile TOF.

d. Trackfile did not enter MEM through TOF, due to bandit maneuvers, jamming, or operator error.

e. Bandit did not maneuver to force MEM condition, or bandit did not fly out of LAR, resulting in IN LAR being removed; no LOST cue.

1506. MRM TIME OF FLIGHT RULE OF THUMB AND TERMINOLOGY

1. **Rule of Thumb (ROT)**

The MRM time of flight (TOF) rule of thumb depends on the quadrant from which the missile is employed (Figure 15-8).

a. Forward quarter fired missiles close with the bandit at a rate of 1 NM every 2 seconds or will impact at half the shot range.

b. Beam fired missiles close at 1 NM every 3 seconds.

c. Rear quarter missiles will close 1 NM every 4 seconds for a co-speed bandit.

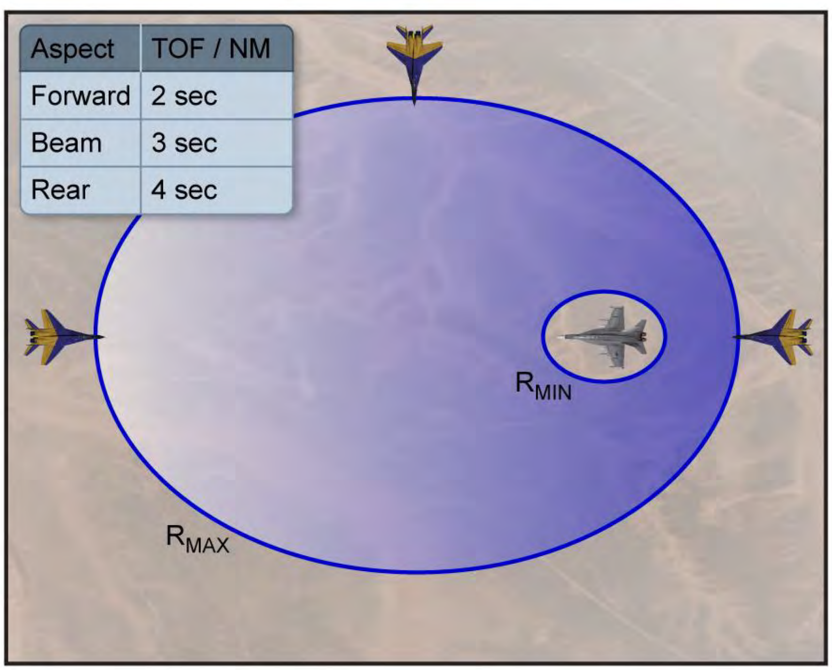


Figure 15-8 VT-86 Missile TOF ROT

2. MRM Employment Terminology

The terms below are commonly communicated during an intercept where BVR missiles are launched. Students will use these terms in training with the MRM. There are certainly more terms to know, but these are an excellent staring point and utilized in almost every air-to-air training intercept.

Fox-3 is the radio call made to announce that a strike fighter has employed an active radar air-to-air missile, assumed against the bandit group.

SNFO (PRI) - "Rage 11 Fox-3"

Timeout is an informative call that announces a previously fired missile has reached its expected target. Timeout does not imply a kill. Rather it is used to let other aircraft know the status of your missile. If radar contact with the bandit is lost following timeout, a kill may have occurred.

SNFO (PRI) - “Rage 11 timeout, west man, single group, fifteen thousand”

Kill is a comm brevity term that provides directive clearance to destroy a bandit. In training, a kill call is *descriptive* call that kill criteria has been met. Simply saying “kill” in multi-aircraft scenarios adds confusion. Identify the contact specifically. In multi-aircraft environments, kill calls may also include group name or the target aircraft’s current maneuver. In combat, the term “Splash” is used to indicate the downing of a hostile air bandit.

SNFO (PRI) - “Rage 11, kill, east man, west group, 15K”

Trashed is an informative comm brevity term that the current missile in flight has been rendered non-viable by ECM, bandit maneuvers, or radar problems. Trashed should be used when a LOST (OFT) or SL (VMTS) cue is displayed beneath the flyout symbol, the missile is considered trashed.

SNFO (PRI) - “Rage 12, trashed”

1507. CONCLUSION

Successful employment of BVR weapons depends on a solid understanding of the capabilities and limitations of your radar and your weapon systems. Strike fighter aircrew must also know the enemies capabilities and tactics.

This chapter covered a number terms, concepts, radar displays, and definitions for employing the MRM and future BVR weapons. The chapter also specified the valid shot requirements for the OFT and VMTS that students will be graded on at VT-86. Tactical considerations are addressed in this chapter but actual tactics will be taught at the FRS and fleet level. All of this information is critical for success at VT-86 and for building skills to successfully employ future tactics in the fleet.

CHAPTER SIXTEEN
ADVANCED INTERCEPTS

1600. INTRODUCTION

The following chapter details the fighter's decisions, timeline, radar mechanics, communication, recognition and corrective reactions to a maneuvering, and potentially threatening, bandit. Fighter aircrew must constantly work to enhance situational awareness to the entire battle space during a mission. The bandit's intentions and actions are no exception to this rule. At VT-86, the Advanced Intercepts phase of training introduces the SNFO to an uncooperative bandit. This chapter teaches the SNFO to recognize a potentially threatening situation and react in order to neutralize or destroy the threat.

1601. RULES AND RESTRICTIONS

Rules and restrictions exist in both the combat and training environments. In the combat environment, the Rules of Engagement (ROE) dictate the threat-specific rules for combat operations. In the training environment, Training Rules exist to attain maximum training proficiency while mitigating risk. During training events, fighter aircrews brief Training Rules with the bandits before every air-to-air training sortie.

Range and air space restrictions are typically referenced during the brief. For large force training exercises, such as Air Wing Fallon, the range and air space restrictions are usually briefed in a mass brief the first day of training. Whether a combat or training mission, the rules and restrictions must be understood and adhered to by fighter aircrew. The SNFO must refer to the most recent version of standardization notes (STAN Notes) for a complete description of the current rules and restrictions governing Advanced Intercept training.

1602. THREAT PICTURE WITH BULLSEYE CONTROL

Bullseye control allows multiple friendly forces in different locations, to be able to assess bandit locations with respect to a universally known reference point, generically known as Bullseye. The Bullseye location is usually chosen based on tactical or geographical significance. Once the location of a Bullseye is established among friendly forces, controllers can provide contact positions with bearing and range from Bullseye. In this way, anyone listening to the common AIC frequency can gain SA concerning the location of bogey, bandit, hostile, neutral, or friendly forces. Advanced intercepts at VT-86 utilize both broadcast and tactical control anchored to bullseye.

Broadcast control communicates useful information from the controller to all the fighters (and other friendly assets), and is not directed to one particular flight element. An example of broadcast control anchored to bullseye is below. In this comm example, "SABRE" is the controller and "Vegas" is bullseye.

> Controller ("SABRE") - "*Showtime 11, SABRE, group Vegas two one five, thirty, 18 thousand medium, track south*"

Notice in the above example that the controller gives a cardinal direction of the contact ("track south"). This is the distinct difference from tactical control anchored to bullseye which gives aspect of the called contact to a specific fighter element. An example of TCDBE is below.

Controller ("SABRE") - "*Showtime 11, SABRE, group Vegas 215, 30, 25 thousand, hot*"

In this example, the controller specifically transmits the aspect of the group ("hot") to Rage 11.

1. **Labels and Names**

Once the called group(s) meets the fighter's commit criteria (discussed later in this chapter) and the fighter element commits, the controller will then label the picture and name the group(s). A label is the relationship between groups. Examples include a single group, two groups azimuth, two groups range, three groups vic, and three groups champagne.

A name is the title given to each individual group in the labeled picture. Examples include, single group, east group, north group, etc. The only time a label and name are the same is for a single group. The example is below. Remember, the controller labels and names the picture after the Fighters commit.

Controller ("SABRE") - "*Showtime 11, SABRE, two groups azimuth ten, east group Vegas 215, 30, 19 thousand, hot…west group, 10 thousand, cold*"

1603. BULLSEYE CARD

The bullseye card is an effective tool used by fighter aircrew to gain situational awareness to the air picture. After receiving the initial picture call from the controller, aircrew can plot the locations of the called bandits on the bullseye card. The bullseye card is a two dimensional representation and does not reflect altitude. Critical to the successful use of the Bullseye card is aircrew knowledge of their own position on the card. Only by comparing the fighter's position to the bandit's position can the aircrew assess the situation. An example of the bullseye card can be found in Figure 16-1.

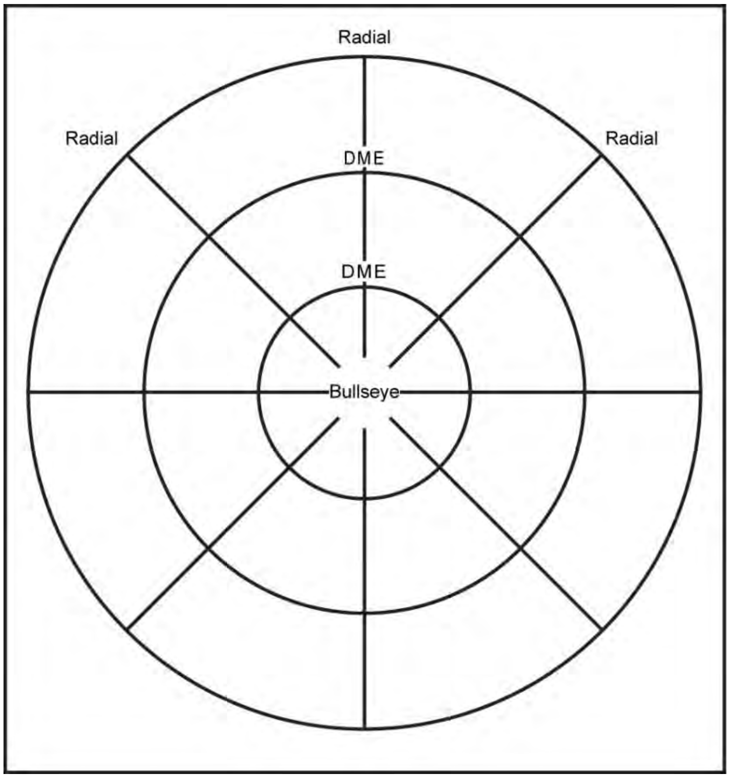


Figure 16-1 Bullseye Card Format

The bullseye center should have the mission assigned name of the geo-reference and the DME scale will be dependent on the battle space. With strike missions, the route often includes a bullseye card overlay.

1604. ADVANCED INTERCEPT PRINCIPLES

The Advanced Phase brings together all previous terminal objectives as expressed in the Master Curriculum Guide. In support of these objectives, the underlying learning objective is proper interpretation of the information provided by the weapon system officer's resources (radar, comms, instruments, visual cues, etc.).

The terminal objectives are accomplished by the demonstration of the student’s ability to interpret available resources (with an emphasis on the radar) and act appropriately to achieve successful air-to-air radar operation, intercept, communication, and aircraft operation. Real time decisions and reactions to bandit maneuvers and timeline awareness will challenge SNFO’s throughout their career. Advanced intercepts is the first opportunity to learn and test these skills in a dynamic air-to-air environment.

1605. RADAR SETUP AND SCAN

Radar game plans are designed to optimize the probability of detection. The initial radar setup (Figure 16-2) at VT-86 for "fencing-in" is as follows:

- RWS
- 6 Bar
- 140 Azimuth
- 80 NM scale
- Acquisition cursor at 25 NM
- Centered on own aircraft altitude

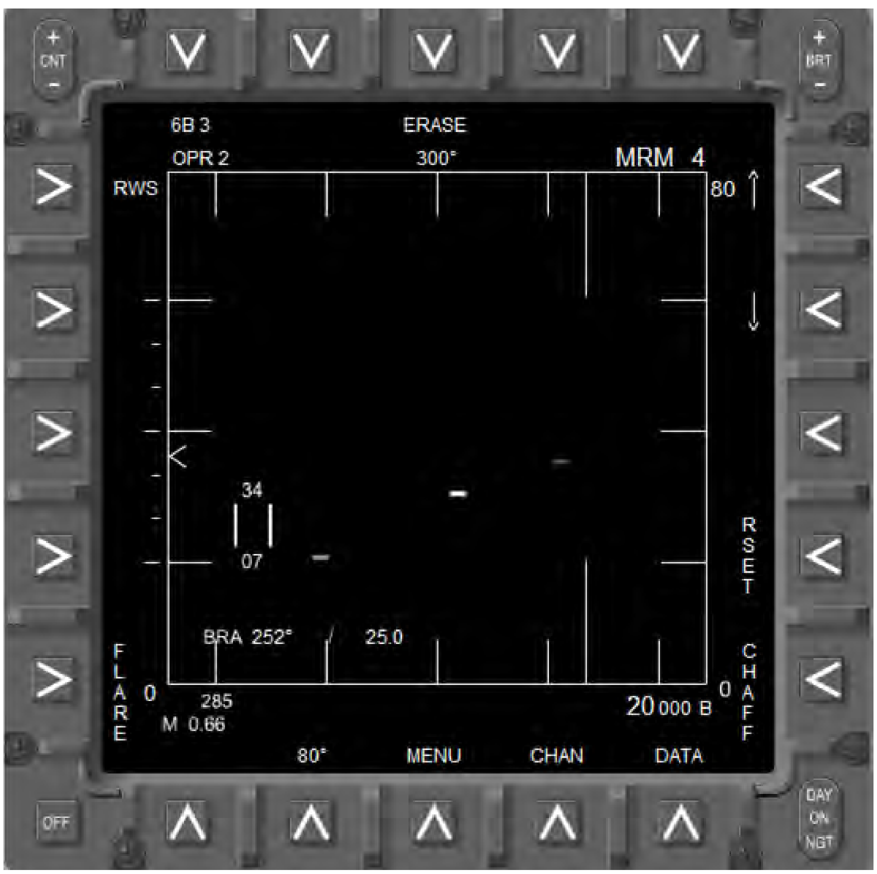


Figure 16-2 Initial Radar Setup

As always, aircrew will need to listen to the calls from the controller, particularly in altitude, to ensure their notional radar system is pointed in the correct threat sector and altitude volume.

1606. COMMIT CRITERIA

Commit criteria is derived from the mission objectives. If the mission objective is to defend a high value asset, the fighter assets will have a more restrictive commit criteria in order to not be "dragged away" from the protected asset. Missions, such as Offensive Counter Air, will have less restrictive commit criteria as they are offensive in nature, vice defensive.

Since tactics are not taught at VT-86, the commit criteria for advanced intercepts is standardized. Commit criteria will be established in the brief. For 1v1 AWIs, commit criteria will be:

- Range NLT 35 NM
- Target Aspect ≤ 60 degrees (Flank or less)

Note that both criteria must be met for the fighters to commit. This ensures that the fighters have the time to perform all timeline tasks against a 0 TA bandit and employ on timeline. After the commit, pilots will accelerate to tactical airspeeds (vice fuel conservation airspeeds on CAP) and work to establish initial intercept geometry. An example of a group meeting commit criteria and the fighter commit call is depicted in Figure 16-3.

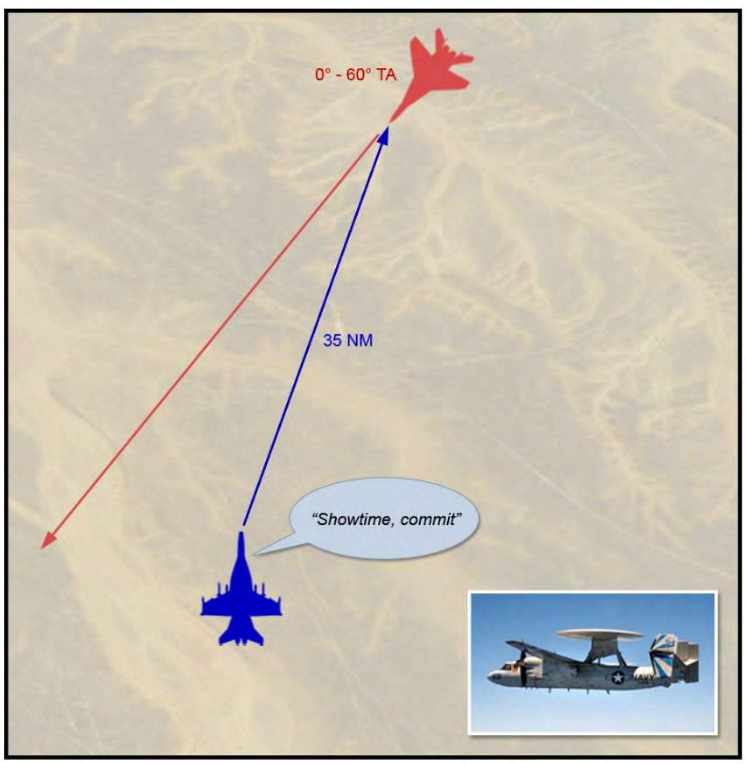


Figure 16-3 Commit Criteria

1607. INITIAL INTERCEPT PHASE

Initially, the fighter brings the contact to the nose to assess the geometry of the intercept. This is called a "point and assess" plan. Once the fighter understands the geometry with the bandit on the nose, the fighter should establish a single side offset (SSO) intercept by placing the contact so that the fighter uses geometry to:

- Manage contact TA.
- Close range as efficiently as possible with the contact.

Placing the contact at 20 degrees AO hot accomplishes these objectives. This geometry stops the growth of TA and allows further action or reaction to bandit maneuvers. This intercept geometry is called a 20 degrees single side offset. The pilot will accelerate to tactical airspeeds and assume tactical formation (for section and division).

1. **Formation, Sensor, Comms**

"Formation, Sensor, Comms" will be briefed and stressed on every air-to-air mission. In Advanced 1v1, formation will not be a tactical concern (since there is no Wingman). However, radar mechanics along with clear and concise tactical communications will be critical for mission success.

After the commit, perform the tasks of search and sanitization using the initial radar setup discussed earlier. Once a contact is detected, correlate the contact. This correlation is made using the BRA format. For example:

SNFO (PRI) - "*SABRE, Showtime 31, contact BRA 190, 25, 25 thousand, declare*"

AIC will then provide correlation and a declaration to the detected contact in the format:

Controller ("SABRE") - "*Showtime 31, SABRE, single group BRA 190, 25, 25 thousand, hostile*"

Once correlation is complete, make the contact an L&S and proceed with setting geometry. Note that radar SA is not required for targeting. Normally, the next communication will be to target the correlated group. Depending on the scenario, targeting may come before or after correlation has taken place. In early training, with only a single group, the targeting call is often forgotten by students. When multiple groups are part of the air picture, targeting becomes more complex and a critical decision in solving multi-group air-to-air engagements. The targeting call for a single group is simple:

SNFO (PRI) - "*SABRE, Showtime 31, target single group*"

2. **Meld**

Meld is a radar mechanic procedure used to provide radar SA to the targeted group. It is typically used in conjunction with a comm call to help the out-of-AOR aircraft adjust their radar to the correct threat sector (most often in elevation). A "30 Miles" call is transmitted by AIC or the fighters to provide SA that they are 5 NM from melding. The meld mechanics at VT-86 are:

a. Range to 40 NM

b. Reduce to 80 degrees Azimuth

c. Center scan volume on meld call with half action trigger (full action VMTS)

d. Center elevation scan volume to bracket meld call altitude

e. Place cursor 2-3 NM in front of contact

f. Command STT on contact

The meld comm call for 1v1 is practiced for later air-to-air events in a multi-plane formation. A meld call will include the name of the group, bearing, range and altitude. A complete meld call example is:

SNFO (AUX) - "*Showtime 31, meld, single group BRA 190/25, 22 thousand*"

In later 2vX events, meld will be executed using the sorting contract to maximize MRM employment within the section. In Advanced 1v1, the single group will only have one contact.

1608. TARGET MANEUVERS

Assume that threat pilots understand basic radar/RWR indications and missile employment timelines, and will take action to thwart the employment plan. Their goal is to force fighters into short range, WVR maneuvering. Anytime STT is commanded on a contact, the contact may be alerted to the fighter's intentions. The threat reaction could be any combination of the following:

- Turning into the fighter to close as rapidly as possible OR turning away in an attempt to escape.
- Perform some pre-planned deceptive maneuver, such as going to the beam.
- Activate electronic countermeasures (ECM).

Assuming STT, the following indications of contact maneuvers will occur.

- Change in V_C. The radar detects and measures the Doppler shift of returning energy and is extremely sensitive to changes in Doppler velocities. Even a subtle change of less than 10 degrees of heading change by the bandit will be very detectable by the radar. Changes in V_C are instantaneous with bandit maneuvers.

- Change in Range Rate of Closure (RROC). A closely related concept to rate of closure is range rate of closure. Where V_C is displayed next to the range caret, RROC is the speed at which the contact moves down the attack display.

- Change in contact heading and drift rate. The contact heading display in the upper left corner of the tactical area is a near instantaneous indication of contact maneuvers. If the track crossing rate of the contact has increased, stagnated, or reversed, a change in contact heading has occurred.

- Change in elevation caret and differential altitude (for altitude maneuvers). The antenna elevation caret, located on the left side of the tactical region, provides the primary cue to changes in altitude. The contact's differential altitude above or below the fighter, is displayed next to the elevation caret. As the bandit changes altitude these numbers change accordingly.

- Change in target aspect vector orientation. The target aspect vector will change with contact changes in heading. The aspect vector is the last maneuver indication the radar will display and will lag relative to actual bandit nose position.

- The MEM cue will appear at the bottom of the radar display indicating aged contact information that is unreliable. An effective defensive maneuver will trigger this radar indication.

- Speed changes will be indicated only by changes in V_C, RROC, and L&S speed information.

When a bandit maneuver is detected, the fighter simultaneously executes the following:

- Turns to place the L&S on the nose to evaluate the stability of the trackfile.

- Enter TWS to expand the scan volume and maintain contact

- Communicate to AIC by transmitting

  "AIC Callsign, callsign, group name, maneuver."

The fighter then monitors the stability of the trackfile and should command STT when the bandit turns hot. If the radar enters MEM, the radar has lost contact on the bandit and the fighter should regain radar SA by:

- Inside of shot range, maintain TWS
- Outside of shot range, return to RWS and bias the scan volume to regain SA
- Once SA is regained, and the bandit turns hot, command STT

If the MEM cue goes away, monitor the maneuver from TWS. If the MEM cue remains, enter RWS via PB20 and monitor the track. After the bandit maneuver is complete and the picture “settles” make another assessment of TA and range.

1609. RESET AND RECOMMIT

In situations where the bandit maneuvers or is no longer a threat, and pursuing it wastes fuel or the fighters cannot rapidly achieve a kill, it makes most sense to turn away and return to the CAP. When the fighter terminates an intercept to return to its cap, it is resetting.

Resetting is a tactical procedure that should be executed in order to ensure the proper disengagement of the targeted group and hand over monitoring of that group to AIC. Note that with TA > 60 degrees, the fighter will not be on the bandit’s radar, so the threat is significantly reduced. However, the bandit could maneuver again and become a factor very quickly.

Anytime the bandit maneuvers to generate more than 60 degrees TA, the fighter is no longer on the bandit’s radar. By maintaining radar contact, the fighter has a tactical advantage.

- Outside of 20 NM, TA > 60 degrees reset, as pursuing a contact at range burns fuel.
- Inside of 20 NM, the bandit would have to maneuver > 95 degrees TA to trigger a reset. The bandit is a serious threat inside of 20 NM.
- Inside of 10 NM, reset is not an option as this is considered within visual range (WVR). Use geometry to decrease range as rapidly as possible and employ valid Fox-3 or Fox-2s to kill the bandit.

Once the bandit reaches commit criteria again, the fighters will commit again.

1. **Reset Procedures**

To ensure safe separation from the bandit at reset, use the following procedure:

a. Turn hard to place the bandit 50 degrees AO on the cold side of the attack display. This is also called “stiff-arming”.

b. Monitor for 5 seconds if outside of 20 NM; 10 seconds if inside 20 NM

c. Execute a hard as possible turn in the shortest direction to put the bandit at the fighter's six o'clock (about 130 degrees of turn); then unload and extend while commanding a buster to set 0.6 IMN. Execute SRR mechanics.

d. Direct AIC to monitor the group. (PRI) - "*SABRE, Showtime 11 reset west, SABRE monitor single group.*"

1610. MRM EMPLOYMENT

After committing, targeting, melding, and sorting into the targeted group, the time has come for weapon employment.

The timeline calls for employment at 20 NM. Take note of the range at which MRMs are employed in order to make the correct follow-on flow decisions. Remember to have a Hostile declaration prior to employment. The timeline in Figure 16-4 depicts the game plan for Advanced Intercepts at VT-86.

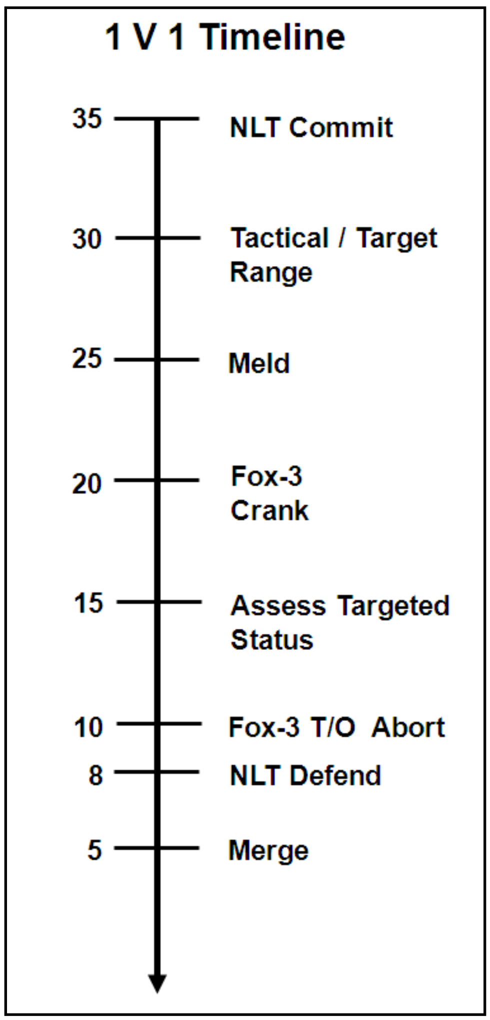


Figure 16-4 Timeline

In order to employ an MRM at the maximum possible range, two conditions must be satisfied:

- A Hostile declaration
- IN LAR condition

Employment comms are as follows:

Fighter (PRI) - "*Showtime 11, Fox-3*"

Fighter (ICS) - "*Crank Right*"

Crank is an informative/directive call that informs all players on the net which direction the fighter element is turning. In 1v1 AWIs, crank by placing the contact 50 degrees AO Cold.

The crank maneuver:

- Minimizes threat WEZ while allowing support of a missile to timeout with an STT.
- Must be at least 50 degrees AO to be effective. Fighter velocity vector must have more of a cross-range component than a downrange component.
- Should be done as to not gimbal the contact, lose track and trash the shot.

While in the crank, evaluate the follow-on flow for the intercept.

- Should the fighter continue to prosecute the intercept by employing follow-on weapons, going to the merge if necessary, or should the fighter time out the current missile and exit the fight?

  i. Continuing the intercept, can be very risky and has a much higher chance of resulting in fighter losses, but may be required for mission success.

  ii. Going “out,” has less risk, but may not result in mission accomplishment. Likewise, fighter losses may be unacceptable and going out may be the only option.

  iii. If the fighter is spiked, the crew must decide whether to defend or flow to the merge.

This decision is not arbitrary and should be based on the best information available.

1611. TRANSITION RANGE

In the crank, consider two things to determine if “winning” or “losing” the engagement. These two factors are:

- Timeline adherence: Did the fighters employ weapons on their contracted sort on timeline?

- Bandit awareness: Does the bandit show indications of targeting the fighters? This is defined as less than 30 degrees TA or if the fighter is spiked.

The combination of these two factors yields the matrix (Figure 16-5) and defines the actions taken upon missile timeout. This decision matrix should be committed to memory.

		TA ≤ 30° or Spiked?	
		Yes	No
On Timeline	Yes	Winning	Winning
	No	Losing	Winning

Figure 16-5 Winning vs. Losing

There may be situations when it is not tactically smart to continue the fight, i.e., the fighters are in a "losing" situation or not in an advantageous position to kill and survive. Based on the determination of winning or losing, and the mission objectives, aircrew will determine if they will "banzai" or "skate."

"Banzai" is a directive call to execute launch and defend tactics. Banzai means the fighter element will support any missile in flight to timeout and then proceed to the merge with the targeted group.

"Skate" is a directive call to execute launch and leave tactics. Skate means the fighter element will still support any missile in flight to timeout, but will not merge with the targeted group. After missile timeout, the fighter element will maneuver aggressively away from the targeted group (i.e., turn "Out").

1. Air-to-Air Radar Missile Defense

If the fighter is behind timeline and spiked, assume that the bandit has employed a missile. In order to defeat this weapon, execute a defensive maneuver. This maneuver is:

a. Place the bandit in the beam, turning in the shortest direction using a hard as possible, level turn.

b. Dispense chaff while turning.

c. Hold the bandit in the beam for at least 5 seconds or until spike goes away.

Defend at timeout range or NLT defend range (8 NM) whichever is first. If the fighter is inside abort range (10 NM) then it is committed to the merge.

Assuming a 50 degree fighter crank, the notch is 40 degrees more of turn, in the direction to place the bandit in the beam. This beam maneuver will defeat the threat radar lock by exploiting the Doppler notch. The fighter should use contact BRA information from the attack display to get an exact beam heading prior to defending. Using the +/- 100-10 method is a quick way to calculate this heading.

2. **Abort**

Aborting the intercept is a worst case action when recognition of low situational awareness occurs. Aborting is an emergency procedure, and should be treated as such.

The abort maneuver is a maximum G, maximum performance maneuver that results in a low altitude, high speed dash away from the threat. Maximum airspeed is mandatory in order to stay outside the threat's WEZ. Any bearing calls from AIC to the threat should be at the 6 o'clock position.

a. The egress heading should be planned to enable maximum separation from the threat while allowing the opportunity to diverge from the threat's flight path.

b. Abort no later than 10 NM versus a radar threat. If spiked, defend to defeat any incoming missiles and then abort.

c. The maneuver should 135 degree overbank, max performance, nose slicing turn to put the threat at the 6 O'clock position.

To execute an abort, direct the pilot while informing AIC with a radio call:

SNFO (PRI) - "*Showtime 11, Abort left, reference 180, buster set 0.7*"

3. **Follow-on MRM Employment**

Look to employ a follow-on Fox-3 against the bandit on a banzai decision.

Never fly through the LAR for one weapon to get to the LAR for another. This means, do not select SRM until:

a. Inside of 10 NM

b. Approaching MRM minimum range

The MRM has a minimum range of around 8 NM. Aircrew also needs to be aware of R_{NE} (OFT only) throughout the intercept.

4. **Transition to WVR**

The transition from BVR employment to WVR employment is a critical moment in the intercept. After the crank and time out of the missile, followed by the decision to "banzai," the fighter crew must adjust their mindset for the employment of WVR tactics. The fighter crew must quickly determine:

a. Does the bandit have SA?

b. Will this be an offensive, defensive or neutral merge or possibly a stern conversion?

c. What is the best first move option post merge?

d. When will I be in an SRM LAR?

1612. WVR/MERGES

When approaching a merge situation, it is imperative for the fighter aircrew to gain a "tally" as soon as possible and to be able to effectively communicate the position of the hostile aircraft to pilot and wingman. "Tally" communication takes practice and experience. Comm brevity and format standardization are key to successful WVR communication. Clock codes are used for directing the pilot and/or wingman's eyes on the bandit(s) using a modified BRA format. For example:

SNFO (AUX) - "*Showtime 11, tally 2, left 10 o'clock, 2 miles, 5 high*"

1. **Unaware or Low SA Bandit Scenario**

a. At 10 NM, bring the bandit to the nose and select SRM. Both aircrew get eyes out of the cockpit to gain a tally for visual identification (VID) and maneuvering to gain/maintain a positional advantage.

b. Look to employ the SRM as soon as a LAR presents itself, but always with an IN LAR cue.

c. If the bandit has no SA, follow the stern conversion game plan (40,000 feet of LS).

d. If the bandit suddenly turns into the fighter, the stern conversion may turn into a merge. Recognize the change in the situation and aggressively transition to the merge game plan.

2. **Aware or High SA Bandit Scenario**

Any TA < 30 degrees or Spiked with TA < 60 degrees means the bandit is aware.

If spiked, the fighter has the option to defend down to 8 NM of range.
Expect to pitch in to the bandit with 110 degrees of turn, out of the notch. Use the HSI/SA display to determine this heading by looking just past 90 left or right.

SNFO (PRI) - "Showtime 11, defend south"

SNFO (AUX) - "heading XXX"

SNFO (PRI) - "Showtime 11, timeout north man lead group"

a. If outside of 5 NM select the following:

   i. SRM set (RWS/20NM/140/6B)

   ii. Cursor 2-3 NM in front

   iii. Bracket last known altitude

b. If inside 5 NM, select

   i. WACQ

   ii. SRM

When radar picks up the contact, bring it to the nose, employ SRM, and prepare to merge.

Approaching the merge, the fighter aircrew transitions to the High Aspect BFM game plan. Ideally, the fighter arrives at the merge with a positional advantage (angles, turning room) an energy advantage (airspeed) and low to high merge geometry for advantage in gaining tally and for weapon optimization (blue sky background). Figure 16-6 depicts the various aspects a fighter aircrew will see at the merge to determine if they have an advantage, are neutral, or at a disadvantage with a bandit.

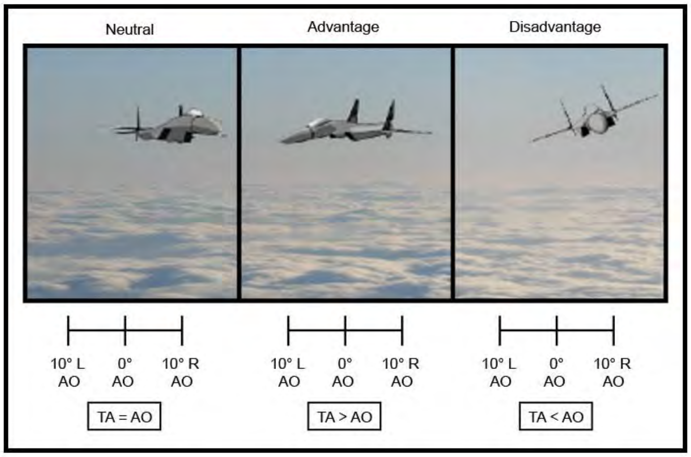


Figure 16-6 Merge Scenarios

1613. GAME PLAN

All of the previous sections within this chapter detail the game plan for Advanced Intercepts. The timeline in Figure 16-7 is generic and represents a basic training tool used to teach correct and timely decision making. Because it is specific to your training at VT-86, realize that your employment game plan and Strike/Fighter timeline will change when you employ tactical aircraft in the Fleet. The timeline must be committed to memory.

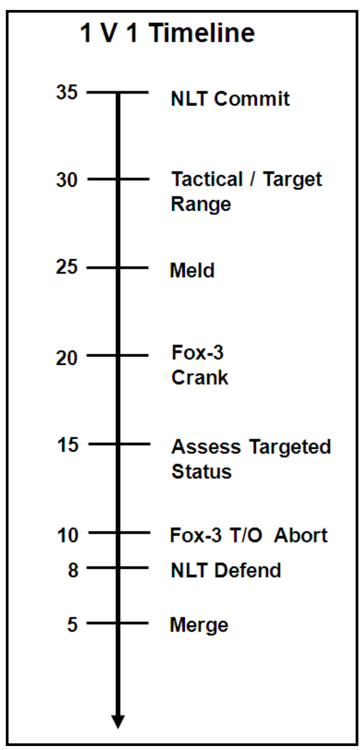


Figure 16-7 Timeline Revisited

1. **Construction of the Timeline and Game Plan Considerations**

The basic considerations used to devise the timeline are outlined below. It is built using "open source" threat capabilities and adjusted to meet specific VT-86 mission and training objectives.

a. Determine desired shot range from threat information.

b. Identify threat shot range as AA-10 Alamo threat with 10-15 NM shot.

c. Identify relationship between Range ROC and timeline tasks based on generic numbers.

d. Compute no later than shot range based on generic numbers.

e. Determine ranges for melding targeting and commit, based on generic information.

f. Determine tactical and NTL Defend range based on generic information.

When constructing the fighter mission conduct based on timeline requirements, the following considerations are included:

a. Coordination with AIC controllers

b. CAP planning (position, types of orbit, orientation)

c. Weapon employment plan and weapon inventory

d. Fuel management plan

e. Training rules and training resources

While there will be many more factors included in the employment of tactical Fleet aircraft, this outline provides a basic road map to A/A mission planning. The key in Advanced Intercepts, as with all air-to-air intercepts, is sound Formation, Radar Mechanics, and Communications.

1614. CONCLUSION

The 1v1 Advanced timeline is the same timeline that will be used for the rest of the AWI phase. The commit, label, name, bandit, meld, sort, shoot, crank, and decide sequence will apply throughout all events. This chapter included an immense amount of information that must be thoroughly understood for success at VT-86. Focus your efforts on knowing this information in great detail as it will provide you with basic skills and knowledge from which to build upon in the future.

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CHAPTER SEVENTEEN
INTRODUCTION TO SECTION AIR-TO-AIR EMPLOYMENT

1700. INTRODUCTION

Fighters rarely employ as a single aircraft. Fighters will typically employ in section, division and as a part of a larger Strike package or Defensive Counter Air package containing multiple elements.

Fighters through history have proven the benefits of having a Wingman in combat. Two aircraft, working together, are more powerful and capable than one, whether their mission is Forward Air Control (Airborne) or a Fighter Sweep. The fighter's in section or division work together to achieve and maintain tactical situational awareness and to achieve air superiority.

This chapter will discuss planning and employment considerations for two aircraft in the air-to-air environment. The information presented here is relevant to both section radar attacks (SRA) and 2vX intercepts. How a section employs in a known 2v2 scenario, such as those seen in SRA, is not different from how the same section will employ in a multi-group environment in 2vX.

1701. SECTION MISSION PLANNING CONSIDERATIONS

As with any kind of military operation, the key to successful employment is robust pre-mission planning. As WWI German General von Moltke stated, "no plan survives contact with the enemy." It is the planning of the mission that allows fighter aircrew to be adaptable to emerging situations and still accomplish the mission. Planning for an air-to-air mission must take into account all of the following:

- Mission requirements
- Enemy situation and capabilities
- Friendly assets and capabilities
- Weather, terrain and environmental effects

1. Mission Requirements

The fighter's must plan to accomplish the mission. All other considerations are secondary. Planning for an OCA mission may be very different from the considerations for the area defense of a Marine landing force or Carrier Battle Group. The Mission Commander must understand the fundamental requirements of the mission and ensure that all planning supports those goals while adhering to standard operating procedures, applicable flight regulations and utilizing prescribed and proven tactics.

In the fleet, tactical and squadron SOPs for employment will serve as a template for employment in many different strike/fighter scenarios. For the 2vX stage of training, the previously introduced SRA timeline is the basis for mission planning. SNFOs should know this timeline from memory and should know how to execute an intercept from any point on the timeline as the tactical situation may dictate.

Some additional considerations that often arise in planning are:

a. Is target destruction required or desired? "Required" will lead to a higher risk mindset than "desired" and will shape the fighter's gameplan accordingly.

b. Are friendly losses acceptable? In operations supporting a no-fly zone or other operations other than war, friendly loses are usually not acceptable. In a military operation, fighter losses may be acceptable, especially if target destruction is required or when defending high value assets such as the Carrier Battle Group. This means that your life and that of your crew depends on your ability to plan and execute effectively and with lethality.

c. Are merges acceptable? Often, the answer to this depends on enemy capabilities. Against a highly trained and capable adversary, skate mindset will probably be briefed as preferable to banzai.

2. **Planning Radar Coverage**

Normally, squadron's tactical SOP will cover the scan volume altitudes and placement, but the aircrew are ultimately responsible for taking into account the specifics of the AOR for the mission including:

a. Terrain elevation and significance

b. Radar resolution and performance

c. Probability of detection, or P_D, of the radar against the expected threat

d. Scan volume parameters, including frame time and target aging

Tactical SOPs usually have these parameters factored in for a greater than 90% solution. However, arguments can be made for modifying scan volume, altitude responsibilities or other parameters to maximize the chance of mission success.

For example, a narrowly defined AOR in a mountainous region where the threat is typified by low altitude strike aircraft and helicopters that may prove difficult for AIC to detect, might dictate that the fighters narrow their scan volume and that both concentrate in a low block look schedule with one fighter scanning above the fighters every few frames in coordination with AIC.

The point of this example is this: Fighter aircrew are the experts at employing their weapons systems to maximum effect. It is ultimately the Mission Commander's responsibility to ensure the mission is accomplished. A thorough understanding of capabilities and limitations is required and may lead to a deviation from "standard" employment. Any deviation from tactical recommendations must be thoroughly researched, briefed and evaluated for operational risk to mission accomplishment.

At VT-86, intercept scenarios are over open water, so standard radar employment considerations from SRA will still apply. Specifically, the fighters should use RWS/140/6B/80 NM setup with 16 second aging in VMTS.

3. **Off Board Cuing Systems**

In the fleet, off board cuing systems, also called data link systems, are now a reality (Figure 17-1). These systems provide the aircrew with an enormous amount of information. So much, in fact, that when they first appeared, the amount of information was so overwhelming that even experienced aircrew were choosing to not have it displayed. However, with the advent of the Multifunction Information Distribution System, or MIDS (called Link-16 in the USAF), and the F/A-18 series multi-sensor integration (MSI) capability, the aircrew now have excellent situational awareness to the battlefield.

MIDS provides the F/A-18 with four functions:

a. High speed, jam resistant, tactical data link

b. Jam resistant digital voice

c. TACAN

d. Precision navigation, if needed

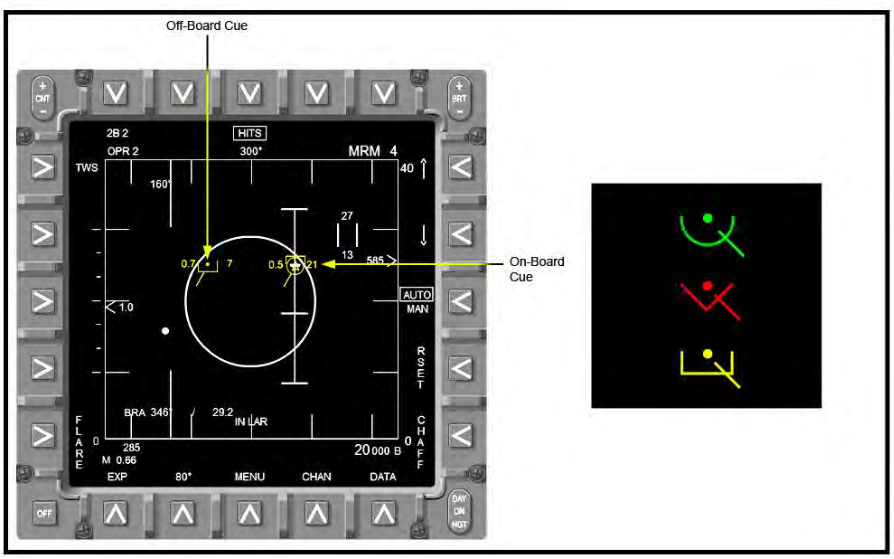

Figure 17-1 Off Board Cuing (OFT Only)

This provides for AIC-to-fighter and fighter-to-fighter sensor contact and information sharing. With MIDS, flight members can maintain SA to contacts that are out of their radar AOR or outside their radar scan volume and/or effective detection ranges. These contacts are displayed as "off board" cues on the radar attack display

Of course, data-link planning comes with its own communications considerations. This includes, net identification, frequencies, which assets are hosts or clients, the coverage of the net and symbology. This communication plan can be confusing if the aircrew is not intimately familiar with their system and associated operating procedures.

1702. BRIEFING AND DEBRIEFING

A solid section flight begins with a solid brief. The crew member briefing, usually the mission commander, should speak from notes and not simply "read" the brief. Mission commander's should speak with confidence and provide specific examples. The briefing officer should:

- Speak to flight related admin in detail including weather and NOTAMS that may affect the flight. These factors can have a tactical impact on the mission such as fuel planning for adverse weather recovery and diverts
- Procedures on and off the route or CAP, especially if they differ from normal procedures
- The communications plan
- Tactical plan and timeline in detail
- Contingencies in detail.

The briefing officer should seek to avoid:

- Reading the brief. The mission commander should know the plan.
- Using the phrase "as SA dictates."
- Briefing items that are SOP. The exceptions to this are safety of flight and mandatory briefing items.
- Using hands to represent aircraft. Use models instead and seek to represent realistic geometry.

Mission commanders should brief the most likely contingencies. However, no briefing can cover every possible contingency.

1. **Conducting the Briefing**

Briefs should follow the standard format of:

a. Administration (Admin)

b. Tactical Administration (Tac Admin)

c. Tactical Conduct (Tac Conduct)

d. Contingencies

Since the SNFO should be intimately familiar with the admin and Tac Admin portions of the briefing, this discussion will focus primarily on the conduct and contingency portions of the briefing.

2. **Briefing Tac Conduct**

The mission commander will brief tactical conduct in great detail. As support for this, the intercept timeline should be displayed on the board. The timeline should be briefed so that formation, sensor employment, communications and crew coordination is covered for each significant part of the intercept. The timeline for section employment is shown in Figure 17-2.

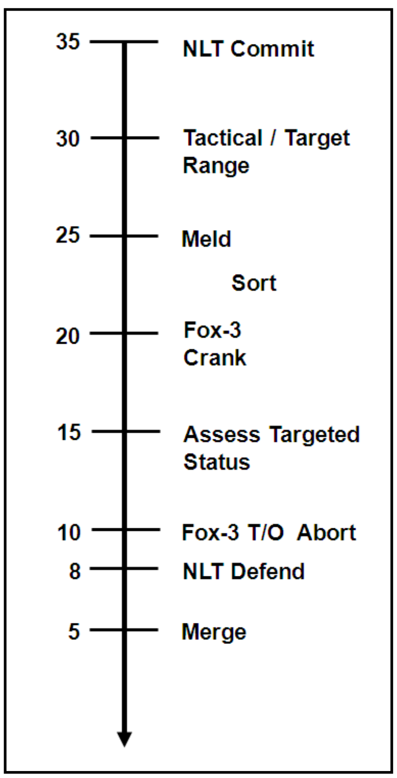

Figure 17-2 SRA and 2vX Timeline from Commit to 10 NM

3. **Section Tasks**

The fighter section must accomplish these intercept tasks any time they commit:

a. Build and recognize the picture with AIC

b. Identify the highest priority group in the picture

c. Commit on timeline

d. Identify the group which the fighters will target

e. Set geometry to achieve an advantage on the targeted group

f. Meld all fighter radars into the targeted group

g. Sort the contacts in the targeted group to engage

h. Employ on timeline

i. Determine weapon effects and follow-on flow

j. Flow to follow-on engagements or separate from the fight

All of those tasks must be planned for to ensure the section acts as a team in accomplishing the mission

4. **Mutual Support**

Section mutual support begins with solid understanding of formation use and sensor planning. In combat, the formation used will be dependent on the tactical situation. In an offensive scenario, the fighters will likely be close to or potentially exceed visual limits using offensive Combat Spread.

At VT-86, T-45C offensive combat spread is defined as:

a. 0 degrees bearing line

b. ≈ 1 NM lateral separation

c. ± 1,000 – 3,000 feet

This formation is used in air-to-air missions and differs from that used on low levels in that the fighters will have at least a 1,000 foot altitude difference. This formation will be briefed for all Tac Conduct portions of the flight with other formations per the SOP for flight management to and from the working area.

Visual mutual support between formation members provides a means to maintain the best defensive posture while executing the fighter mission. Without a visual, the fighters rely solely on aircraft sensors and communications to provide mutual support. The concept of mutual support will be addressed in more detail later in this chapter during the visual engaged maneuvering discussion.

5. **Section Communications**

The briefing officer should use clear, concise, short correct communication examples for all stages of the intercept. The Lead SNFO should also brief examples of section fuel, weapon checks and all appropriate communications brevity that will be used, where appropriate.

6. **The Four Assumptions**

When briefing communications, the flight should assume that that the other fighter is:

a. Visual – meaning they have sight of the other fighter

b. No Joy – meaning they do not have a tally on any unknown or hostile aircraft

c. Naked – meaning the fighters are not spiked by hostile radars

d. Clean – meaning the fighter has no radar contacts

If any of the above change, the fighter must inform the other aircraft on the applicable radio.

7. **Sensor Setup**

The fighters should brief a sensor setup that covers:

a. Mode

b. Azimuth

c. Bar scan

d. Range scale

In written form, this can be written as: Mode/Azimuth/Bar Scan/Range. For example, range while search, 140, 6 bar, 80-mile scale:

RWS/140/6B/80

VMTS radar can retain sets via the SET option on the attack display.

8. **Sensor Employment**

The Lead SNFO is responsible for briefing sensor employment this should include a depiction of the attack display on the board with bullseye and GeoRef information (Figure 17-3). This drawing should allow the briefing officer to update mode, range, azimuth, bar scan and cursor placement (with appropriate altitude scan volume indications) as required during the brief to demonstrate expected sensor employment. Correct details here matter.

Contacts should be displayed with the appropriate symbology for the mode being used. This means the briefer should have a well-studied scenario ready to brief.

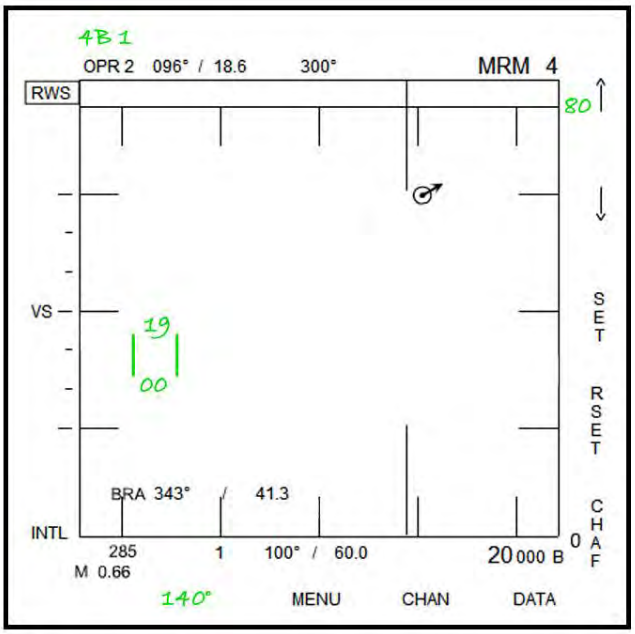

Figure 17-3 Radar Attack Display on a "White Board"

9. **Crew Coordination**

Effective section employment mandates that all crew members understand and can communicate about the tactical situation. These responsibilities are:

a. Lead pilot

i. Maintains orientation on CAP

ii. Maintains altitude and airspeeds as directed by Lead SNFO

iii. Performs flight management comm

iv. Overall responsibility for flight

b. Lead SNFO

i. Backs up pilot on navigation, area and fuel management

ii. Performs mission communications

iii. Primary sensor operator

iv. Directs Lead Pilot for intercept maneuvering

v. Directs Wing SNFO on sensor and weapon employment, as required, if different from brief

vi. Responsible for mission accomplishment

c. Wing Pilot

i. Keep sight of Lead

ii. Maintains formation as briefed

iii. Backs up Lead with navigation, fuel and area management

iv. Maneuvers as directed by Wing SNFO and Lead Pilot

d. Wing SNFO

i. Primary sensor operator

ii. Conducts Wing specific mission communications

iii. Backs up Lead SNFO on sensor and weapons employment

The Lead SNFO will be responsible for mission accomplishment, but the Wing SNFO is responsible for backing up the tactical decisions of the Lead SNFO. As always, safety of flight is the responsibility of all aircrew, with the Flight Lead retaining ultimate safety of flight decision making authority.

10. **Contingencies**

The briefing officer must brief, at a minimum, contingencies for no AIC, adverse weather, system degradations, and any other appropriate contingency that may affect mission accomplishment.

1703. TYPES OF MISSIONS

A section may be employed in either an offensive or defensive counter air mission. The differences are briefly discussed below.

1. **Offensive Counter Air**

OCA missions are offensive operations to destroy, disrupt, or neutralize enemy aircraft, missiles, launch platforms, and their supporting structures and systems both before and after launch, but as close to their source as possible. These operations include attack operations, fighter sweep, escort, and suppression of enemy air defenses (SEAD). OCA missions are not confined to just air-to-air combat. Rather, any mission undertaken to disable airfields, aircraft or their supporting structures is an OCA mission. Figure 17-4 highlights a generic OCA strike package. Specific fighter missions may include:

a. Fighter Sweep – may or may not be associated with a strike package

b. Escort – ensure the safety of the strike package

c. Close Escort – dedicated air-to-air players embedded with the strikers

d. SEAD – suppress enemy air defenses

e. Strike – destroy surface targets that impact the enemy's air order of battle

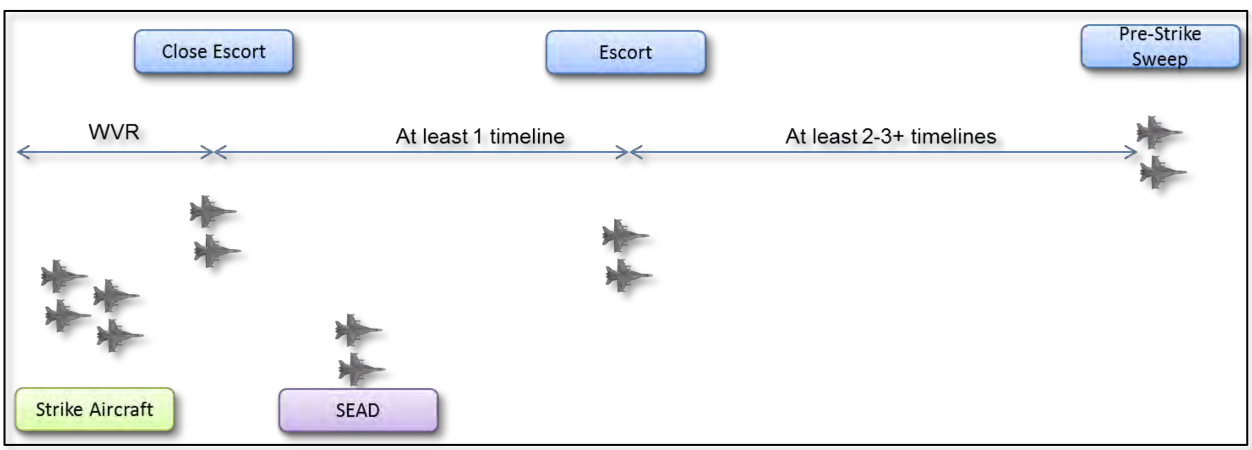

Figure 17-4 Generic OCA Strike Package

These missions may all occur simultaneously as shown in the theoretical OCA strike package example below. Note that the ranges here are notional and are tied to the air-to-air timeline, allowing the actual distance to vary depending upon the threat. This allows for each dedicated air-to-air section to perform all timeline tasks without overrunning the preceding section's execution.

2. Defensive Counter Air

The DCA mission is used to detect, identify, intercept, and destroy or negate enemy forces attempting to attack or penetrate the friendly air environment. DCA is often divided into either a point or area defense. Point defense is the defense of a specific asset or location, such as a disabled ship or the Battle Group's Aircraft Carrier. Area defense is the defense of a series or group of assets across a broader geographic region, such as a country border or an assault landing area. Friendly ("blue") losses will likely be deemed "acceptable" if required to protect the asset. Typical DCA missions include combat air patrols (CAP), and:

a. Barrier Combat Air Patrol (BARCAP) – defense of an area with the intent to not let hostile aircraft past a designated line; the proverbial line in the sand (Figure 17-5)

b. High Value Airborne Asset Protection or CAP (HVAAP/HVAACAP) – defense of a high value asset such as the E-2, E-3, Growler or other national asset

c. RESCAP – CAP established in to support rescue or Tactical Recovery of Aircraft or Personnel (TRAP) missions

d. Point Defense

e. Area Defense

An example of a DCA arrangement is shown in Figure 17-5. DCA CAP missions often must integrate with surface based air defense, such as Patriot or AEGIS systems to provide a gap-free and multi-layer defense for friendly forces.

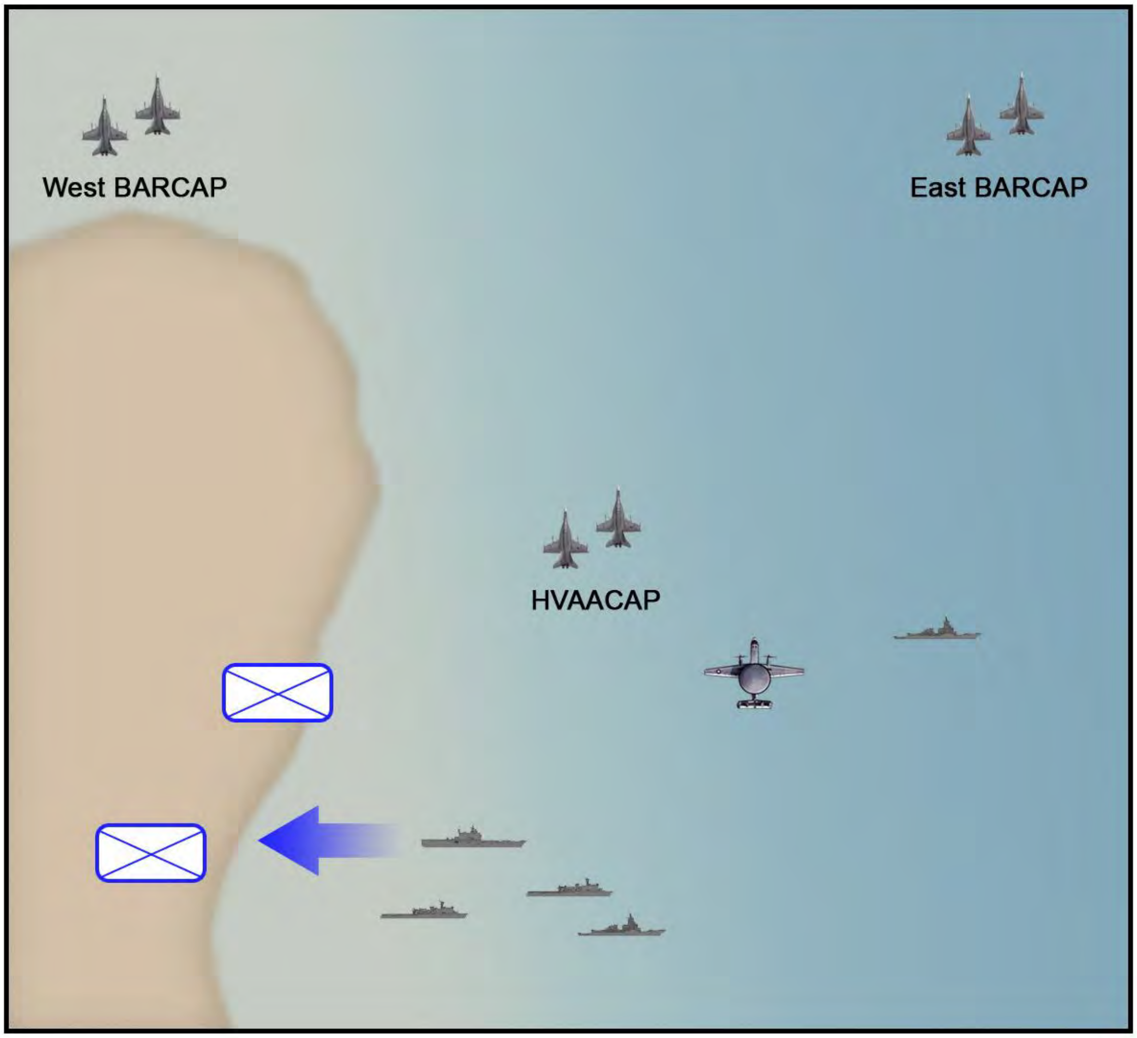

Figure 17-5 DCA BARCAPS

1704. THE ROLE OF THE FIGHTER SECTION IN AIR-TO-AIR WARFARE

Regardless of the briefed mission, the fighter section coordinates their actions to accomplish the following:

- Sanitize airspace
- Detect and Identify unknown contacts
- Destroy hostile contacts meeting ROE
- Integrate into the larger air defense picture

Whether OCA or DCA, the role of the fighter section can be summed up by the above.

1705. 2V2 VERSUS 2VX INTERCEPT EXECUTION

The remainder of this chapter will discuss section intercept procedures. SNFOs will encounter a single, sortable group against which they will practice the timeline skills inherent to a section intercept. These intercepts consist of two fighters versus one bandit (2v1) or two fighters versus a single group of two bandits (2v2) scenarios. This stage is known as section radar attacks or SRA. These scenarios provide introduction and practice of section radar employment skills.

Following SRA, the SNFOs will encounter multiple group scenarios against an unknown number of bandits (2vX). In these scenarios, the section will be tested on teamwork and decision making in addition to the skills initially encountered in SRA.

Procedurally, there is no difference between the two intercepts. The fighter section should approach every scenario as a potential 2vX scenario until AIC or fighter SA demonstrates that the scenario is not.

1706. INTERCEPT EXECUTION

Any section intercept will follow the timeline shown previously to accomplish the following intercept tasks in order:

- Pre-commit picture building
- Commit
- Label / Name
- Target
- Meld
- Sort
- Shoot (Employ)
- Decide
- Merge

Regardless of the number of hostile, bandit or bogey groups, the fighters will execute these tasks against every group meeting commit criteria.

1707. PRE-COMMIT PICTURE BUILDING

The air-to-air picture is a combination of situational awareness: AIC, and both of the fighters. Initially, the picture will be built using broadcast control anchored to bullseye. The brief should follow the "form, sensor, comm." format as shown in Figure 17-6.

Range	Action	Form/Geometry	Sensors	Comm
	Pre-Commit	Cap – Alt as briefed/ 250 KIAS	MRM/RWS/140/ 6B/80 NM Mate 25 NM	*"Rage, tapes on, fight's on" or "Commex, Commex"* PRI BDCT anchored to Bullseye

Figure 17-6 Briefing Should Follow "Form, Sensor, Comm" Format

1. **Pre-Commit Formation**

Prior to the commit, the fighters will be on CAP. Flight Lead/SNFO will brief a CAP management plan including types of turns and CAP orientation. The CAP should be oriented to have sensors focus into the threat sector on "Hot" legs. In place turns will be used unless otherwise briefed or called in flight. "*Hot R/L*" and "*Cold R/L*" imply in place turns onto the CAP leg. "*Visual*" and "*Six Clear*" calls are not required while on cap.

The fighters will CAP in defensive combat spread at 250 KIAS at briefed CAP altitude.

2. **Pre-Commit Sensor Employment**

The fighters should sanitize airspace with MRM selected in RWS/140/6B/80NM. The fighters should mate their radars at 25 NM. This is done by placing the cursor at 25 NM, and adjusting the elevation so that no altitude gap in fighter coverage exists. This is shown in Figure 17-7.

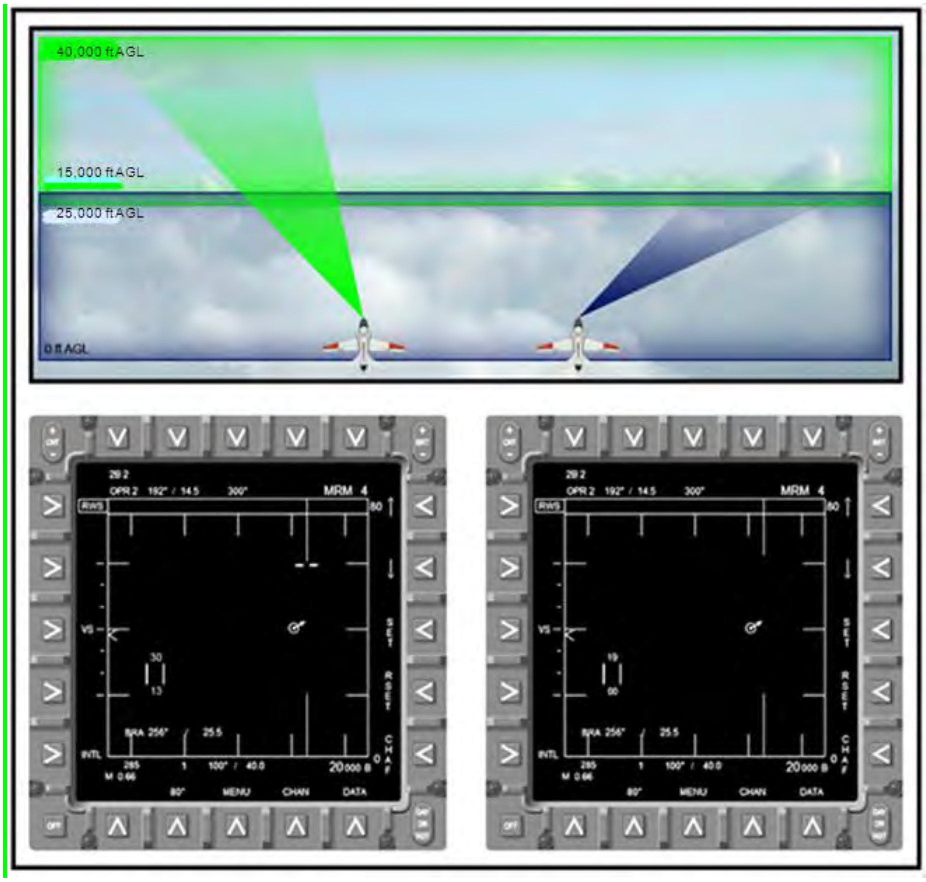

Figure 17-7 Properly Mated Radars at 25 NM

3. **Pre-Commit Communications**

The picture will continue in broadcast control, anchored to bullseye until the fighter's commit. A typical call will be:

LEAD (PRI) - "*SABRE, Rage 11, picture*"

AIC (PRI) - "*Rage 11, three groups, group Vegas 215, 25, 19 thousand track south, hostile; group Vegas 270, 50, 22 thousand, track east, hostile; group Vegas 250, 60, 22 thousand, track east, hostile.*"

Once a group meets commit criteria, the fighters will commit and control will change to tactical control, anchored to bullseye.

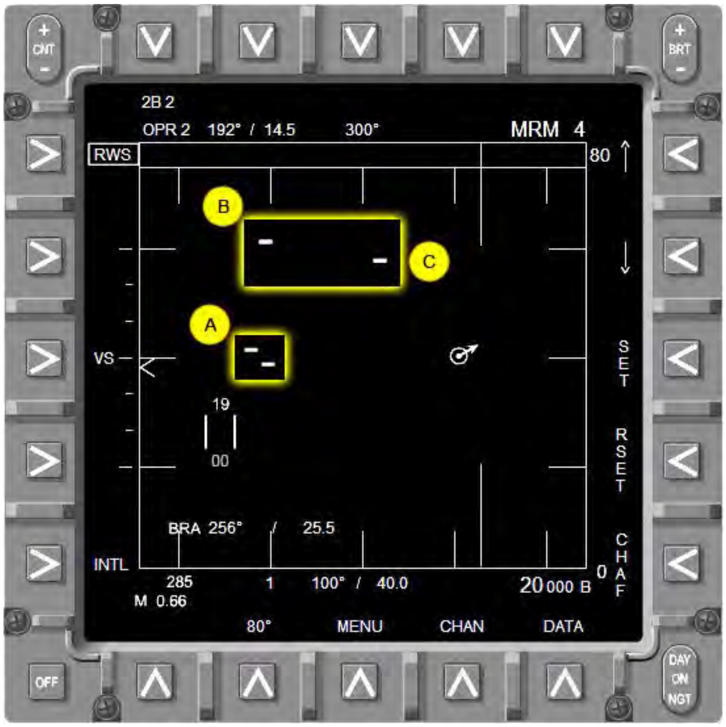

Figure 17-8 Group Definition

A group is defined as two or more contacts within 5 NM range, 5 NM azimuth and within 5,000 feet in elevation. The rule of 60 or the cursor BRA information can be used to determine azimuth requirements for a group. In the Figure 17-8, group A has two contacts at 40 NM. Those contacts are less than 5 NM in range and are 4 degrees in azimuth. At 40 NM 4 degrees is 3 NM in azimuth, so the contacts in A are labeled a "group." Groups B and C are 35 degree apart in azimuth at 60 NM. By the rule of 60, they are 35 miles apart making them separate groups. The radar picture in Figure 17-8 contains three groups and could be described in a similar manner as the picture call from the example above.

As a review of AIC communication control and formats:

a. Broadcast control will identify groups by their location in a way relevant to all listeners and is normally anchored to bullseye.

b. Tactical control adds a target aspect to each group, relevant to the fighter under tactical control with the addition of labels and names

c. Format anchored to bullseye references group positions from a designated geographical reference

d. The BRAA format anchors group locations to the fighter's nose

Communication formats and priority talkers are shown in the Figure 17-9:

Figure 17-9 Comm Format and Priority Talkers to MRM Employment

1708. COMMIT

1. Commit Criteria

Commit criteria for 2v2 or 2vX intercepts will be slightly different:

a. SRA – commit when the single group is no closer than 35 NM with flank aspect or less

b. 2vX – commit when a group in the picture meets briefed commit criteria. At a minimum this will be a group at 35 NM with flank or less aspect

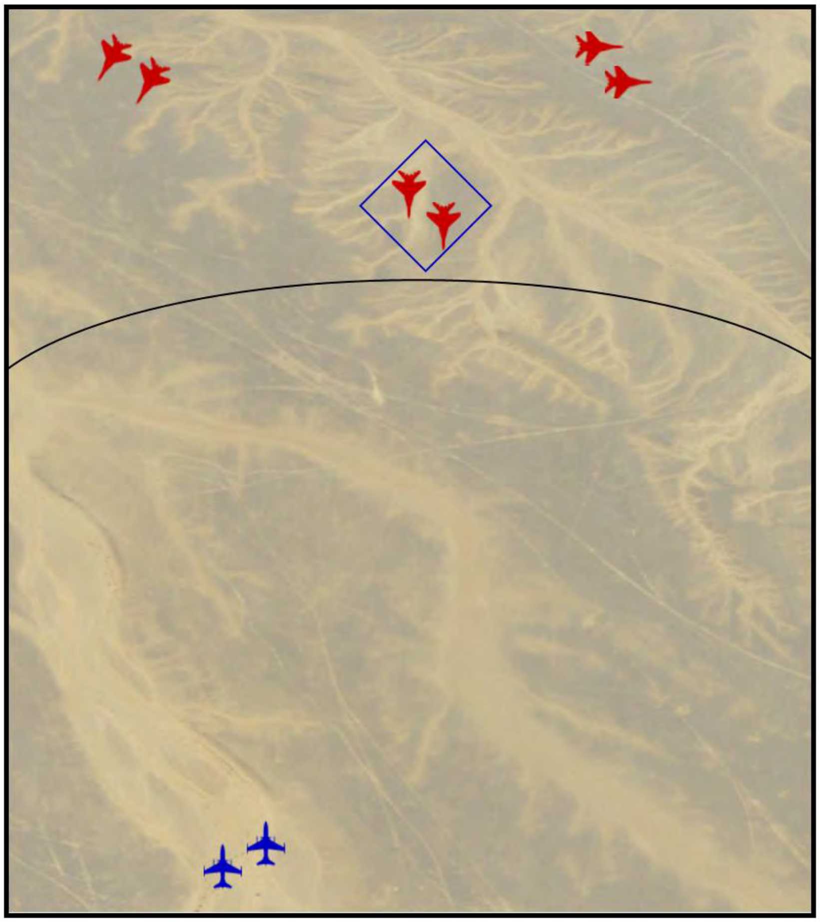

Figure 17-10 Group Meeting Commit Criteria

The Lead SNFO must realize that the group that meets commit criteria may not be in the lead's AOR. Wing should be prepared to recommend commit if Lead does not recognize that a group in the low AOR meets commit criteria (Figure 17-10).

2. **Formation at Commit**

At the commit, the fighters will maintain offensive combat spread. The fighters should set geometry by placing the group which meets commit criteria on the nose initially while labeling and naming occur.

3. **Sensor Employment at Commit**

The fighters should continue to sanitize in their AOR using the sanitization set, mated at 25 NM.

4. **Commit Communications**

Communication for the commit should use the fighter's entire callsign to avoid any confusion. At commit, AIC will automatically transition from broadcast to tactical control. For example:

Lead SNFO (PRI) - "*Rage 11, commit*"

(AUX) - "*Check Tapes, Master Arm*"

AIC (PRI) - "SABRE copy commit"

Figure 17-11 shows formation, sensor employment, and communications at the commit.

	Pre-Commit	Cap – Alt as briefed/ 250 KIAS	MRM/RWS/140/ 6B/80 NM Mate 25 NM	*"Rage, tapes on, fight's on" or "Commex, Commex"* PRI BDCT anchored to Bullseye
35	Commit	DCS Point and assess		*"Rage-11 Commit"* PRI *"Check tapes M/A"* AUX Tactical Control anchored Bullseye
		Single side offset- 20 degrees	Sanitize AOR	*"AIC, Rage-11, lead group BRA XXX/YY, ZZ thousand declare"* PRI

Figure 17-11 Commit Actions Form, Sensors and Comm

5. **When should Wing speak up?**

Outside of 30 NM, Wing is obligated to speak whenever the following occurs:

a. Any of the four assumptions violated

b. Wing sees a group or possesses information not being talked about by AIC or Lead

c. "*Viking 22, clean*" is required if AIC is calling a group in Wing's AOR that is not seen by Wing (no radar SA to a group in your AOR).

d. As Wing and outside of 30 NM, speak only when your comm enhances overall SA.

As Wing, when transmitting on the control frequency (PRI), use clear, concise, SA building comm with appropriate brevity. One bad call can trash SA for all who hear it. Wing's comm must be as clear and concise as Lead's and/or AIC.

Wingmen should not hesitate to contribute SA building information, but should ensure they broadcast information that is not already known by the other blue players.

Inside 30 NM, comm priority is Lead, AIC, Wing. Wingmen should understand when they are required to speak, what information to pass and when it is appropriate in accordance with the briefed plan and this FTI.

1709. LABELING AND NAMING

Once the fighter's commit, AIC will label the picture and include group names if possible.

1. Labeling

The picture will be labeled only if it fits one of the pre-briefed labels agreed upon between the fighters and AIC(shown in Figure17-12).

In SRA stage, the fighters will encounter only a single group. Single group labels and definitions include:

a. Single group

i. Two contacts (strength 2)

ii. This is the group label and name

Possible fillers:

b. "Heavy" - more than strength 2

c. "Stack" - contacts have significant altitude difference

In 2vX, the fighters can expect to encounter any number of groups in any configuration.

2. Naming

Groups will be named appropriately based on their location. When the picture fits a prebriefed label, the groups will be named accordingly. In SRAs, only single groups are presented and named "Single Group." A single group scenario is the only time the label and name will be the same. If the single group contains more than two contacts, AIC will add the modifier "strength X" where X is the total number of contacts, if AIC has that SA. If the number of contacts is not resolved, but thought to be more than two, the modifier "heavy" will be used. Group names for labeled pictures are shown in Figure 17-12.

Two groups in echelon will be labeled as either range or azimuth first, then echelon will be used as a descriptive modifier. For example: "Two groups azimuth 20, echelon northeast" describes two groups with 20nm azimuth separation with the east group offset in range to the northeast (Figure 17-12, middle right). The only configuration of two groups that does not fit into one of these pre-briefed labels is "two groups stack" (not shown) in which the two groups are directly above/below each other in altitude.

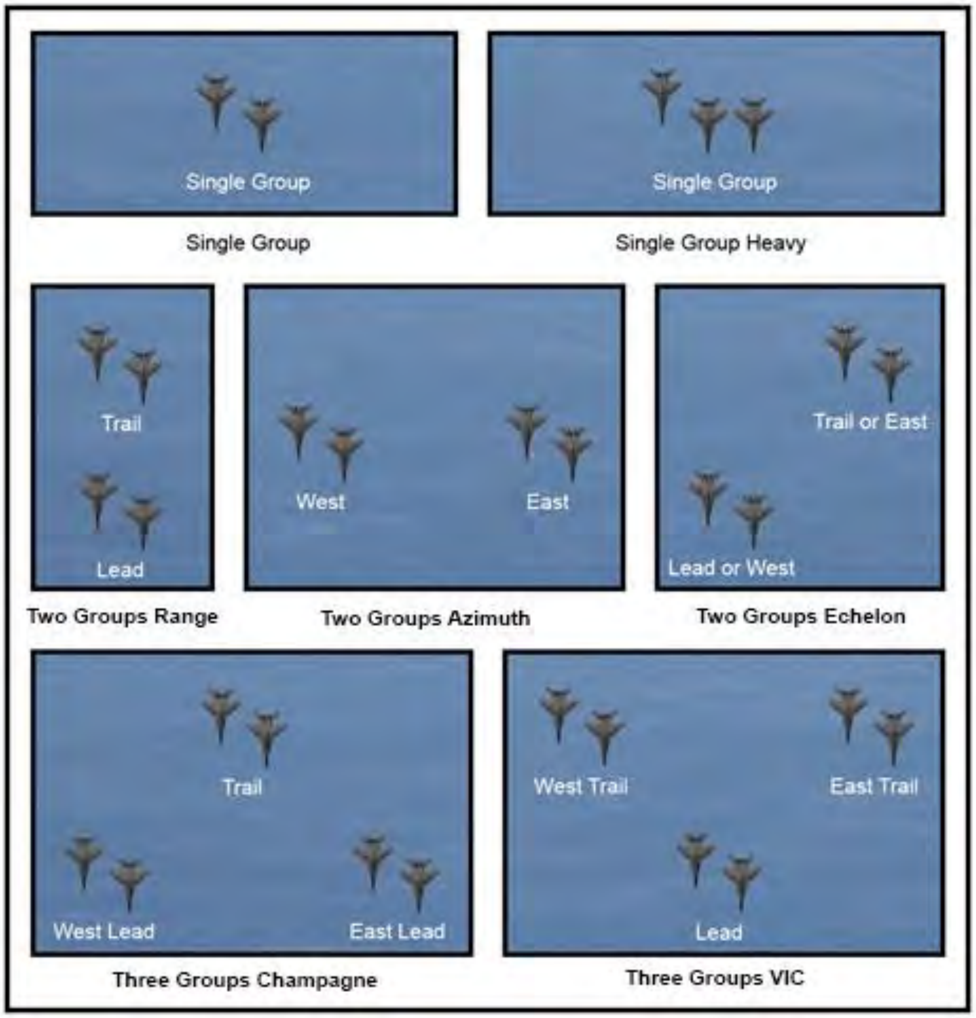

Figure 17-12 Picture Labels and Group Names

3. **Labeling and Naming Communications**

Unless in extremis or without any AIC available, the fighters will not label the picture or name the groups. Lead fighter can recommend a label and group names or ask for a new picture if the tactical situation dictates. AIC will communicate the label names in tactical control anchored to bullseye as shown in the following examples:

4. **Single Group**

Single group scenarios are the only case where the picture label and name are the same.

a. AIC - "*Single group, Vegas 270, 35, 25 thousand, hot, hostile*"

b. AIC - "*Single group, Vegas 270, 35, 25 thousand, hot, heavy, hostile*"

5. **Two Groups Range or Azimuth**

In two group pictures, the picture can be defined by the location of the first group identified; AIC may not provide a bullseye location to the second group. In other words, "*two groups range 30*" implies that the lead group will be identified and the trail group is 30 NM behind the lead group. The same applies in azimuth. AIC is required to transmit the altitude, if known, aspect and declaration to the other group. For example:

a. AIC - "*Two groups range 30. Lead group Vegas 250, 40, 26 thousand, hot, hostile. Trail group 30 thousand, flank southwest, hostile*"

b. AIC - "*Two groups azimuth 30. West group Vegas 140, 35, 30 thousand hot hostile. East group 20 thousand, beam east, hostile*"

6. **Two Groups Echelon (+ sub-cardinal direction)**

Two groups in an echelon will be named according to the range or azimuth convention, depending on the depth or width of the echelon. For example, an echelon with more range than azimuth will be labeled as "two groups range" with the modifier "echelon" and a subcardinal direction. AIC is not required to provide position information for the second group once the picture is anchored, but may do so if it enhances situational awareness. For example:

a. AIC - "*Two groups, range 30, echelon northeast, Lead group Vegas 205, 40, 19 thousand hot hostile; Trail group 22 thousand, flank southwest, hostile.*"

b. AIC - "*Two groups, azimuth 30, echelon northeast. West group Vegas 205, 40, 19 thousand hot, hostile; East group 15 thousand, flank southeast, hostile.*

7. **Naming with More than Two Groups**

There are too many possible arrangements for three or more groups of bandits to all be covered here. AIC will label the picture and name the groups in a logical fashion using the basic guidelines presented here. . The SNFO should be able to recognize the picture by being familiar with the labels and names presented here.

1710. TARGETING

The presence of multiple groups does not mean all groups will be factor groups, or have any impact on the tactical picture. The true intent for any enemy formation is often unknown. The fighters may receive information from "off board" sources that aid in determining which groups of bandits are "fighters" and which are "strikers." As a general planning principle:

a. On OCA sweep missions:

i. Commit will be "liberal"

ii. “Sweep” mentality; kill anything flying declared hostile

iii. More tactical employment options

b. On OCA escort missions:

i. Escort’s purpose is to defend the strikers

ii. Groups not a threat to strikers are not targeted

iii. Limited tactical employment options

c. DCA point or area defense:

i. Defend friendly assets

ii. Kill only threat groups

iii. Priority target enemy strikers

iv. Very limited tactical employment options

1. **Targeting Priorities**

The next phase of the intercept after labeling and naming is targeting. The fighters will target the group that is the highest factor in the tactical picture. The highest factor group is called the priority group.

A 35 NM NLT commit provides time to identify the priority group based on the following criteria:

a. Elevation

b. Range

c. Azimuth

Other, mission dependent considerations:

d. Bogey over bandit or hostile (DCA)

e. Strikers over escort or screen (DCA)

The type of fighter mission will determine what criteria will be used to determine the priority group. On a DCA mission, for example, the enemy’s strike aircraft will have a higher priority than their escort or screen fighters.

2. **Flow Range**

Flow range is the minimum distance needed between two groups that allows the fighters to perform all timeline tasks versus the targeted group, take that intercept to a logical conclusion and then execute all timeline tasks against the follow on group. Usually this range is not less than meld range. Other considerations for flow range include, but are not limited to:

a. Allows for destruction/merge with targeted group

b. Immediate meld to far group for BVR weapon employment

c. Time-to-kill (TTK) considerations with the first group using WVR ACM (always strive to minimize TTK)

d. Acquire and meld into the follow-on group on timeline

At VT-86 flow range will be 30 NM.

a. Flow range is not a consideration for:

   i. Single group

   ii. Single group heavy

   iii. Single group stack

b. Flow range is always a consideration for:

   i. Two groups range

   ii. Two groups azimuth

   iii. Two groups echelon

3. **Formation and Geometry at Targeting**

The fighters will remain in defensive combat spread throughout the intercept. The fighters must take into account their area of responsibility (working area in training), hostile surface threats, engagement zones and follow-on group flow when determining which direction and how much to offset. All things being equal, the fighters should establish a 20 degree single side offset by placing the targeted group at 20 AO hot if possible at a minimum to affect intercept geometry and create a positional advantage.

The Lead SNFO must realize that the targeted group may not be in the high AOR and should be prepared to not have radar contact with the targeted group until meld.

4. **Turn Azimuth into Range**

In a multi-group environment, the fighters should choose an offset that provides the best opportunity to turn an echelon or azimuth presentation into a range problem. For an echelon, this means offsetting away from the farthest group (the echelon) in a manner that will produce range flow from group to group following the first merge. For azimuth presentations an aggressive offset to the "outside" of the closest group will assist in converting the azimuth problem into more of a range problem by the first merge.

The reason for this is simple: The timeline is designed for sequential, not simultaneous, engagements. In future training, when more than one fighter section is present or when the threat level dictates, the fighter's may split into two sections or target as singles. At VT-86, the section will always stay together and target one group at a time.

5. **Targeting Sensors**

The fighters should continue to sanitize using the sanitization set. Fighters should designate an appropriate L&S at the targeting call.

6. **Targeting Communications**

Once the fighters have determined which group in the picture to target, this is communicated to AIC using the following call:

a. In SRA - Lead SNFO (PRI) - *"Rage 11, target single group"*

b. In 2vX - Lead SNFO (PRI) - *"Rage 11, target lead group, SABRE monitor trail group."*

1711. 30 NM TACTICAL RANGE AND FOLLOW-ON FLOW

The 30 NM tactical range call is a reminder to all players that meld is 30 seconds away and serves to update everyone's timeline SA.

1. **30 NM Range Formation and Geometry**

The fighters will remain in defensive combat spread, but should begin a climb or descent to get 1,000 feet of lookup on the targeted group by weapons employment. If the fighters recognize that the initial set geometry was incorrect, the Lead can direct, and Wing can recommend, a geometry change up to this range. After 30 NM the fighters focus is on employing weapons on the targeted group and not correcting intercept geometry.

2. **30 NM Range Sensors**

At 30 NM, the fighters are 5 NM or 30 seconds away from meld. They have two more frames with which to sanitize their AOR and correlate any contacts found. The fighters must remain patient and let the radar sanitize their AOR so as not to miss any undetected groups.

3. **30 NM Communications**

At 30 NM, the fighter with the targeted group in AOR will call "*Callsign, group name, 30 miles.*" For example, in SRA with a single group at 13,000 (the low AOR):

Wing SNFO (PRI) - "*Rage 12, single group, 30 miles*"

Or, in 2vX in a range presentation with the targeted group at 28,000

Lead SNFO (PRI) - "*Rage 11, lead group, 30 miles*"

1712. MELD AND SORT

Melding is the act of bringing all the fighter radars into the targeted group for sorting and weapons employment. Melding was introduced in Advanced 1v1 AWI and will be revisited here in the context of section employment. Sorting is determining which contact in the targeted group that each fighter will employ weapons against.

Melding and sorting is the foundation for air-to-air success. Fighters will rarely employ as a single ship. Many threat nations use formations that are large in number and closely spaced. Often an unobserved bandit entry into the visual arena is directly traceable to:

- Poor/lazy/inappropriate sanitization at range
- Poor meld mechanics
- Not having a sort
- Poor visual lookout

Disciplined radar employment is key to BVR air-to-air success. A WSO's reputation is often built on their ability to execute disciplined intercept procedures in a timely and accurate fashion.

1. **Meld**

The melding and sorting procedures should commence no earlier than 25 NM and are executed with the same discipline and procedural knowledge as an immediate action "boldface" procedure.

2. **Meld Formation**

The fighters remain in defensive combat spread during meld and sort

3. **Meld Sensor Employment**

Meld mechanics were introduced in Advanced 1v1. As a review, the meld procedure is:

a. Range to 40 NM

b. Reduce to 80 degree azimuth

c. Center scan volume on meld call with half action trigger (full action VMTS)

d. Center elevation scan volume to bracket meld call altitude

e. Place cursor 2-3 NM in front of BRAA call

f. Command STT on contact (full action in OFT; two full action VMTS)

g. Enter TWS via the TWS push button

SNFOs are encouraged to use HOTAS for bump functionality to adjust range and azimuth. While this is a taught here as "technique," it will be the preferred method in the F/A-18. Execution of the correct procedure is more important than the technique used.

The purpose in entering STT prior to TWS in sort mechanics is to force the radar into AUTO scan centering . SNFOs should not deviate from the meld mechanics by going directly to TWS from RWS. The meld procedure ensures the TWS scan volume is centered in azimuth and altitude on the targeted group.

4. **Meld Communication**

At meld, communications will transition to tactical control in the BRA format for the remainder of the intercept.

The purpose of meld is to bring all the fighter radars into the targeted group. Since the fighters are sanitizing the same amount of azimuth volume, but different altitudes, the most important part of the meld call is altitude.

The fighter with targeted group and radar contact in AOR makes the meld call. Flight callsign is used, not individual aircraft callsign. The meld call format is "*Callsign, meld, group name, BRA XXX, YY, ZZ Thousand.*"

For example, with the group at 25 thousand feet in SRA:

Lead SNFO (AUX) - "*Rage, meld, single group, BRA 320, 25, 25 thousand*"

For contact at 15 thousand in Wing's AOR:

Wing SNFO (AUX) - "*Rage, meld, lead group, BRA 320, 25, 15 thousand*"

5. **Sort**

Meld is followed immediately by sort. When sorting, the fighters will designate the contact within the targeted group against which they will employ weapons.

6. **Sort priorities, assumptions and assignments**

The sort "contract" within the section is briefed using the sort priorities of:

a. Azimuth

b. Range

c. Elevation

When sorting, the following assumptions are made:

a. Group is strength 2

b. Group formation is sortable in azimuth

c. No comm is required if assumptions are met

If the assumptions are met, the following sort assignments can be made:

a. Lead will sort

   i. Left

   ii. Lead

   iii. High

b. Wing will sort

   i. Right

   ii. Trail

   iii. Low

7. **Sort Formation**

The fighters remain in defensive combat spread while sorting.

8. **Sort Sensor Employment**

The most important part of sensor employment is sorting the correct contact. The briefed sorting gameplan is known as the "sort contract." The standard sort contract used at VT-86 is shown below in Figure 17-13.

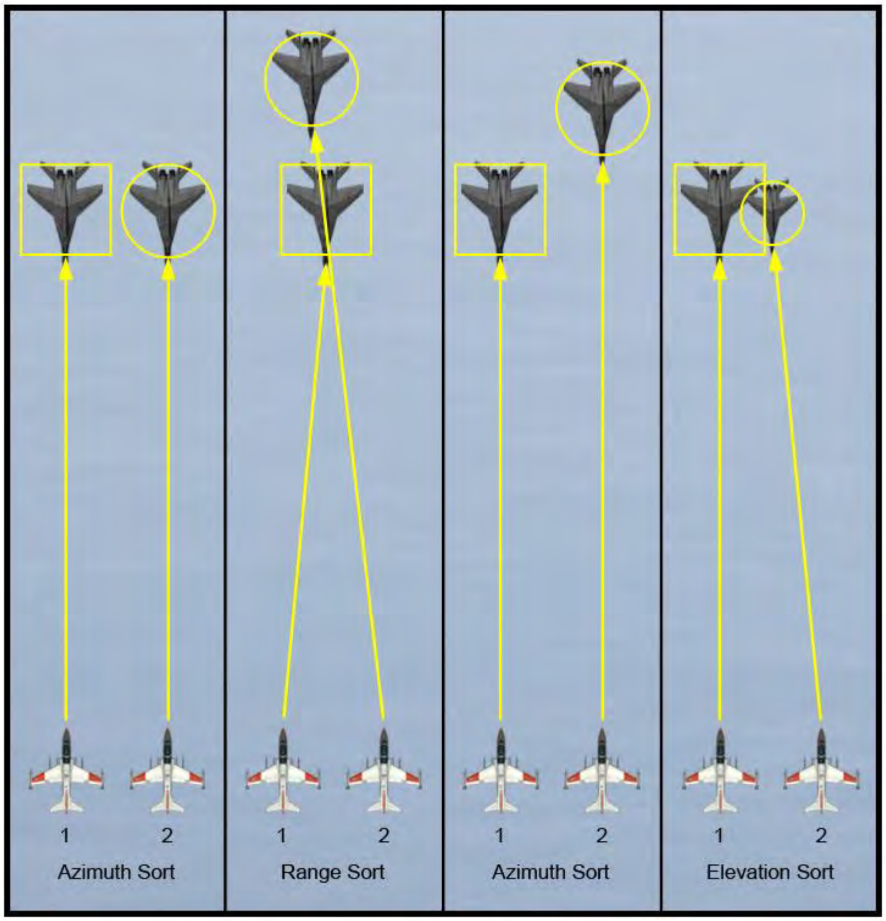

Figure 17-13 Sorting Plan

If all assumptions are met, the section will use an azimuth sort with Lead sorting left and Wing sorting right. If a "B-sweep" can fit between the two contacts then the group is sortable in azimuth.

9. **Sort Mechanics**

In VMTS, there is not an Expand function for the radar. The VMTS sort procedure is:

a. Lead

i. Make sort contract the L&S

ii. Designate the other contact as a DT2

b. Wing

i. Make sort contract the L&S

ii. Command STT on sort contract

10. **Post Sort Radar**

Figure 17-14 shows an OFT Wing sort on the left (STT), and a VMTS Lead sort on the right (TWS AUTO).

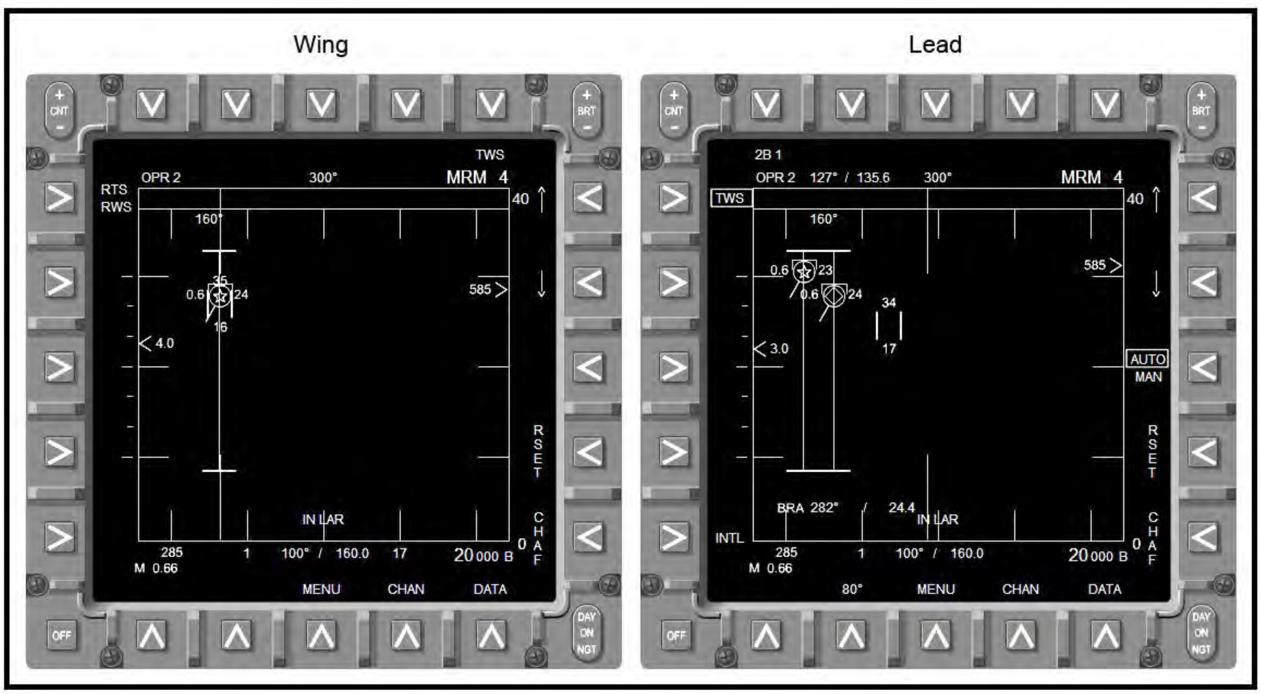

Figure 17-13 Post Sort Radars for Wing (Left) and Lead (Right)

11. **Groups Not Sortable in Azimuth**

A group is considered not sortable in azimuth if a B-sweep will not fit between the contacts. This is shown in Figure 17-15. This situation should be recognized by both fighters.

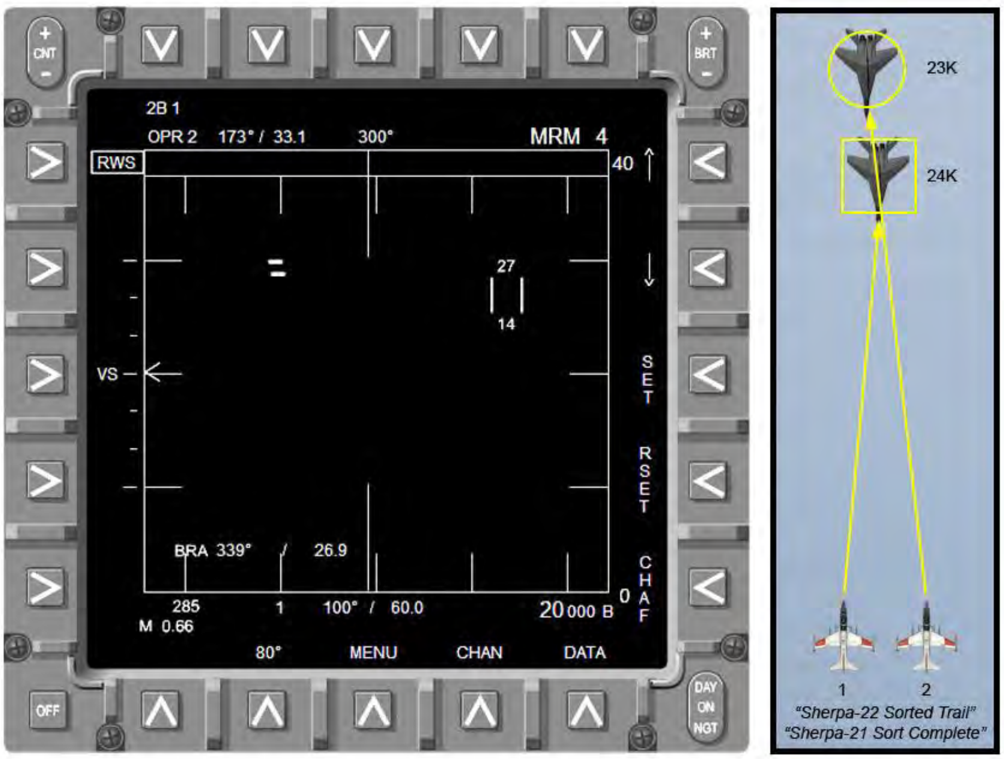

Figure 17-15 Groups Not Sortable in Azimuth are Sorted in Range

If this case is recognized by Lead, then Lead directs a range sort with the following call:

Lead SNFO - *Rage 11, Sort Range*"

If recognized by Wing, the call is descriptive:

Wing SNFO - *Rage 12, sorted trailer*"

12. **Single Contact in a Group**

A group with a single contact will be identified by the fighter with SA on AUX as "*Single only, XX thousand.*" If the other fighter agrees, Lead will employ on the single contact from TWS. Wing will remain in TWS and sanitize around the contact from TWS.

If the section disagrees, the fighter with two contacts will sort around the single contact called by the other fighter using altitude as the discriminant.

13. **"Sorted" vs. "Locked"**

If a fighter has an STT but was unsure of sort, then the fighter is "locked, XX thousand." The other fighter will attempt to sort around this call using altitude as the discriminant. Disciplined sort mechanics will prevent a "locked" status.

14. **Directive Sort**

If the assumptions for an azimuth sort are not met, then Lead will direct the sort as a range or elevation sort as depicted in Figure 17-17.

15. **Disagreement about a Single Contact**

If the fighters disagree about the group being a single only then the following applies:

If Wing calls "*Single Only*" with altitude AND Lead sees two contacts then Lead sorts around Wing using altitude as a discriminant. Wing employs from STT.

If Wing calls "Single Only" with altitude AND Lead sees one contact – Lead will employ on the single contact from TWS. Wing will remain in TWS and sanitize around the contact from TWS

16. **Meld and Sort Summary**

A successful intercept in either SRA or 2vX depends on disciplined execution of meld and sort mechanics prior to weapon employment. It is the SNFO's primary responsibility during the intercept to ensure that the correct sort is made, every time. The entire intercept can fall apart inside 20 NM without a good sort. The SNFO should never give up trying to get a sort or ensuring that the section has the maximum amount or SA prior to weapon employment.

1713. SECTION WEAPONS EMPLOYMENT AND CRANK

Weapon employment is the culmination of all intercept tasks to 20 NM. At weapon employment, the fighters will shoot and crank as a section. Recall from previous chapters that the primary consideration for a valid MRM employment is an "IN LAR" condition at launch. The fighter crew must continue to assess shot quality throughout missile time of flight. The fighters must employ IN LAR and on timeline.

The employment tree (Figure 17-16) graphically depicts the sorting and employment plan for bandit formations from a single aircraft to a three-ship. It assumes a group sortable in azimuth. A single bandit will be engaged by Lead from TWS. For a two-ship, Lead will employ from TWS on the left bandit, Wing will employ from STT on the right bandit. In a strength 3 group, Lead will employ from TWS on the center and left contacts while Wing employs on the right contact from TWS.

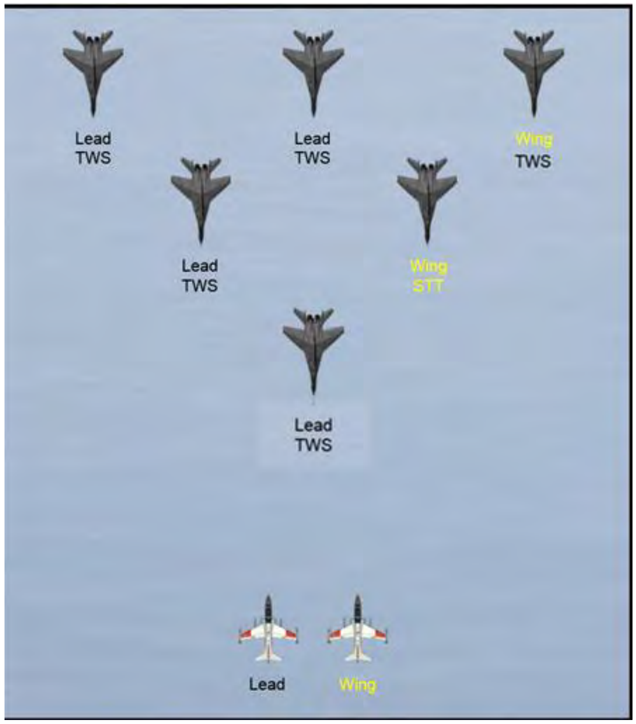

Figure 17-16 Employment "Tree"

1. **Section Employment Considerations**

Assuming a correct sort, the following will happen:

a. Wing will employ a single missile from STT on sort contract.

b. Lead will employ from TWS:

i. Sort contract

ii. Up to two missiles one on each of the left contacts in group with strength 3

If the section is locked: Both Lead and Wing will employ, Lead attempt sort.

In the event a group strength 3 is encountered, Lead will employ one missile on each of the left most contacts from TWS while Wing will employ from TWS on the right bandit. This is summarized in the employment "tree" graphic in Figure 17-17.

2. **Post-Employment WEZ Management – The Crank**

Immediately following employment, the fighters will turn away to manage the enemy WEZ as introduced in 1v1 AWI.

3. **Employment/Crank Formation**

Immediately following employment, the fighters will maneuver to manage the hostile WEZ. This maneuver is called a crank. The fighters will crank whether or not they employ (such as in the case of a group declared bogey).

In SRA, the fighters will crank to place their sort contract at 50 degrees AO cold and adjust to maintain visual mutual support.

In 2vX the fighters will crank in the most favorable direction based on the following considerations:

a. Away from follow-on groups

b. Away from surface threats

c. Influence flow to follow-on groups

d. Airspace considerations

Deconfliction is the responsibility of the Wing pilot. The wingman may become acute due to the crank geometry.

4. **Employment Sensor Consideration**

Per Figure 17-17, Lead will employ out of TWS. Wing will employ out of STT. The fighters should evaluate their shots through time of flight to determine if follow-on BVR employment is warranted or if their shots are valid. If the fighters see a LOST missile status, then the shot is likely trashed and follow-on employment should be considered.

5. **Employment and Crank Communications**

Comm brevity for MRM employment will follow the BVR employment standard on PRI:

a. "*Fox 3*" is used for the employment of one missile

b. "*Fox-3, two ship*" means employment has occurred against more than one trackfile

c. "C*allsign, second Fox-3*" indicates follow-on employment against the same trackfile with the previous missile still in flight (i.e., prior to timeout)

Following the employment call, the Lead fighter should call for the crank on AUX:

Lead SNFO (PRI) - "*Rage 11, Fox-3*"

Wing SNFO (PRI) - "*Rage 12, Fox-3*"

Lead SNFO (AUX) - "*Rage, crank Left (or Right)*"

If, due to geometry, Wing is at risk of losing radar contact, Wing can call on AUX "*Rage 12, gimbals Right (or Left).*" Lead should immediately adjust geometry to compensate while maintaining geometry and section visual support.

At missile timeout, the fighters should make the appropriate timeout call. If trashed, the fighters should make a trashed call.

1714. DECISION RANGE AND TRANSITION TO WVR

1. Winning and Losing

As a refresher from 1v1 AWI, you are winning if the section:

a. Sorted, and

b. Employed/cranked on time, and

c. Neither fighter is spiked

Or

d. Sorted, and

e. Employed/cranked on time, and

f. Spiked

Or

g. Sorted, and

h. Employed/cranked late, and

i. Naked or TA >30 degrees

You are losing if:

a. Locked/unresolved sort, and

b. Employed behind timeline, and

c. Spiked

Or

d. No contact by 16 NM

e. Spiked

2. **Banzai**

"Banzai" is a directive call to timeout missiles currently in flight and fight to the merge, regardless of the affect those missiles have on the hostile forces. At VT-86, the section will banzai whenever they are winning. This is a briefed assumption and communication is required only when there may be confusion about whether or not he section will banzai. The call on AUX is "*Callsign, banzai.*"

3. **Section Execution of Defense and Banzai**

If either of the fighters are spiked, they should defend as a section no later than 8 NM. Although the defense is an individual effort, the section will both turn to place the spike azimuth in the beam and dispense chaff. While in the beam, the fighters should select the SRM set (RWS/140/6B/20NM) in preparation of turning in.

Once naked, the fighters should turn in approximately 110 degrees from the defense heading to place the threat on the nose and prepare for SRM employment and the merge (Figure 17-17).

If turning in inside of 5 NM the fighters should pitch in in WACQ with SRM selected.

4. **Banzai Communications**

Banzai communications are initiated by the fighter that is spiked and will flow as follows:

Wing SNFO (AUX) - "*Rage 12, spiked*"
(PRI) - *"Rage-12, timeout single group"*

Lead SNFO (PRI) - "*Rage defend east*"
(PRI) - "*Rage, timeout single group*

When Wing goes naked:

Wing SNFO(AUX) -"*Rage 12, naked*"

Lead SNFO (PRI) - "*Rage in left (right)*"

If lead is spiked, the spiked call is not required. Lead will direct the defense and turn in as appropriate.

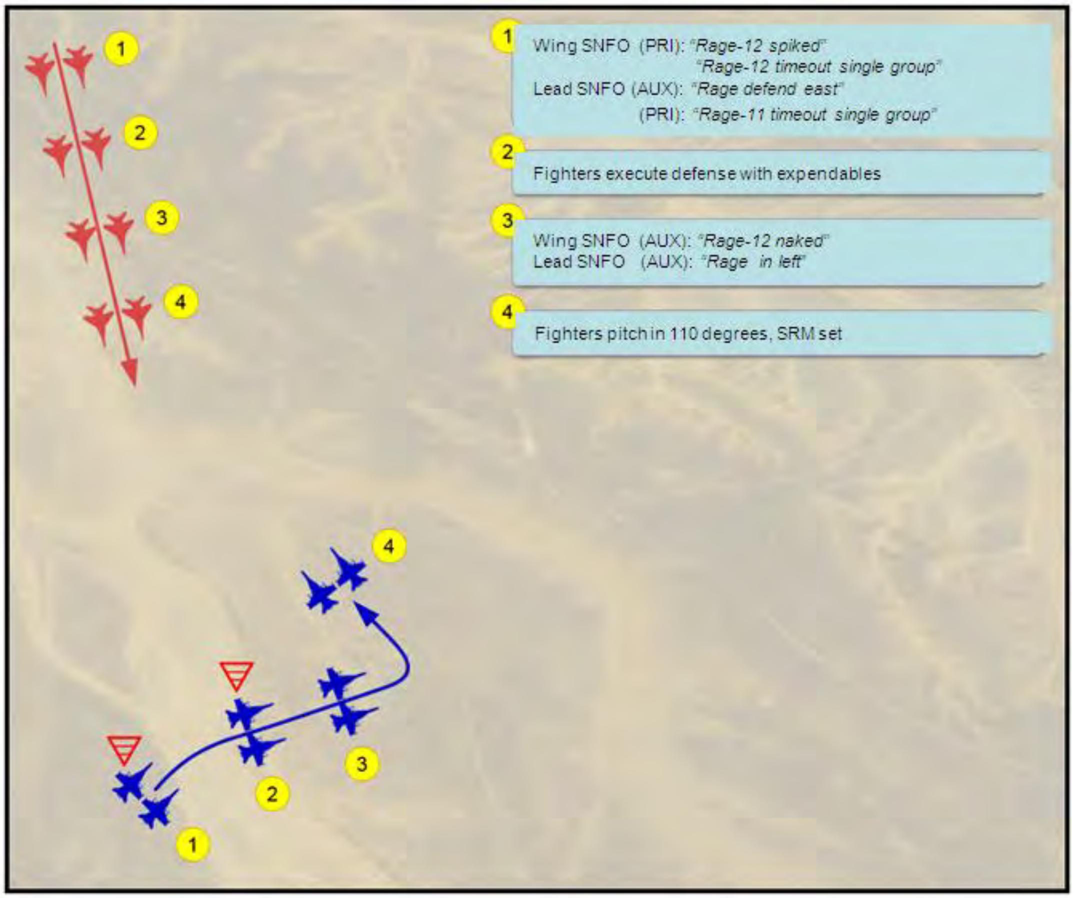

Figure 17-17 Banzai Geometry and Comm

5. **Skate**

"Skate" is a directive call to timeout missiles currently in flight and go out. Skate is executed from the crank. This is shown in Figure 17-18.

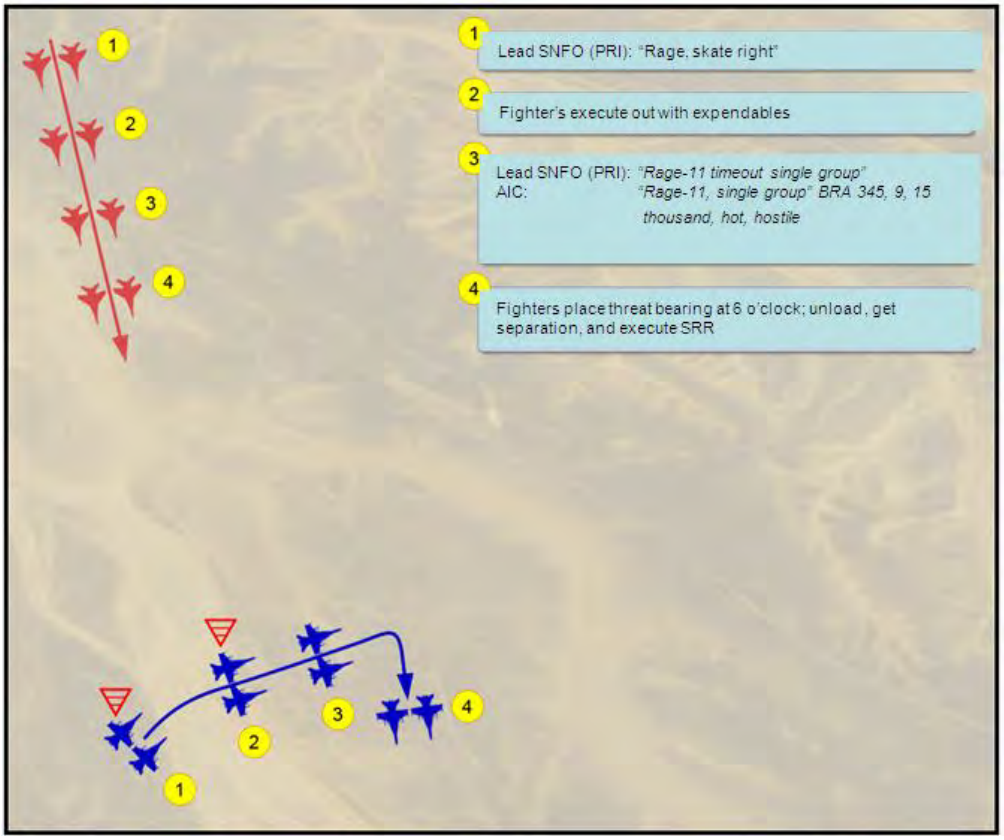

Figure 17-18 Skate Geometry and Comm

6. Minimum Defense Range

Minimum Defense Range (MDR) is the range at which the skate or banzai decision is executed, not the range at which the decision is made. In general in SRAs the fighters should:

a. Banzai against a single group when they are winning

b. Skate against a single group when they are losing

c. Either option is a defendable decision against a single, strength 3 group with two kills at timeout if the fighters are otherwise winning. Be prepared to defend the decision that is made.

In 2vX the fighters should:

a. Banzai when winning against the targeted group with separation of 30 NM from the closest, non-targeted group AND AIC has SA to the follow-on group

b. Skate in all other circumstances

i. If winning against targeted group and no SA to follow-on group(s)

ii. If losing against targeted group

The decision to skate or banzai may be defendable, even if executed against the guidance here. However, the SNFO choosing to deviate from this guidance must be prepared to defend the decision and discuss the consequences.

1715. SECTION SHORT-RANGE RADAR EMPLOYMENT

As with BVR radar employment, the section must coordinate short-range radar (SRR) mechanics in order to maximize their effectiveness. Section SRR procedures are used anytime the fighters clear merges or make a kill. SRR procedure is designed to rebuild the fighter's radar SA from short to long-range in preparation of flowing to the next group. If performed properly, SRR mechanics take approximately 30 seconds to accomplish. This means that a group at flow range of 30 NM will potentially be at 25 NM by the time the fighter gets a radar into the AOR and detect the follow-on group. Section SRR mechanics are:

a. Select SRM, BST and then WACQ

  i. This enters scan to clear flight path

  ii. Hold this for 10 seconds

b. Exit ACM mode to enter the SRM set RWS/20 NM/140/6B

  i. Mate at 10 NM

  ii. scan volume elevation set 1K above ownship altitude and below for Wing

  iii. scan volume elevation set 1K below ownship altitude and above for Lead

  iv. Hold for 10 seconds

c. Select MRM and enter RWS/80 NM/140/6B

  - Mate at 25 NM

Once the fighters have mated at 25 NM, follow-on targeting can occur. When flowing group to group, the fighters should be prepared to enter the timeline at the 30 NM tactical range call or less. With a group at flow range when the fighters merge with the first group, the follow-on group may be at meld when the fighters get radar SA to them. In that case, the fighter's first communication will be a meld call.

The key to short range employment as a section is coordination with AIC and strict adherence to the timeline on the follow-on group. If SA is high, the fighters can immediately meld, sort and employ on timeline to the follow-on group. Banzai may be an option.

In the event the fighters have low SA to the follow-on group and are employing behind timeline, they should skate or even abort.

The fighters should strive to target, meld, sort, shoot and crank on the follow-on group. If the timeline dictates, a meld call implies targeting.

1716. WVR SECTION EMPLOYMENT

Inside 10 NM, the fighters are within visual range (WVR). The fighter's priorities switch from radar mechanics, sanitization and employment to section engaged maneuvering. The fighter's priorities are:

- Maintain mutual support
- Get tallies
- Maintain SA
- Kill, or bug-out, together
- Minimize time-to-kill

1. **Mutual Support**

There are three types of mutual support: Visual, Sensor and Communication.

2. **Visual Mutual Support**

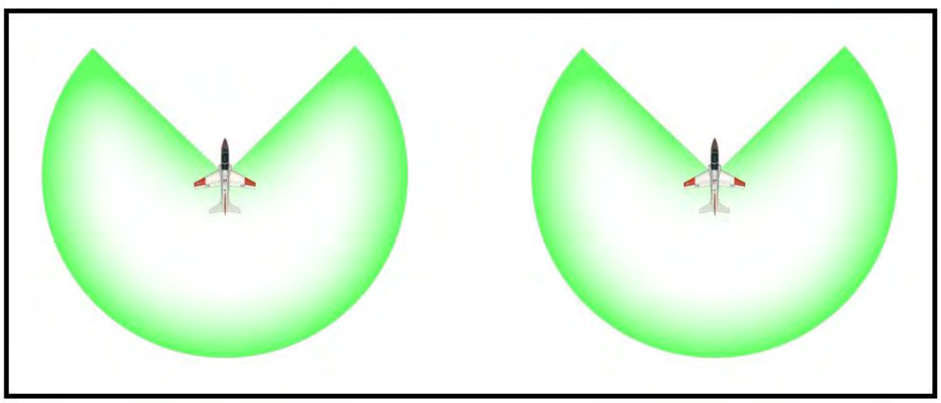

Figure 17-19 SNFO/WSO Visual Lookout AOR

When supporting each other visually, the pilots will visually clear their own aircraft's 10 to 2 o'clock as well as clear through the section while maintaining sight of the other aircraft.

The SNFO responsibility is to visually clear their own aircraft's 2 to 10 o'clock and outside the section. This is shown in Figure 17-19.

3. **Sensor Mutual Support**

Sensor mutual support (Figure 17-20) exists when one fighter has radar contact with the other, but is not visual. This may occur during or after a turning fight, or if the fighters become separated due to intercept geometry, such as in a VID scenario. The ability to discriminate which contact is friendly and which is the bandit in a turning engagement requires effective communication.

The fighter without a "visual" must use good sensor selection, be descriptive about own SA and work to obtain tally and visual. This should be done with clear, concise, SA building comm.

"Status" is a request for clear, concise, SA building information. For example:

Lead SNFO - "*Wolf 41, status*"

Wing SNFO - "*Wolf 42 engaged, offensive, 2-circle left turn, 15 thousand Vegas, 210/55*"

Or more specifically with a tally 2 a fighter can call "Hunter 21 tally two hi/low, status?"

If asked for status, a fighter should respond appropriately for the situation referencing their own aircraft position. An appropriate response to "*Hunter 21 tally two hi/low, status*" would be "*Hunter 22, high***.**"

Giving impertinent or too much information should be avoided such as "*Left turn coming nose-low passing 22, merging.*"

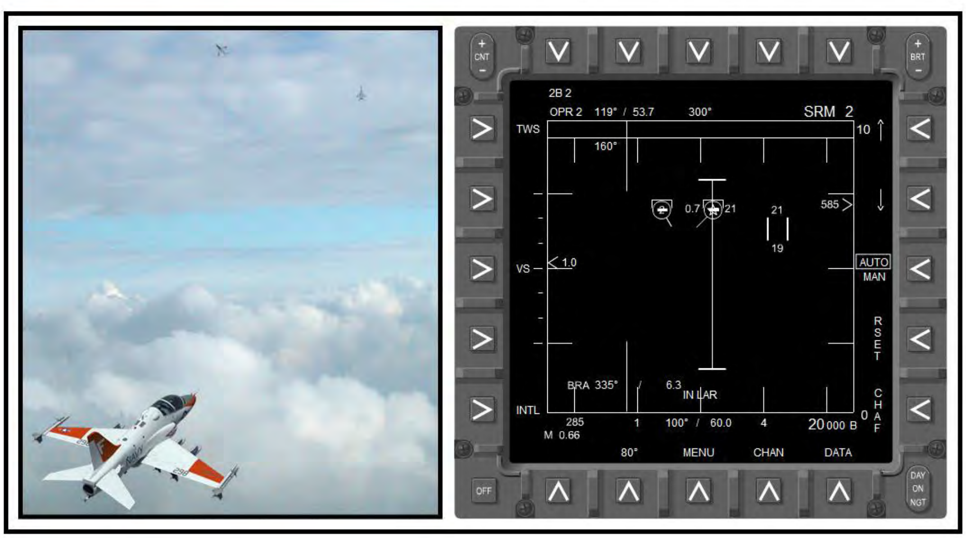

Figure 17-20 Sensor Mutual Support

4. **Support through Comm**

The goal of support through comm should be to establish sensor or visual support as soon as possible. Lead should describe their position and flow direction to Wing until sensor or visual support is regained. At a minimum, Lead should provide Wing with a direction and altitude or a destination to which flow should be initiated.

5. **Turn Decision**

The decision to turn or blow through is based on fighter SA prior to the merge. Generally, it is acceptable for the fighters to turn at the merge if tallies plus observed “fireballs” equals pre-merge radar SA raid count. . Turning with low SA against an unknown or unobserved number of bandits will likely result in unnecessary blue losses.

The fighters should not turn if they have low SA and instead should blow through the merge. To blow through, the fighters should:

a. Set up close to a 180 degrees pass with the remaining bandit(s) on the attack display.

b. At the merge (0 range on the attack display) unload to create separation.

If a tally is made at the merge and the bandit begins to turn behind the fighter, the fighters should execute a hard turn of 30 degrees across the bandits tail to keep the bandit at their 6 o’clock and assess intentions. As AIC regains the ability to discriminate bandits from fighter tracks, the fighters should adjust heading to gain maximum separation from the bandit.

Handling a bandit that is running down the fighters in a tail chase is beyond the scope of this training and will be taught in the Fleet.

6. **Minimizing TTK**

The key to the fighters flowing group to group if forced to turn is their ability to minimize the time it takes to kill the surviving bandits they are merging with. The fighters should:

a. Merge when required, but turn only with high SA.

b. Attrite to 2v1 prior to merge.

    i. Employ FQ SRM against hostile groups.

    ii. Maintain section mutual support.

c. Perform sound engaged maneuvering utilizing turning room for a quick post-merge kill if required.

7. **Section Engaged Maneuvering (SEM)**

The coordination of two fighters in visual air combat maneuvering against one or more bandit is the subject of more than one syllabus flight in the FRS and fleet training programs. It is a complex subject with an almost infinite number of possibilities, depending on fighter loadout, aircrew experience, bandit type and bandit pilot training. Since this subject is so complex, the information presented here should be recognized as a basic introduction to the concepts involved and not a definitive dissertation on the subject matter.

As previously stated, the goal of the fighter section inside 10 NM is to effectively coordinate their actions to minimize the time-to-kill with the bandits they are merging with while maintaining section mutual support. The first step in this coordination is getting a tally on the surviving bandit(s).

8. **Lookout Doctrine**

The importance of disciplined lookout doctrine by both aircrew cannot be over emphasized (Figure 17-21). The SNFO is responsible for clearing his aircraft's six and outside the section. The pilot is responsible for clearing 10 to 2 o'clock and inside the section. To aid in getting a tally, aircrew should focus on a distant cloud or the horizon momentarily to get their eyes focused out at range instead of inside the cockpit. Then, they should perform a disciplined visual scan pattern by looking first at the extremes of high and low then work toward the horizon. Because the eye detects movement, aircrew should not move their eyes. Rather, they should fix their focus into the current block they are scanning and look for the relative motion of the bandit against a near static background.

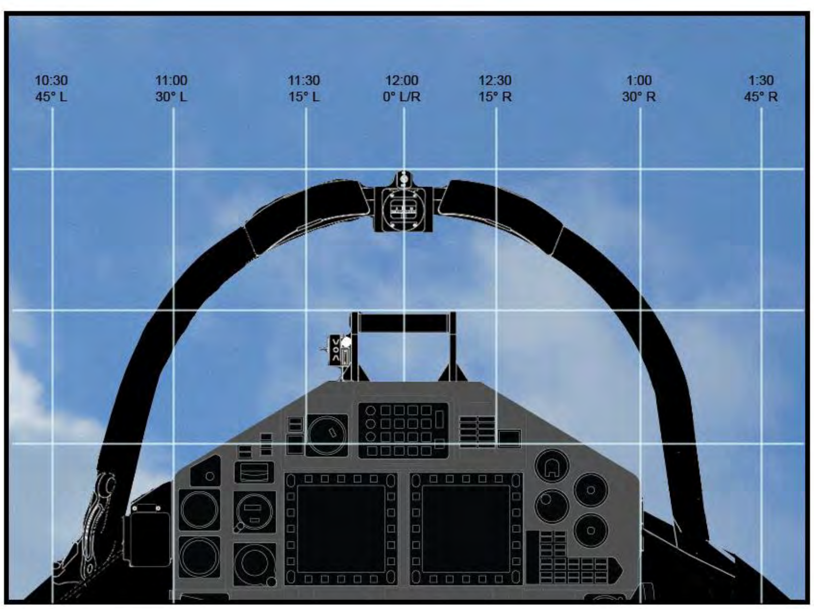

Figure 17-21 Visual Lookout from the Rear Cockpit

The SNFO should continue with AREO calls until the pilot calls tally. If the SNFO gets a tally first, use standard comm to talk the pilot's eyes onto the bandit. SNFOs should be directive over descriptive, and tell the pilot how to maneuver the aircraft while talking the pilot's eyes onto the bandit.

9. **Establishing Roles**

With a tally, the priority is to make a merge happen. Using BFM principles, the fighters must honor the bandit's nose and make their individual merges happen with as much advantage as possible. Once both fighters have cleared the merge they can establish roles of engaged or free.

As a general rule, the engaged fighter is:

a. The most defensive

b. The most offensive

c. Last to merge

d. Flight Lead

The engaged fighter has the following responsibilities:

a. Survive

b. Kill

c. Make bandit predictable

d. Fly good BFM

The responsibilities of the free fighter are:

a. Keep visual mutual support/lookout while gaining separation (turning room)

b. Kill the bandit

c. Maintain overall SA (location; fuel)

If the fight is drawn out, the fighters will likely reverse roles several times. The key to minimizing time-to-kill is:

a. Using effective, clear and concise communication

b. Making the bandit predictable

c. Recognizing employment opportunities and taking them

d. Flying their best BFM when engaged

e. Extending for adequate weapon separation when free

Once roles are established the fighters should work out of phase and out-of-plane to keep one fighter on each side of the bandit's canopy. A simplified example of this is shown in Figure 17-22.

10. **SEM Example**

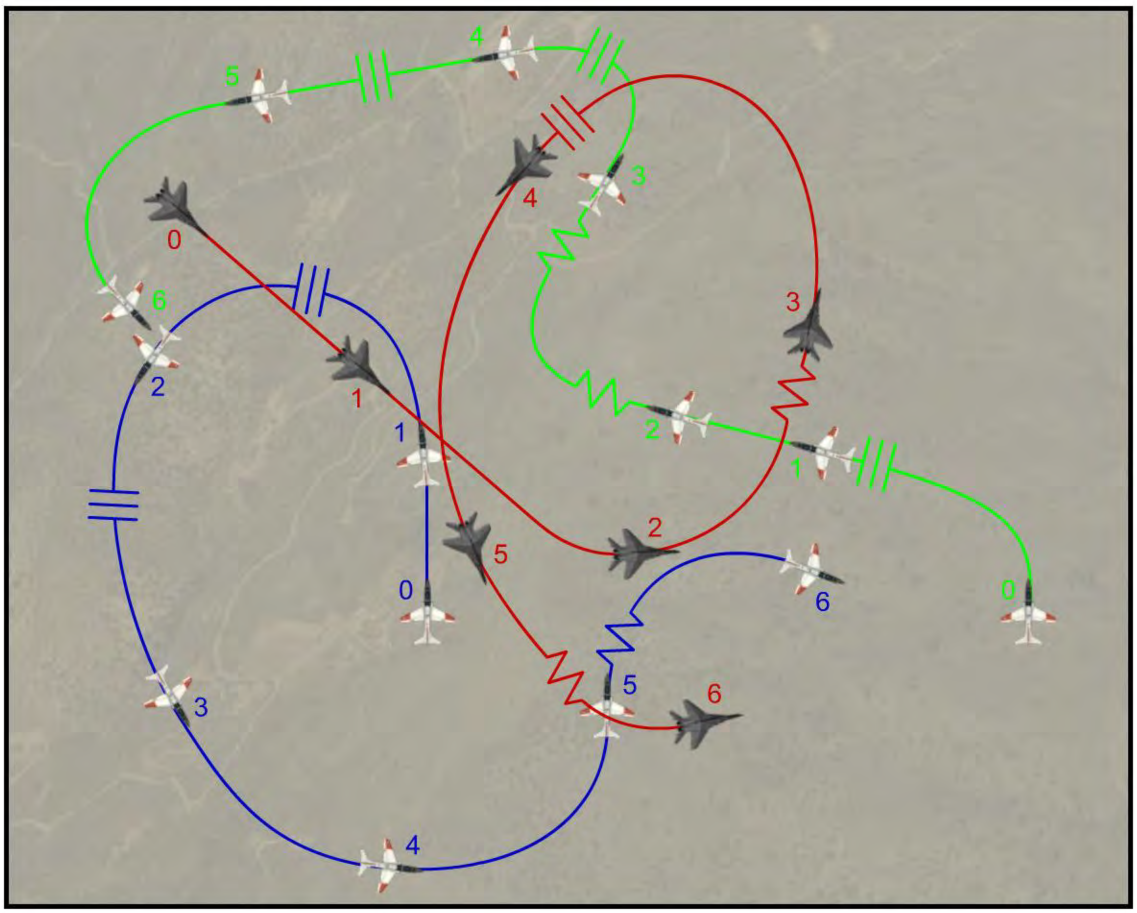

Figure 17-22 A Typical SEM Engagement

In Figure 17-23, the fighters begin at position 0 with a tally on the bandit in combat spread with Wing stepped up 3,000 feet and the bandit co-altitude with Lead. The Lead fighter is the blue line, Wing is the green line and the bandit is red. The fight, with comm progresses as follows:

T = 0

Lead SNFO (AUX) - "*Eagle 11 tally one 11 o'clock*"

Wing SNFO (AUX) - "*Eagle 12 tally one*"

Both fighters turn to make as neutral a merge as possible happen with the bandit. Both fighters are engaged.

T = 1

Lead Pilot (AUX) - "*Eagle 11 engaged left hand two-circle*"

Wing Pilot (AUX) - "*Eagle 12 turning right nose-high, one-circle*"

Lead merges with the bandit and turns left, nose-low to create two-circle flow. Wing descends to meet the bandit. Both fighters are engaged. Wing must make a merge happen while Lead is turning to engage. Wing declares his intent to turn right and nose-high tie up the bandit in one-circle flow.

T = 2

Wing Pilot - "*Eagle 12 engaged nose-high right one-circle*"

Lead Pilot - "*Eagle 11 free extending*"

Wing assumes the engaged role by turning right and nose-high to match the bandit's maneuver. Lead attempts to extend to the South to gain weapons separation.

T = 3

Wing Pilot - "*Eagle 12, switch switch, he's coming to you*"

Lead Pilot - "*Eagle 11 engaged*"

After one pass of Flat Scissors, the bandit turns nose-low to engage Lead. Wing recognizes the opportunity to become free and calls for the switch

T = 4

Lead Pilot - "*Eagle 11 defensive*"

Wing Pilot- "*Eagle 12 free extending*"

Lead recognizes he is defensive against the bandit and turns to defend and honor the bandits nose while Wing gains weapons separation.

T = 5

Lead Pilot - "*Eagle 11 nose-high right one-circle*"

Wing Pilot - "*Eagle 12 shot in 3*"

Lead merges defensively with the bandit, recognizing that he has given up angles in his previous attempt to get free. Lead turns right and nose-high to force one-circle flow. Wing has extended and is approaching weapons employment opportunity.

T = 6

Lead Pilot - "*Eagle 11 defending right*"

Wing SNFO - "*Eagle 12 Fox-2*"

Lead defends against a potential bandit gunshot. Wing has achieved weapon separation and employs an SRM.

This example highlights the mix of comm brevity and plain language that may be used to execute a coordinated attack in the visual environment. When communicating, the fighter's should remember:

a. Strive to use comm brevity wherever possible

b. Use plain language if comm brevity does not fit or is not descriptive

c. Keep transmissions short; prioritize directive over descriptive

d. Do not pass inaccurate information

1717. VISUAL IDENTIFICATION PROCEDURES

A "bogey" declaration presents the fighters with a very dangerous situation. If the identity of the group remains bogey throughout the intercept, the fighters will be forced to visually identify the aircraft and then likely enter a visual turning fight if the group is visually identified as hostile. In order to survive when faced with this situation, the fighters must rely on sound execution.

Bogey groups may receive priority targeting above bandit or hostile groups if they meet commit criteria based on the type of mission and its objectives. A bogey group in the battlespace is a true unknown, and every friendly asset will be working to identify that group's identity.

1. Visual ID Execution

Visual Identification (VID), if required for mission accomplishment, is directed if there is a bogey declaration, or no declaration, by 10 NM. The fighters should establish "eyeball" and "shooter" roles. The eyeball will make the VID while the shooter will employ immediately on its sort contract if the group is visually identified and declared hostile. VID role establishment Comm is:

Lead SNFO (AUX) - "*Sherpa 11 eyeball*"

Wing SNFO (AUX) - "*Sherpa 12 shooter*"

Although either aircraft may assume either role, all things being equal, Lead will make the ID and Wing will be the shooter. Wing should establish 3,000-5,000 feet of vertical separation from Lead and adequate SRM employment separation, while maintaining visual of lead in order to gain a tally at the merge.

Lead should then attempt to perform a stern conversion on the bogey group to make the ID. If the group forces the merge, Lead will then set up for a close aboard, high aspect pass with his sort contact.

Wing's responsibility is to be tally two, visual when Lead merges and makes the ID. If hostile, Wing should immediately employ to kill one at the merge. With one bandit destroyed, the section can then transition to SEM. The fighters should minimize TTK, then flow to the next engagement.

2. **VID Comm**

When making the ID, the eyeball uses the directive comm: "*shoot, shoot*" or "*skip it*" and identify the aircraft by its NATO codename. For example:

Lead SNFO (PRI) - "C/S, standby (group name)"

Lead SNFO (PRI) - "*Shoot, Shoot, FULCRUM*"

Wing SNFO (PRI) - "*Fox-2*"

Or

Lead SNFO (PRI) - "*Friendlies, friendlies, skip it*"

When properly executed, a VID against a group visually identified as a hostile should result in one kill at the merge by the shooter and another shortly thereafter by the eyeball.

1718. CONTINGENCIES IN THE SRA AND 2VX ENVIRONMENT

1. **Abort**

If the fighters have no SA to the targeted group by 15 NM the fighters should abort. Abort is a "tactical emergency procedure." When the fighters abort they will execute a maximum performance nose low slice to place the threat at their six o'clock position and accelerate to maintain maximum separation.

Abort is maximum performance, 135 degree overbank, nose slicing turn to put threat a 6 o'clock position and should not be confused with skate, which is an informed decision to go out.

Comm for the abort is "*Callsign, Abort, Reference (heading)*."

2. **Bent Gadget/ECM**

In the event one fighter's radar suffers a failure during the intercept, the fighters should maintain visual support and plan to skate. The fighter with a working radar should employ one MRM against each trackfile in the targeted group from TWS.

If neither radar is working, the fighters should abort no later than 20 NM.

3. **Presence of ECM**

Anytime ECM is present it can seriously degrade radar and missile performance. If the fighters encounter ECM, they should execute the briefed counter ECM plan by changing modes and channels until a functional combination is obtained.

The presence of ECM indicates the bandits are aware, regardless of their aspect.

1719. SECTION EMPLOYMENT SUMMARY

The fighter section is the smallest unit expected to employ autonomously in the air-to-air environment. The timeline is the same for SRA as 2vX. Keys to success as a section start with proper planning and briefing. Once airborne, success depends on proper formation management, effective, coordinated sensor employment, knowing and adhering to the timeline, executing tasks on time and effective communications.

Section tactical employment is a very dynamic environment. The principles in this chapter serve as a foundation for training at VT-86 and building blocks for future training in the fleet.

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CHAPTER EIGHTEEN
THE SELF ESCORT STRIKE ROUTE

1800. INTRODUCTION

A self-escort strike is a mission in which the strike aircraft are expected to provide their own defense and response to air-to-air threats during ingress to and egress from the target area. The "strike route" more closely simulates the multitasking demand of modern fighters. SES is a culmination of skills from Strike (A/G) and AWI (A/A) stages. SNFOs are expected to:

- Build a mental picture of the special relationships between the fighter, planned strike route, target and multiple threat groups

- Effectively transition from the air-to-air to air-to-surface mindset and vice versa during mission execution

- Make sound decisions with regard to targeting, threat avoidance and target attack timing

1801. ROLE OBJECTIVES

1. **Role**

The role of a strike fighter on a self-escort mission is complex. SES missions are characterized by the fighter having a limited air-to-air load out based on the necessity to carry air-to-surface weapons to destroy the target.

The key to SES is recognizing that the primary mission is to strike the target, on time, with the correct amount of ordnance. The air-to-air portion of the mission is secondary and executed as required only for self-protection. That being said, the fighters cannot strike the target if they get killed or if they are forced to jettison their ordnance in order to survive.

2. **Objectives**

Specifically stated, the objectives of the SES at VT-86 are:

a. Bombs on time, on target (BOTOT)

b. Target all factor groups

c. No blue losses

1802. SCENARIOS/THREAT

1. Scenario Generation

The SNFO will be required to generate a scenario in which the SES mission will occur. The scenario may be based on current events. The scenario briefed should include all of the information listed below. The scenario should build a framework of geographical and political factors that are behind the military's involvement in the situation. An example of a simple scenario:

> *"The country of Escambia has been providing a safe haven for pirate activity in the Gulf of Mexico. NATO has responded with an increased naval presence centered on Carrier Strike Group 2 (CARSTRKGRU 2, or CSG-2) based on the USS George H.W. Bush (CVN-77). The coalition task force is conducting interdiction operations from port of Panama City to Gulfport to destroy or disrupt potential pirate activity. The Escambian military has responded to the presence of the task force with an increased defensive posture, including active air patrols inside their air space."*

The scenario should include a description of threat nation, reasons for military action and how that action is being accomplished.

2. Mission Statement

The mission statement is a statement that clearly identifies the purpose for the mission. The briefing officer needs to explain how the fighter's mission fits into the bigger picture of a larger campaign without spending an inordinate amount of time on the subject.

The mission statement should serve as a foundation by which mission success or failure can be measured. This can be done by giving a brief explanation of the "Commander's intent" for the outcome of the mission. Blue losses will not be acceptable. A typical mission statement may be:

> *"Our mission is to destroy the ATC radar site at NAS Pensacola in order to degrade the enemy's ability to coordinate their air defense assets. Target destruction is desired; blue losses are not acceptable"*

3. Threat

The threat for self-escort strike will be comprised of both surface and air threats. The air threats will be a MiG-29 or Su-27 series aircraft with a AA-10 SAR missiles with a maximum range of 15 NM and a AA-11 IR missiles with 3 NM FQ and 1.5 NM RQ WEZ.

The surface threat should include at least one medium range, surface-to-air (SAM) system. Anti-aircraft artillery (AAA) is expected below 15,000 feet in all scenarios, as are MANPADS below 10,000 feet.

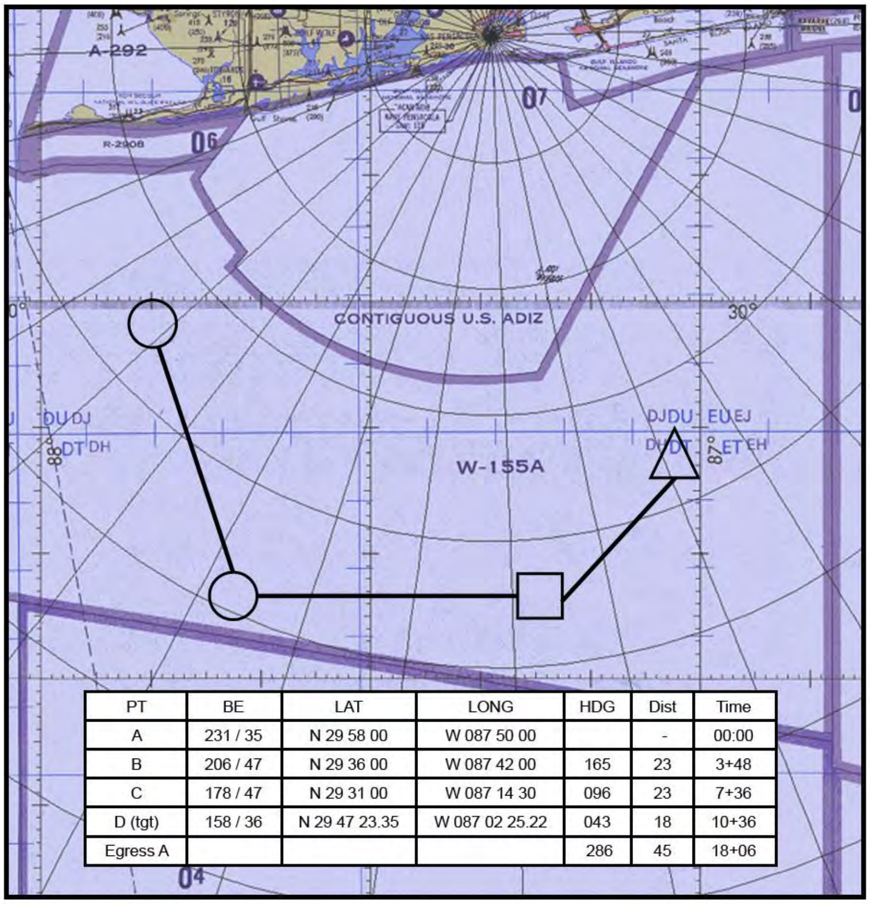
All threat information can be summed up by the enemy's order of battle (EOB). The Air Order of Battle (AOB) and Ground Order of Battle (GOB), which includes SAMs, should be briefed by the briefing officer.

1803. ROUTES

SNFOs should refer to the latest STAN notes and the latest edition of the briefing guide for the most current list of routes, waypoints, GeoRefs and other pertinent information. The WHODAT will be the primary SES area. If any other area is briefed (i.e., PNSS MOA, DESOTO MOA, etc.) route information and restrictions need to be thoroughly briefed.

SNFOs should produce route cards (Figure 18-1) that include at a minimum:

- SNFO names and route number
- Bullseye
- Route points and labels, including bullseye location of route points and target
- ETAs for route points and distances
- Point coordinates



PT	BE	LAT	LONG	HDG	Dist	Time
A	231 / 35	N 29 58 00	W 087 50 00		-	00:00
B	206 / 47	N 29 36 00	W 087 42 00	165	23	3+48
C	178 / 47	N 29 31 00	W 087 14 30	096	23	7+36
D (tgt)	158 / 36	N 29 47 23.35	W 087 02 25.22	043	18	10+36
Egress A				286	45	18+06

Figure 18-1 Typical Route Card for W-155A

1804. THREAT PRESENTATIONS

SNFOs should expect multiple group presentations on both the ingress and egress portions of the route. These groups may or may not be a factor to the mission. A solid set of commit criteria and a targeting plan should be briefed to accommodate up to two groups in the picture, with one affecting the route at any given time.

Both friendlies and hostile aircraft will be present. At a minimum, the brief should cover:

- Suppression of Enemy Air Defense (SEAD) plan for EA-18G/EA-6B; time on station
- Expect jamming platform to turn "music" on at your pre-planned IP time
- Controlling agency (E-2) callsign and location

Multiple friendly and bandit/unknown groups will clutter the picture. Clear, concise and SA building communications are key to success. Correlation will be important to avoid potential fratricide (blue on blue) or blue on white (commercial or private air traffic).

1805. COMMUNICATIONS

The SNFO will brief and use simulated exercise communications for the SES route. Simulated exercise communications will be transmitted on PRI. "*COMEX, COMEX, COMEX.*" (Commence exercise) will be called two-minutes prior to the start of the route. At that point, AIC will start building the picture with broadcast control, anchored to bullseye.

At push time, the fighters will call, "*Hammer, push*" to inform all players that the fighters are starting the route.

At the IP, the fighters will call "*Hammer, IP inbound*" to inform all players that they are beginning the target attack. This is on PRI in addition to the *"Attack"* call the fighters give as part of their target attack.

If the fighters are off the route due to an intercept and need to proceed directly to the IP rather than return to the route, the call "*Hammer, target direct*" can be used to inform all players of the fighter's intent. This call is made to ensure that AIC and all fighters understand the intent of the fighters is to proceed with the target attack and not flow group to group.

Both the "IP inbound" and "target direct" calls are used as SA building calls to ensure all strike assets are aware of the striker's intentions.

Finally, once the last striker has delivered ordnance on the target, the call "*Hammer, Miller time*" will be made on PRI to inform all assets that the strikers are egressing the target area.

1806. TIMING PROBLEMS AND CORRECTIONS

The real challenge of SES is integrating a required air-air intercept into the strike timing problem using a preplanned route. Route planning considerations, taught in earlier stages of training, provide useful tools when faced with an air threat delaying the fighters along the route. Specifically, a nonlinear path from the push point to the IP affords the strikers the opportunity to use time and distance geometry to correct for delays along the route. Without this preplanned geometry, there is no way the fighter can make up time proceeding directly to the IP or target after prosecuting an airborne threat.

1. **Setting TOT**

Time on target (TOT) will be determined and briefed by the Lead SNFO using whole minutes. For strike execution a 1 minute TOT window is acceptable using TOT +/- 30 seconds. For example, a TOT of 10:17 means bombs on target no earlier than 10:16:30 and no later than 10:17:30.

2. **Correcting Timing**

The SNFO should use all available cues (SA page, HSI, spider card) to maintain positional awareness to the target. A 35 NM intercept from commit through merge may take 3+ minutes and large deviations off the route may create timing problems. Understanding the geometry of the route is the key to fixing timing problems that develop and making the TOT window.

Prioritize using route geometry over speed increases for timing corrections. This is a real world factor since strike fighter aircraft are always fuel limited, as are T-45's. Set ground speed to meet timing gates at either 300 KGS=5 miles/minute, 360 KGS=6 miles/minute. The target leg MUST be run at no less than 300 KGS, with 360 preferred.

If early, the fighter should use an offset prior to the IP to delay if the tactical situation allows it. If late, turn direct to the IP or target to make up the difference.

The air-to-air intercept can draw a fighter far from the planned route. SNFOs need to be cognizant of their location in relation to the planned route and drop/reset against groups that no longer meet commit criteria. The call from the fighters should be:

LEAD SNFO (PRI) - "*Hammer, drop West group BRA 160, 28*"

AIC should then pick up monitoring the group while the fighters resume the strike route.

3. **Back Up TOT**

As a last resort, the SNFO can request a backup TOT from the instructor prior to the planned IP time. The new TOT should be communicated with *"Tiger-11, new TOT 10:19."* As before, TOT is given in whole minutes.

1807. WEAPONS DELIVERY

Weapons delivery for SES will be in accordance with Strike Stage Standards as delineated in the current Strike STAN notes. SNFOs should plan on a radar aided PGM delivery on a pre-briefed waypoint unless a target of opportunity is provided.

1808. EVENT BRIEFING AND EXECUTION

1. **Brief**

As with 2vX, a successful Self Escort Strike flight begins with a professional brief. The briefing should include all 2vX considerations as well as a target acquisition and attack considerations. See the STAN notes for the latest SES board layout.

2. **Execution**

a. System Setup: Radar - The fighters should call "COMEX" when established and ready to proceed with the event. MRM sanitization set, A/A waypoints, GeoRefs on the HSI and sequences for the route and the area should all be briefed, selected and displayed prior to COMEX. In the MRM sanitization set, the fighters are covering an enormous amount of area (Figure 18-2). The SNFO needs to recognize what a contact on the edge of the attack display means in relation to the strike route.

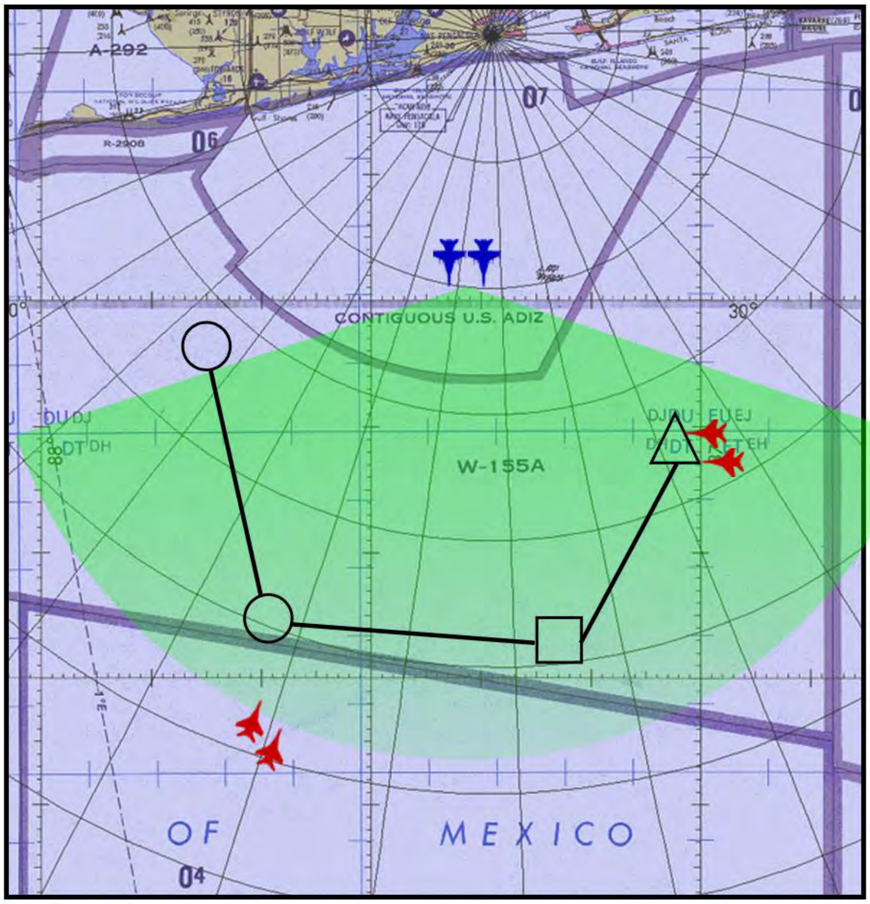


Figure 18-2 Radar Coverage

b. System Setup: Navigation - In the OFT, the HSI should be set up per SOP for strike flights. This may include:

i. Route sequenced

ii. Area Sequenced

iii. GeoRefs per SOP

iv. TACAN A/A

v. Waypoint - manual per SOP

c. In the VMTS T-45, the SA page should be set up to display the following

i. Route sequenced

ii. Area Sequenced

iii. GeoRefs per SOP

iv. A/A Waypoint – 0

v. AIR and GROUND Boxed

vi. AUTO per SOP

3. Event Flow

The SES event sequence will flow as one scenario beginning with the COMEX call and ending with a KIO. The fighters will begin the route, build the picture, commit, target, complete the intercept, decide whether to flow group to group, perform a PGM attack on the target, and egress without breaks or reloads. If possible, the route will be run twice, with a new COMEX call following the first *"knock it off."*

The SNFO should apply all concepts from 2vX and consummate A/A engagement if required for self-protection on the ingress and for survival on the egress. The fighters should use geometry to stiff arm hostile groups if possible. The fighters may be required to VID on either the ingress or egress and should be prepared for any air-to-air situation they have previously encountered in training, to include ECM and deceptive tactics on the part of the enemy.

Specific training objectives for the SES events are:

a. Target factor groups

b. Bombs on time, on target

c. Section mutual support to kill/survive

The priority is to strike the target and survive to return home. This should drive all of the fighter's decision making.

4. Commit Criteria

The fighters should adhere to the 2vX timeline for both ingress and egress, with a 35 NM NLT commit on groups showing flank or less aspect. The fighters should assume the any contact with less than 60 TA has radar SA to the fight. Also, any presence of ECM indicates that the bandits are aware of the fighter's presence.

5. **Post Commit Geometry**

The fighters must consider post commit intercept geometry as it will affect the route, follow-on group to group flow and route timing. Applying aggressive offsets to turn echelon or azimuth presentations into range problems can severely impact timing on the route. If the fighters adhere only to the planned route, they will likely find themselves in tactically disadvantageous positions.

The fighters should always target factor groups while closely monitoring reset/resume criteria to avoid getting pulled too far off the route. Follow-on group flow and route geometry will determine how the fighters will set geometry after the commit.

6. **30 NM, Meld and Sort**

As in 2vX, 30 NM will remain flow range. The 30 NM tactical call will be given to remind all fighters and AIC that the section is 30 seconds from meld on the targeted group.

Meld and sort should be on timeline as performed in 2vX. Lead will employ from TWS and Wing from STT. The flight should maintain section visual support throughout the intercept and should use AIC to maintain SA to untargeted groups.

7. **MRM Employment, Crank, and Decision Range**

The fighters should employ on timeline in accordance with the 2vX employment tree. The fighters should then immediately crank with the following priorities:

a. Away from follow-on groups/threats

b. Cold on targeted group

c. Area management

d. Toward strike route

The fighters should plan to banzai unless a tactical situation is presented that dictates they skate.

8. **Timeout and Flow**

Fighters should timeout their weapons and execute the standard 2vX timeline procedures, coming nose-on at 10 NM and minimizing the time-to-kill with surviving bandits. Forward quarter SRM and execution of efficient section engaged maneuvering are keys to minimizing TTK.

Group to group flow should begin with disciplined execution of SRR mechanics once section visual support has been regained. Anticipate that the fighters may be faced with an immediate meld to a follow-on group and be prepared to execute on timeline without delay. Flow decisions into follow-on groups must be made using the same considerations of geometry, threat locations, and strike route. SNFOs are responsible for managing follow-on group geometry and applying these considerations.

If there is a group in the vicinity of the target, or between the target and IP, that is hot to the fighters, then making the planned TOT is unlikely. A request for a new TOT should be issued, and the fighters should flow into the next engagement as in 2vX, prior to executing the target attack.

A group that is in the fighters beam or flank position (60 degrees AO or greater on the attack display) away from the route or a path directly to the target will not be a factor during the target attack. However, this group may close the distance and become an immediate factor to the fighters once they are off target, but should not impact the fighter's target attack decision or execution.

Third, any group that is not a factor on the ingress will still be alive and may be a factor on egress. Target only factor groups. Fighters on the way home shouldn't be looking for a fight, especially when they are low on fuel and air-to-air weapons.

9. Target Area Commit and Target Attack

The decision to attack a target or commit on an airborne threat in the vicinity of the target is called target area commit criteria. At VT-86, SNFOs should make a picture call at the IP. If the Lead SNFO assesses that the fighters can flow to target, release ordinance, and have flow range to the called group at weapon impact, the fighters will attack the target. If range to the follow-on group is expected to be less than flow range at weapon impact, the fighters must target the follow-on group and take that intercept to a logical conclusion at the expense of striking the target.

At VT-86, the SNFOs can expect that there will not be bandits in the target area. However if there are:

a. Request new TOT (2-3 minutes) or abort attack

b. Employ on time

c. Consider employment of a P_K enhancing MRM

d. Flow toward target

The fighters should also remain cognizant of the surface to air threats in the area, and whether the bandits are attempting to drag the fighters into a SAM WEZ by their actions.

10. **Target Attack**

The target attack is the same PGM attack used in Strike Stage. It is shown in Figure 18-3 as a reminder.

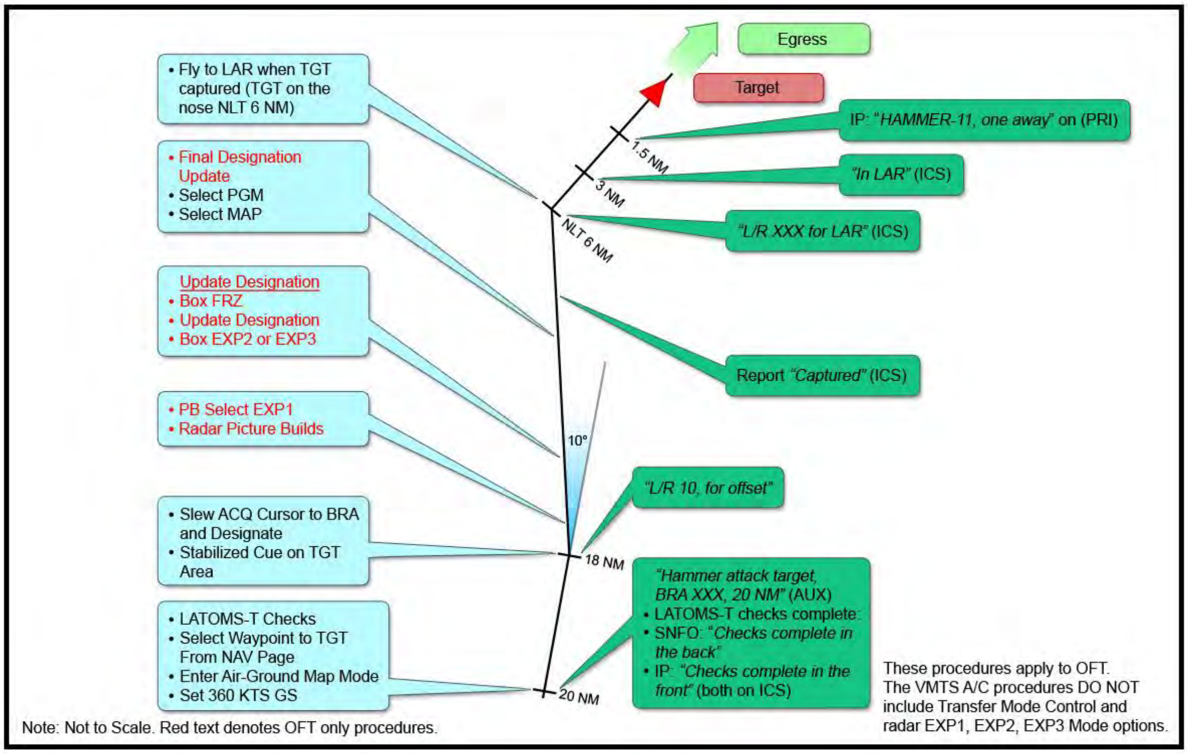


Figure 18-3 VT-86 SOP Sensor Aided PGM Attack

11. **Egress**

At "*Miller time*" the fighters should execute short range radar procedures and begin to rebuild the picture. The SNFO should select steering back to the push point. The Lead SNFO will direct the flow of the flight.

Lead SNFO (AUX) - *"Hammer, flow 270"*

Lead SNFO (PRI) - *"SABRE, Hammer Vegas 160/70 flow west, picture"*

AIC will assist the fighters in their egress by providing tactical control. The fighter should sanitize their AOR during egress to cover gaps in AIC coverage.

The fighters must remember that they have to survive and RTB. A speed increase can be used, fuel permitting. Stiff-arming groups is preferred to being drug off the egress route. Be alert, separate and avoid being dragged back into the SAM threat ring. Mission commanders should be decisive and disciplined. Lazy execution against an aggressive bandit will get the fighters shot down over hostile territory after they have released their bombs.

1809. SUMMARY

SES is the culmination of all of the skills the SNFO has acquired during flight training from start to finish. SNFOs are expected to demonstrate airmanship, leadership and sound headwork in a tactical environment to achieve mission success. The air-to-air employment of the section must be sound and flow seamlessly into air-to-ground employment.

SES at VT-86 is the closest thing to a “real world” Strike/Fighter mission in the NATRACOM. Keep in mind that there are often multiple solutions to any tactical presentation. SNFOs should rely on their training, good headwork and application of sound tactics to accomplish the mission.

APPENDIX A
MULTI-SERVICE TACTICAL BREVITY CODES

Abort(ing)(ed)	Directive/informative to cease action/attack/event/mission
Action	Directive to initiate a brief attack sequence or maneuver
Active	An emitter is radiating
Alpha Check	Request for/confirmation of ownship bearing and range to described point
Anchor(ed)	1. Orbit about a specific point; reference point flown by tanker 2. Informative to indicate a turning engagement about a specific location
Angels	Altitude of friendly aircraft in thousands of feet MSL
Azimuth	Two or more groups separated laterally in bearing
Bandit	A positively identified enemy aircraft. The term is a function of identification and does not necessarily imply direction or authority to engage.
Beam(ing)	Target maneuvering stabilized within 70 to 110 degrees aspect; generally given with cardinal directions; east, west, north, or south
Bent	System indicated is inoperative
Bingo	Prebriefed fuel state which is needed for recovery using prebriefed parameters
Bird	Friendly surface-to-air missile (SAM)
Bittersweet	Notification of possible BLUE ON BLUE situation relative to a designated track or friendly aircraft
Blind	No visual contact with friendly aircraft/ground position. Opposite of Visual.
Blow Through	Directive/informative call that indicates aircraft will continue straight ahead at the merge and not turn with target/targets
Bogey	An unidentified air contact
Bogey Dope	Request for target information as requested or for the closest group in BRAA

BRAA	Format of tactical control providing target bearing, range, altitude, and aspect from fighter
Bracket	Indicates geometry where friendly aircraft will maneuver to a position on opposing sides, either laterally or vertically from the target
Break (direction)	Directive to perform an immediate maximum performance turn in the direction indicated. Assume a defensive situation.
Broke Lock	Loss of radar/IR lock (advisory)
Buddy Lock	Locked to a known friendly aircraft
Bugout (direction)	Separation from that particular engagement/attack/operation; no intent to re-engage/return
Bullseye	An established point from which the position of an object can be referenced by bearing and range.
Buster	Directive call to fly a max continuous speed (military power)
CAP/Capping	1. Directive call to establish an orbit at a specified location 2. An orbit at a specified location
Capture	Aircrew has identified and is able to track a specified A/G target with an onboard sensor
Cease Engagement	In air defense, break the engagement on the target specified and prepare to engage another target. Missiles in flight will continue to intercept.
Cease Fire	Do not open fire, or discontinue firing; missiles in flight are allowed to continue to intercept; continue to track
Chattermark	Begin using briefed radio procedures to counter communications jamming
Check (Left/Right)	Turn degrees left or right and maintain new heading
Cherubs	Altitude of a friendly aircraft in hundreds of feet above surface (usually refers to helicopter traffic)
Chicks	Admin term used to denote friendly aircraft
Clean	1. No radar contacts on bandits, bogies or aircraft of interest 2. No visible battle damage
Cleared	Requested action is authorized (no engaged/support role are assumed)

Cleared Hot	Ordnance release is authorized
Closing	Decreasing in range/separation
Cold	1. Attack geometry will result in a pass or roll out behind the target 2. On a leg of the CAP pointed away from the anticipated threats 3. Threat group heading away from fighters
Come off	(Left-Right/Low-High) 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."
Commit(ted)	Fighter intent to engage/intercept groups of interest
Cons/Conning	Unknown/non-friendly aircraft leaving contrails
Contact	1. Sensor contact at the stated position 2. Acknowledges sighting of a specified reference point
Continue	Continue present maneuver, does not imply clearance to engage or expend ordnance
Crank	Maneuver to put target at gimbal limits to manage target weapons envelope
Cutoff	Request for, or directive to intercept using cutoff geometry
Dash (#)	Aircraft position within a flight. Use if specific callsign is unknown.
Deadeye	Informative call by the laser designator indicating the laser/IR system is inoperative
Declare	Inquiry as to the ID of a correlated group, a specific track, or target
Defensive	(Spiked/Missile/SAM/Mud/AAA) Aircraft is in a defensive position and maneuvering with reference to the stated condition and unable to ensure deconfliction of mutual support.
Divert	Proceed to alternate base
Drag(ing)	1. (AF) Target maneuvering to 0-60 degree aspect 2. (NAVAL) Target maneuvering to 120-180 degree aspect
Drop(ing)	Directive/informative to stop monitoring a specified emitter/target and resume search responsibilities

Echelon	Fill-in to a picture label describing groups aligned behind and to the side of the closet group.
Engaged	Maneuvering with the intent to kill. If no additional information is provided (bearing, range, etc.) this implies visual/radar acquisition of target
Estimate	Estimate of size, range, height or other parameter of a specified contact; implies degradation
Extended	Short term maneuver to gain energy, distance or separation; normally with the intent of re-engaging
Eyeball	Fighter with primary visual identification responsibility
Faded	Radar contact is lost on unknown/non-friendly contact
Father	TACAN station
Feet Wet/Dry	Flying over water/land
Fence (In/Out)	Set cockpit switches as appropriate prior to entering/exiting the combat area
Fireball	Visual confirmation an air-to-air contact has been destroyed
Flank(ing)	1. (USAF) Target with a stable AA of 120-150 degree 2. (NAVAL) Target with stable aspect of 30-60 degree
Flash	Temporarily torn on prebriefed IFF mode or system
Float	Directive/informative to expand the formation laterally within visual limits to maintain a radar contact or prepare for defensive response
Fox (number)	Simulated/actual launch of air-to-air weapons ONE- semi-active radar-guided missile TWO- Infrared-guided missile THREE- active radar-guided missile
Friendly	A positively identified friendly contact
Furball	A turning fight involving multiple aircraft; non-friendly and friendly aircraft are in close proximity
Gadget	Radar or emitter equipment

Gimbal	Radar target is approaching azimuth or elevation limits
Gorilla	Large force of indeterminate numbers and formation
Green	A descriptive term referring to the direction the fighter must head in order to move away from threats
Group	Radar targets within 3 NM in azimuth and range of each other
Guns	An air-to-air or air-to-surface gunshot
Hard (Direction)	High-G, energy sustaining turn in direction called
Head/Head On	1. (USAF) Target with an aspect of 160-180 degrees 2. (NAVAL) target with an aspect of 0-20 degrees
Heads Up	Alert of an activity of interest
Heavy	A group known to contain three or more contacts
Hit(s)	1. (A/A) Radar return in search with altitude reference 2. (A/G) Weapons impact within lethal distance
Holding Hands	Aircraft in visual formation
Hold Fire	An emergency fire control order used to stop firing on a designated target, to include destruction of any missiles in flight
Home Plate	Home airfield or carrier
Hostile	A contact positively identified as enemy in accordance with theater rules of engagement and may be engaged with a clear field of fire
Hot	1. Attack geometry will result in roll out in front of the target 2. On a leg of the CAP pointing towards the anticipated threats 3. Threat group heading towards fighters. Opposite of Cold Navy: 0 - 20 Aspect 4. Ordnance employment intended or completed 5. Defined area is expected to receive fire
Hotdog	Informative/directive call that an aircraft is approaching or at a specified stand-off distance from the sovereign airspace of a nation (as defined by national boundaries or territorial sea and airspace) (COLOR may indicate additional standoff distance) Follow briefed procedures

I.D.	1. Directive to identify the target 2. I.D. accomplished followed by type
In	(Direction) Informative indication a turn to a hot aspect relative to a threat/target
India	Mode IV IFF
Jink	Unpredictable maneuvers to negate a gun tracking solution
Joker	Fuel state above Bingo at which separation/bugout/event termination should begin
Judy	Aircrew has radar/visual contact on the correct target, has taken control of the intercept, and only requires situation awareness information. Controller will minimize radio transmissions.
Kill	1. Clearance to fire 2. In training, a fighter call to indicate kill criteria have been fulfilled
Knock It Off	Directive to cease all phases of air combat maneuvers/attack/exercise activities
Ladder	Three or more groups/contacts in range
Laser On	Start/acknowledge laser designation
Lead/Trail	A descriptive term referring to a single **group** in a multi-group range or echelon presentation
Leaker(s)	Airborne threat has passed through a defensive layer. Call should include amplifying information.
Line Abreast	Two contacts within a group side-by-side
Locked	(BRAA/Direction) Final radar lock-on; sort is not assumed
Magnum	Launch of friendly anti-radiation missile
Mapping	Multi-function radar in an A/G mode
Marking	Friendly aircraft leaving contrails
Marshal(ing)	Establish(ed) at a specific point

Merge (merged plot)	1. Information that friendlies and targets arrived in the same visual arena 2. Call indication radar returns have come together and bearing and range information will be unavailable until aircraft separation is achieved
Monitor	Maintain radar awareness on or assume responsibility for specific group
Mother	Parent ship
New Picture	Used by controller or aircrew when tactical picture has changed. Supersedes all previous calls and reestablishes picture for all players
No Factor	Not a threat
No Joy	Aircrew does not have visual contact with the target/bandit/landmark. Opposite of Tally
Off (Direction)	Informative call indication attack is terminated and maneuvering to the indicated direction
Offset	Informative call indicating maneuver in a specified direction with reference to the target
On Station	Informative unit/aircraft has reached assigned station
Opening	Increasing separation
Out	(Direction) Informative indicating a turn to a cold aspect relative to the threat. Opposite of In.
Package	Geographically isolated collection of groups/contacts/formations
Padlocked	Informative call indicating aircrew cannot take eyes off an aircraft or surface position without risk of losing tally/visual
Parrot	IFF transponder
Picture	Request of provide air information pertinent to the mission in a digital bullseye format
Pig	JSOW launch
Pigeon	Magnetic bearing and range to Homeplate (or specified destination)
Pince/Pincer	Threat maneuvering for a bracket attack

Playmate	Cooperating aircraft
Playtime	Amount of time aircraft can remain on station
Pop	Starting climb for air-to-surface attack
Popeye	Flying into IMC (i.e., clouds or area of reduced visibility)
Popup	Informative that a contact has suddenly appeared inside a prebriefed range
Posit	Request for position; response in terms of a geographic landmark, or off a common reference point
Post Attack	Directive transmission to indicate direction after completion of intercept/engagement
Post Hole	Rapid descending spiral
Press	Directive to continue the attack; mutual support will be maintained. Supportive role will be assumed
Pump	A briefed maneuver to low aspect to stop closure on the threat or geographical boundary with the intent to re-engage
Pure	Informative indicating pure pursuit is being used or directive to go pure pursuit
Push	(Channel) Go to designated frequency
Pushing	Departing designated point
Range	Two or more groups separated in range
Reference (Heading)	Directive to assume stated heading
Reset	Proceed to a prebriefed position or area of operation
Resume	Resume last formation/station/mission ordered
Rider	A bogey that is conforming with safe passage routing/airspeed/altitude procedures
Ripple	Two or more munitions released or fired in close succession
Rolex (Time +/-)	Timeline adjustment in minutes from preplanned mission execution time

SAM	Visual acquisition of a SAM or SAM launch, should include clock code position
Scram	Emergency directive to egress for defensive or survival reasons
Separate	Leave a specific engagement; may or may not reenter
Shackle	A crossing weave/scissors maneuver to adjust/regain formation parameters that contains a single flight path crossing between lead and wing
Shooter	Aircraft/unit designated to employ weapons
Shotgun	Prebriefed weapons loadout at which separation/bugout should begin
Skate	Informative/directive to execute launch and leave tactics
Skip It	Veto of fighter commit, usually followed with further directions
Skosh	Aircraft is out of/or unable to employ active radar missiles
Snap (Direction)	Immediate vector to the group described
Sort	Directive to assign responsibility within a group; criteria can be met visually, electronically (radar) or both
Sorted	Sort responsibility has been met
Sour	1. Equipment indicated is operating inefficiently 2. Invalid response to an administrative IFF check
Spitter	An aircraft that has departed from the engagement or is departing the engaged fighters targeting responsibility
Splash	1. Air target destroyed 2. Weapons impact
Split	Request to leave formation to engage a threat; visual may not be maintained
Spoofing	Information that voice deception is being employed
Spot	Acquisition of laser designation
Squawk	Operate IFF as indicated or IFF is operating as indicated

Stack	Two or more groups/contacts/formation with high/low altitude separation in relation to each other
Status	Request for tactical situation/position
Steady	Directive to stop oscillation of IR pointer
Steer	Set magnetic heading indicated
Stern	Request for, or directive to, intercept using stern geometry
Stinger	Formation of two or more aircraft with a single aircraft in trail
Stop	Stop IR illumination of a target
Stranger	Unidentified traffic that is not associated with the action in progress
Strangle	Turn off equipment indicated, usually IFF
Stripped	Informative call from Wingman/element indicating out of briefed formation/position
Sweet	1. Equipment indicated is operating efficiently 2. Valid response to an administrative IFF check
Switch	Indicates an attacker is changing from one aircraft to another
Tactical	Request/directive to switch to tactical control
Tally	Sighting of a target/bandit/landmark. Opposite of No Joy
Target	Directive to assign group responsibility to aircraft in a flight
Targeted	Group responsibility has been met
Ten Seconds	Directive to terminal controller to standby for “Laser On” call in approximately 10 seconds
Terminate	1. Stop laser illumination of a target 2. Cease local engagement without affecting the overall exercise
Threat	Untargeted HOSTILE/Bandit/Bogey within prebriefed range/aspect of a friendly
Tied	Positive radar contact with element/aircraft

Tiger	Enough fuel and ordnance to accept a commit
Tracking	1. Stabilized gun solution 2. Continuous illumination of a target 3. Contact heading
Trashed	Informative call that missile has been defeated
Unable	Cannot comply as requested/directed
Uniform	UHF radio
Victor	VHF/AM radio
Visual	Sighting of a friendly, aircraft/ground position; opposite of Blind
Warning (Color)	Hostile attack is: RED - imminent or in progress YELLOW - probable WHITE - improbable (all clear)
Weapons	(Fire only): FREE - on a target not identified as friendly in accordance with current ROE TIGHT - at target positively identified as hostile in accordance with current ROE SAFE - in self-defense or in response to a formal order
What Luck	Request for results of missions or tasks
What State	Report amount of fuel and missiles remaining. Ammunition and oxygen are reported only when specifically requested or critical ACTIVE - number of active radar missiles remaining RADAR - number of semi-active missiles remaining HEAT - number of IR missiles remaining FUEL - pounds of fuel or time remaining
Winchester	No ordnance remaining
Words	Mission-pertinent information
Yard	Directive to use A/A TACAN for ranging

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APPENDIX B
OFT AIRCRAFT RECOGNITION GUIDE

The information in this Appendix is taken from the U.S. Army Field Manual 44-80, **Visual Aircraft Recognition** dated September 1996. FM-44-80 is a document originated by the U.S. Army Air Defense Artillery School. Its purpose is to train U.S. Army ground observers with little or no aviation experience how to identify aircraft and tell friendly aircraft from hostile aircraft. Although this perspective differs slightly from those of the SNFO and fighter aircrew, the fundamentals presented in FM 44-80 are sound and a good starting point to aircraft identification.

Aircraft recognition is a required aircrew skill. Being able to visually identify aircraft is a starting point. In follow-on training you will be required to associate sensors and weapons systems with particular aircraft and sub-models in order to better prepare and brief your mission. The farther out an aircraft can be detected, recognized, and identified, the more time aircrew have available to make an engagement decision. However, in the air, identification can be difficult as many aircraft share design features.

All aircraft are built with the same basic elements, recalled as WEFT (Figure B-1):

WEFT Features			
Wings	Engines	Fuselage	Tail
Type Position Slant Shape Taper	Type Number Location Intakes Exhausts	Shape Nose Mid Rear Cockpit Special	Location Slant Number Shape

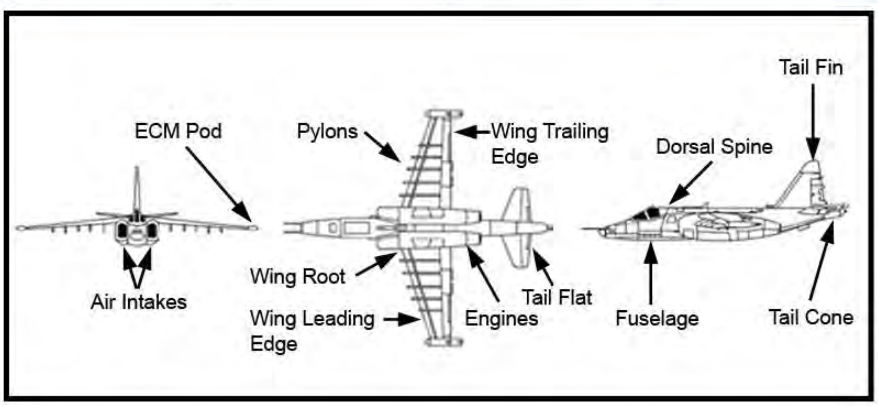

Figure B-1 WEFT Recognition

The WEFT features are unique to each aircraft, and will assist strike fighter aircrews with positive identification. The key to using these features is studying aircraft and knowing what the NATO identifications are for the aircraft being identified. Aircrew need to invest ample amounts of time on-deck studying aircraft from all corners of the globe. The Battle Group is mobile and strike fighter aircrew will operate anywhere in the world.

The information here pertains specifically to the aircraft available in the Aircrew Training Device 2F205A, also known as the Operational Flight Trainer (OFT). The complete FM 44-80 is available from multiple sources and online. It is unclassified, distribution is unlimited, and is now considered obsolete. Nevertheless, the information is still valid. Aircraft recognition is a required aircrew skill. Being able to visually identify aircraft is only a starting point. Aircrew are required to associate sensors and weapons systems with particular aircraft and sub-models in order to better prepare and execute missions.

1. **Wings**

There are many different types of aircraft wings. General attributes that can used to identify an aircraft by its wings are:

a. Type

b. Position

c. Slant

d. Shape

e. Taper

Wing examples are shown below in Figure B-2.

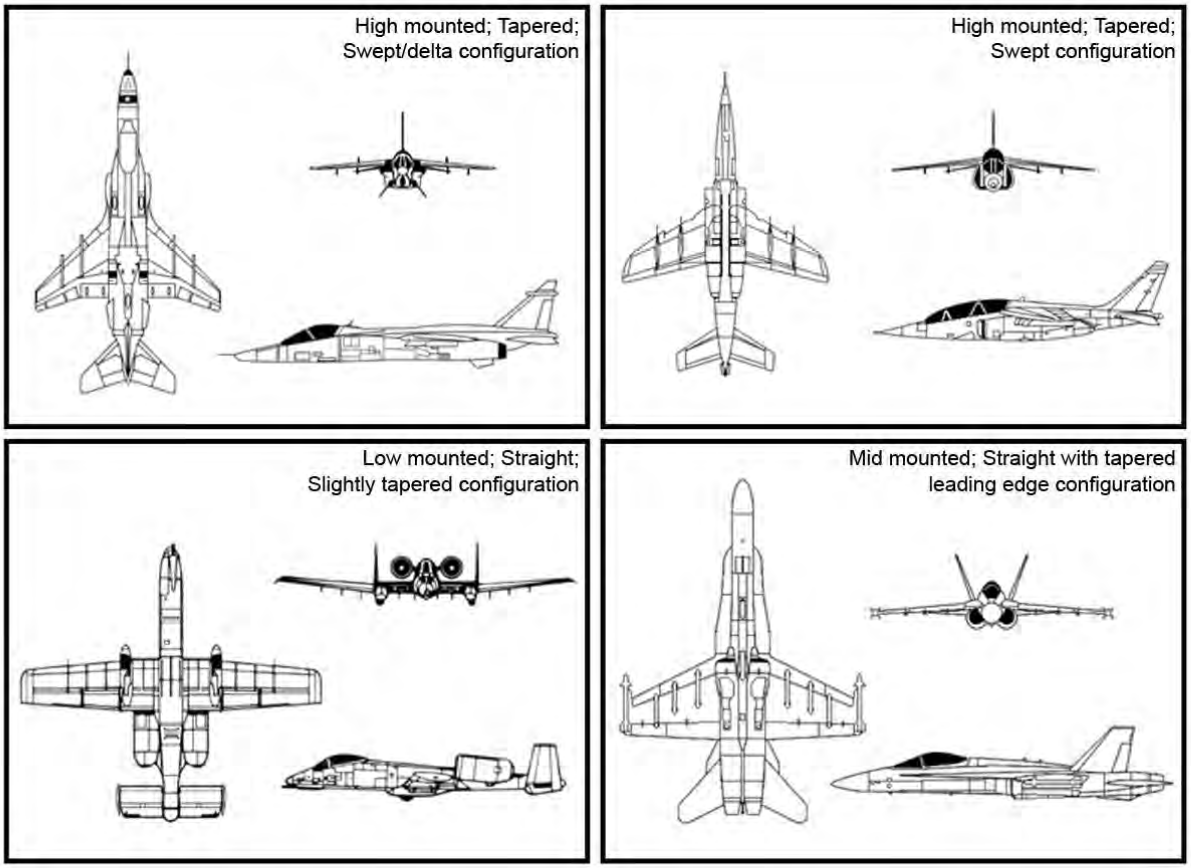

Figure B-2 Various Wing Types

2. **Engines**

Engine identification characteristics include:

a. Type

b. Number

c. Location

d. Intakes

e. Exhaust

Engine examples are shown in Figure B-3.

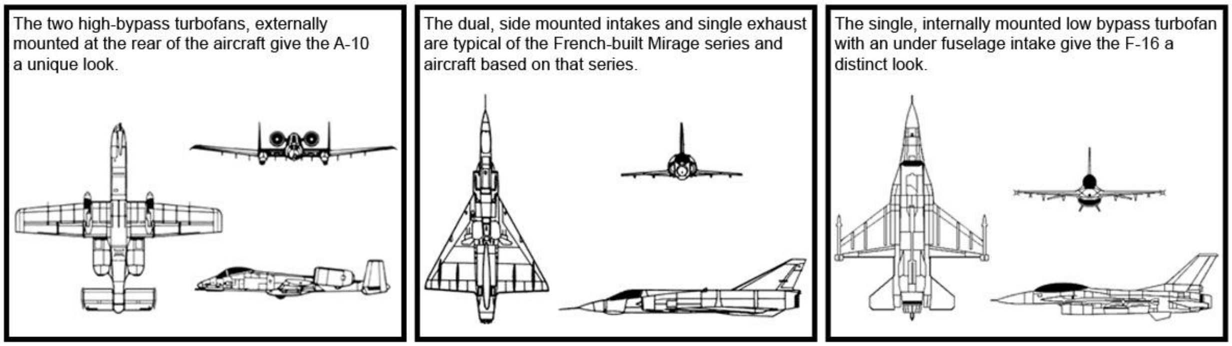

Figure B-3 Engine Number and Mounting

3. **Fuselage**

Intricacies of fuselage design are difficult to identify in modern fighters. However, some basic features include:

a. Overall shape

b. Nose, mid-section and rear shape and appearance

c. Cockpit location

d. Canopy

Fuselage examples are shown in Figure B-4.

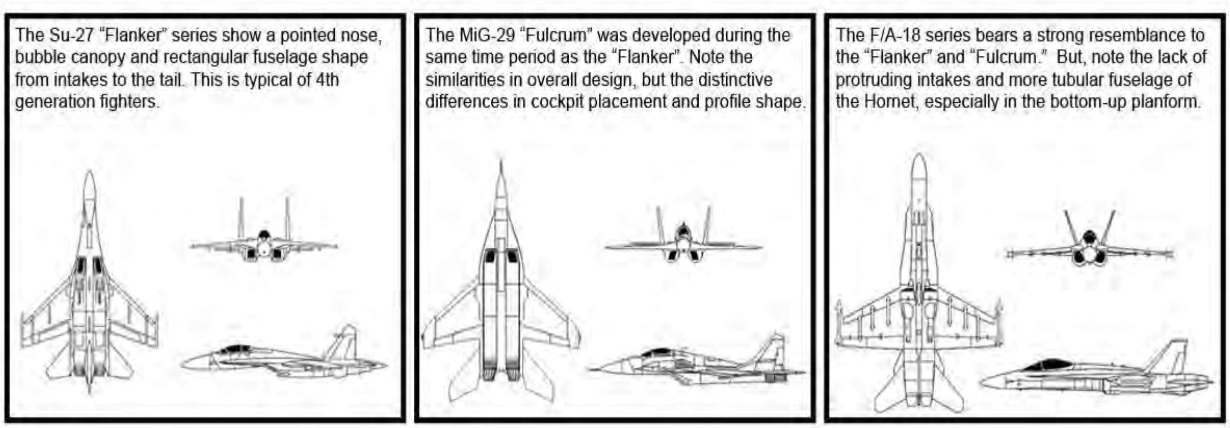

Figure B-4 Fuselage Configurations

4. **Tail**

The tail of an aircraft is often as distinctive as the wing shape and even more than the fuselage. Some basic features include:

a. Location of vertical and horizontal stabilizers

b. Number of vertical stabilizers

c. Slant

d. Shape

Tail examples are shown in Figure B-5.

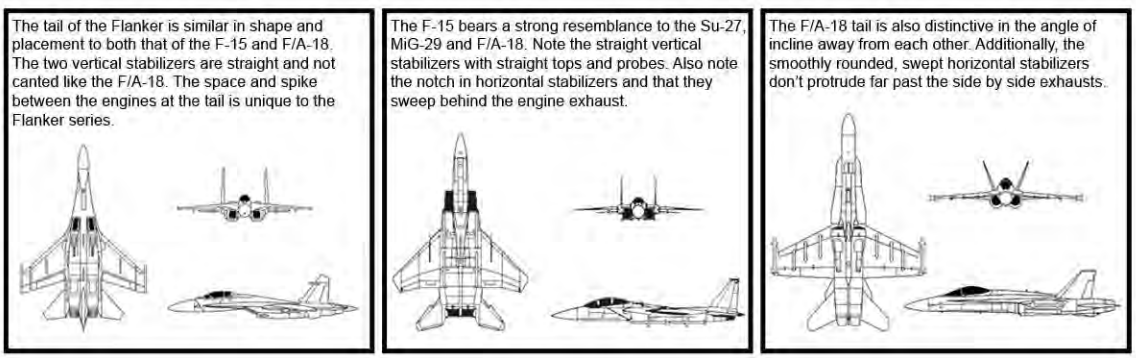

Figure B-5 Tail Configurations of Three Similar Aircraft

The remainder of this Appendix is devoted to aircraft found in the OFT. The SNFO should be able to recognize any of these when prompted by the scenario or instructor.

a. F-15E Strike Eagle

b. F-16C Fighting Falcon

c. F/A-18A+/C/D Hornet

d. F/A-18E/F/G Super Hornet

e. F-35 Lightning II

f. E-2C/D Hawkeye

g. E-3 Sentry

h. KC-10 Extender

i. F-4 Phantom II

j. F-5 Tiger

k. F-14B

l. Mirage 2000

m. MiG-21

n. MiG-29

o. Su-27/30

5. F-15E Strike Eagle

The F-15E Strike Eagle (Figure B-6) is the multi-role version of the F-15 Eagle. It is optimized for strike missions and carries a crew of two, a pilot and weapon systems officer (WSO).

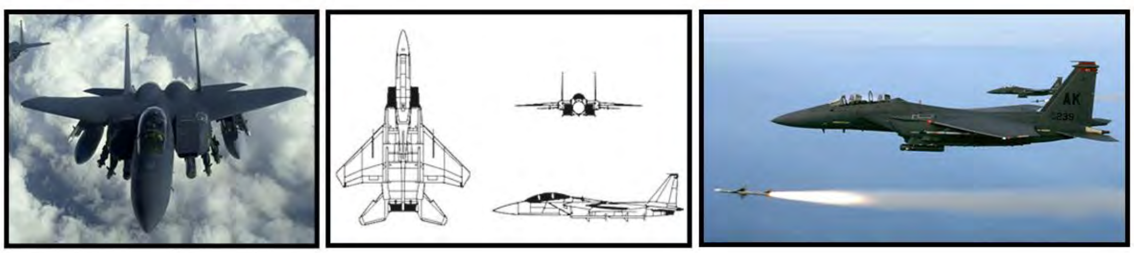

Figure B-6 F-15E Strike Eagle

Length	63 feet 9 inches
Wingspan	42 feet, 9 inches
Wings	High, semi-delta, blunt, angled tips;
Engines	Two mounted in the rear. Diagonally-shaped, box-like air intakes alongside the fuselage. Dual exhausts.
Fuselage	Long, pointed nose and a bubble canopy. Large, box-like center section that tapers slightly to the front and rear.
Tail	Two fins; tapered leading edges, straight trailing edges, and square tips; mid-mounted, swept, tapered with saw tooth horizontals
Similar Aircraft	F-14 Tomcat, Su-24 FENCER, Tornado, MiG-29 FULCRUM, Su-27 FLANKER.

6. F-16 Fighting Falcon

The F-16 Fighting Falcon (Figure B-7), is a small, agile, single engine multi-role aircraft. The F-16 is the most numerous U.S. jet fighter produced with over 4,500 produced for 25 countries.

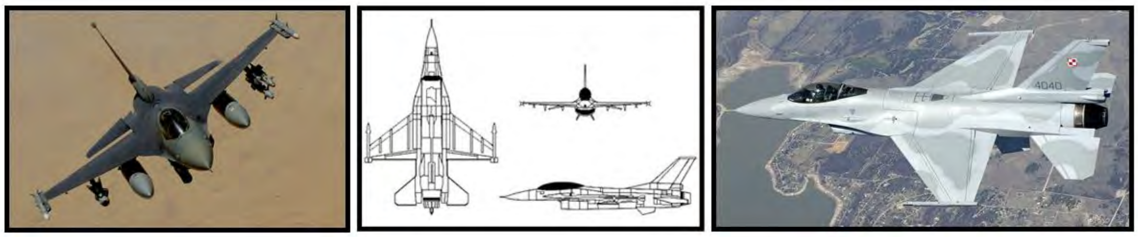

Figure B-7 F-16 Fighting Falcon

Length	47 feet, 8 inches
Wingspan	31 feet
Wings	Mid-mounted, delta-shaped. Missiles are normally mounted at the wing tips.
Engine	One in body. Oval air intake under the center of the fuselage. Single exhaust.
Fuselage	Long and slender with widening at the intake; bubble canopy with one or two aircrew (dependent on model)
Tail	Swept-back, tapered fin with square tip. Flats mid-mounted on the fuselage, delta-shaped with square tips, and a slight negative slant. Two belly fins.
Similar Aircraft	F/A-18 Hornet, MiG-29 FULCRUM, Mirage F1

7. F/A-18A+/C/D Hornet

The F/A-18A+/C/D Hornet (Figure B-8) is the primary fighter of the Navy and Marine Corps. All A models in service have been upgraded to the A+ standard. The USMC is the only U.S. service to use the D operationally.

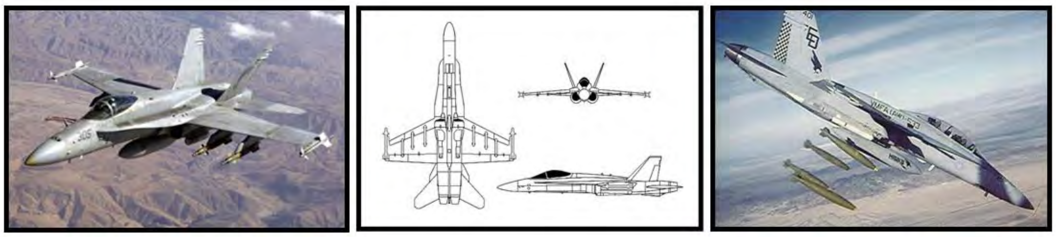

Figure B-8 F/A-18A+/C/D Hornet

Length	56 feet
Wingspan	37 feet, 6 inches
Wings	Mid-mounted, semi-delta with prominent leading edge root extension on sides of fuselage from the wing to the front of the cockpit. Missiles are usually on square tips.
Engines	Two turbofans mounted in the aircraft rear section. Oval air intakes under the wings.
Fuselage	Barrel-shaped with solid, pointed nose. Aircraft widens at the air intakes and tapers to the rear. Bubble canopy for one (A+/C) or two aircrew (D model)
Tail	Swept-back and tapered tail flats mid-mounted on the body. Twin, swept-back, and tapered tail fins mounted forward on the fuselage. Fins have an outward tilt.
Similar Aircraft	F-16 Fighting Falcon, MiG-29 FULCRUM, Su-27 FLANKER, F-15 Eagle

8. **F/A-18E/F Super Hornet**

The F/A-18E/F Super Hornet (Figure B-9) is about 25% larger than the C/D model and incorporates a new radar and new mission computers. It also serves as the basis for the EA-18G Growler.

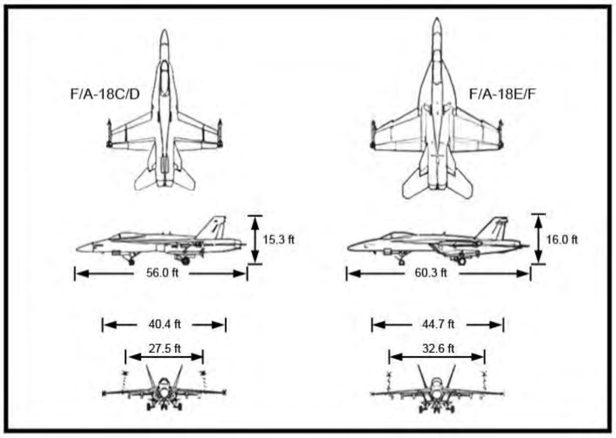

Figure B-9 F/A-18E/F Super Hornet

Length	60 feet, 4 inches
Wingspan	44 feet, 7 inches
Wings	Mid-mounted, semi-delta with large LEX on sides of fuselage
Engines	Two mounted on aircraft rear section with rectangular air intakes and oval exhaust
Fuselage	Barrel-shaped with widening at the intakes and a bubble canopy for one (E model) or two aircrew (F model)
Tail	Twin vertical stabilizers canted outward
Similar Aircraft	F-16 Fighting Falcon, MiG-29 FULCRUM, Su-27 FLANKER, F-15 Eagle

9. **F-35 Lightning II (Joint Strike Fighter)**

The F-35 Lightning II (Figure B-10), also known as the Joint Strike Fighter, is the U.S. Military's next generation tactical aircraft. It is being built in three versions, one each for the Navy (F-35C), Marine Corps (F-35B) and Air Force (F-35A).

Figure B-10 F-35 Lightning II

Length	51 feet, 2 inches (A&B) 51 feet , 4 inches (C)
Wingspan	35 feet (A & B); 43 feet (C)
Wings	Mid-mounted, semi-delta with prominent leading edge root extension
Engines	Two rectangular intakes at cockpit; one exhaust between tails
Fuselage	Barrel-shaped with solid, pointed nose; aircraft widens at the air intakes and tapers to the rear
Tail	Swept-back, and tapered tail; twin, swept-back, tapered tail fins with an outward tilt
Similar Aircraft	F-16 Fighting Falcon, MiG-29 FULCRUM, Su-27 FLANKER, F-15 Eagle, F-22 Raptor

10. **E-2C/D Hawkeye**

The only carrier based, turboprop aircraft, the E-2 (Figure B-11) family has provided Airborne Warning and Control (AWACS) functions for Carrier Strike Groups (CSG) since Vietnam.

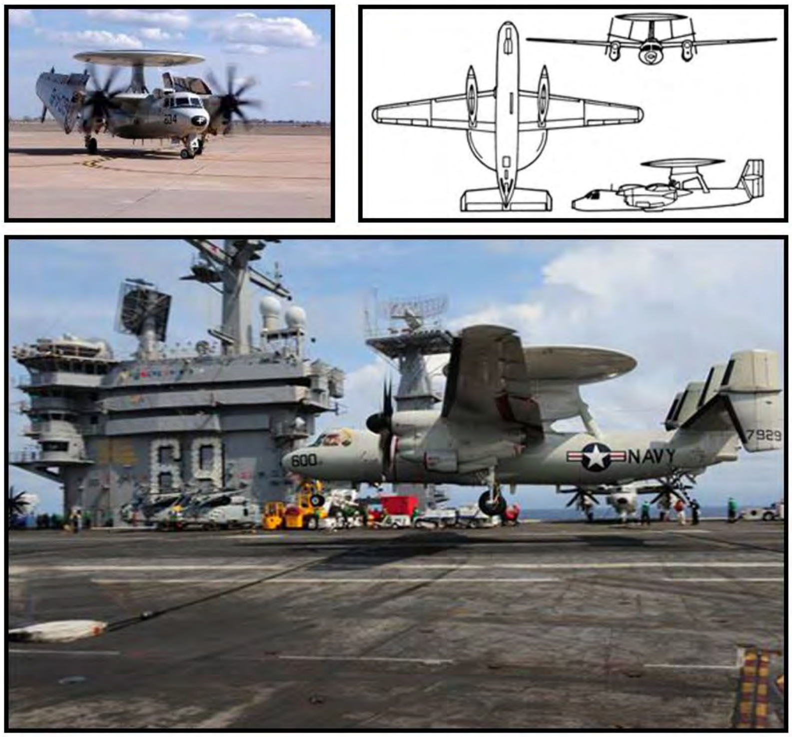

Figure B-11 E-2C/D Hawkeye

Length	57 feet, 6 inches
Wingspan	80 feet, 6 inches
Wings	High-mounted and equally tapered with blunt tips
Engines	Two turboprops mounted under the wings; engines extend well beyond the wings' leading edges
Fuselage	Oval that tapers to the rear; rounded nose; stepped-up cockpit; large radome
Tail	Four fins, horizontal stabilizers that are high-mounted on the fuselage with an upward slant
Similar Aircraft	C-160 Transall, G.222, An-24, An-26; none have distinct radome. C-2 is similar design, used for carrier on-board delivery (COD).

11. **E-3 Sentry**

The E-3 Sentry (Figure B-12) is an Airborne Early Warning and Control System, or AWACS aircraft used by the USAF and other U.S. allies. It is based on the Boeing 707 airframe.

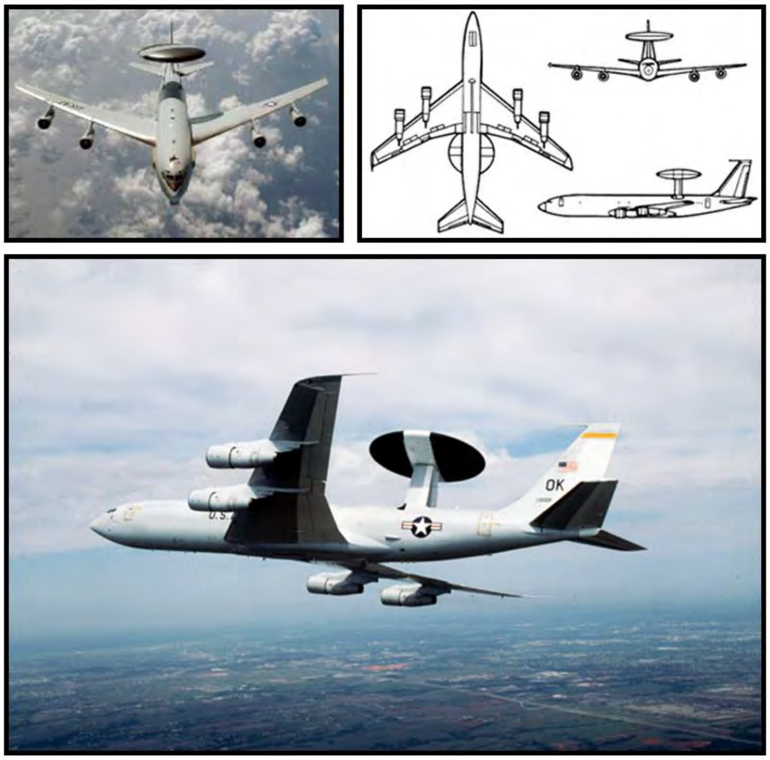

Figure B-12 E-3 Sentry

Length	152 feet, 9 inches
Wingspan	154 feet, 7 inches
Wings	Low-mounted, swept-back, and tapered
Engines	Four mounted on pylons under the wings
Fuselage	Round, cigar-shaped, tapers to the rear; large radome on top of the body between the wings and tail section
Tail	Swept-back, tapered fin with a square tip; horizontal stabilizers are swept-back, tapered, and mid-mounted on the fuselage
Similar Aircraft	An-50 Mainstay (AEW aircraft based on the Il-76 transport) KC-135 based on same 707 airframe

12. **KC-10 Extender**

Based on the DC-10, the KC-10 Extender (Figure B-13) is the primary USAF tanker. It was designed to refuel aircraft using both USAF and USN/USMC methods during the same mission.

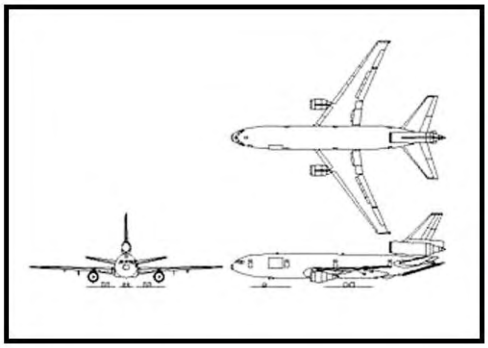


Figure B-13 KC-10 Extender

Length	181 feet, 7 inches
Wingspan	165 feet, 4.5 inches
Wings	Low-mounted, swept-back, and tapered
Engines	Three; one in each under wing pylon, one in the vertical tail
Fuselage	Cylindrical, tapered at each end; a refueling boom is beneath the aft end
Tail	Swept-back, tapered fin with a square tip; engine-mounted, horizontal stabilizers are swept-back, tapered, and mid-mounted on the fuselage
Similar Aircraft	KC-135 in role; DC-10, MD-11, L-1011 similar looking, 3 engine airliners

13. **F-4E Phantom II**

The F-4E Phantom II (Figure B-14) is a two seat, twin engine, all weather, long range supersonic fighter-bomber. The Islamic Republic of Iran Air Force (IRIAF) has approximately 200 F-4D and E models in service.

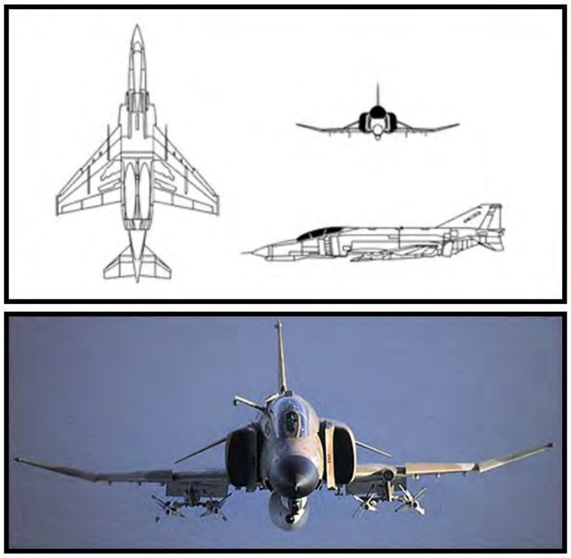

Figure B-14 F-4E Phantom II

Length	63 feet
Wingspan	38 feet, 5 inches
Wings	Low-mounted, swept-back, semi-delta with square tips; positive slanted wing tips and a saw tooth in leading edges of the wings
Engines	Two engines; rectangular air intakes both sides rear cockpit; two exhausts beneath an overhanging rear section
Fuselage	Rectangular midsection, pointed droopy nose
Tail	Horizontal stabilizers are mid-mounted on body; delta-shaped with a negative slant; sharply back-tapered fin with a square tip
Similar Aircraft	Jaguar, A-4 Skyhawk, Super Etendard.

14. **F-5E Tiger II**

The F-5 (Figure B-15) was exported to many countries, including Iran, during the 1970s. The IRIAF maintains 75 in their inventory. It is also used extensively by the US military as an aggressor, due to its similarity to the MiG-21, and many US allies.

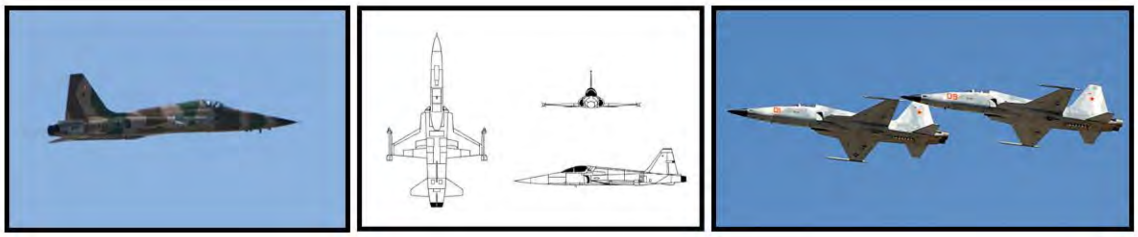

Figure B-15 F-5E Tiger II

Length	48 feet
Wingspan	26 feet, 8 inches
Wings	Low-mounted, stubby, and unequally tapered; missile rails on tips for AIM-9 or equivalent
Engine	Two engines inside the body, semicircular air intakes forward of the wing roots
Fuselage	Bullet-shaped, long, drooping nose; bottom is flat from the air intakes to the dual exhausts
Tail	Horizontal stabilizers are low mounted and equally tapered; fin is large and equally tapered with a square tip

15. **F-14A Tomcat**

The only air force to still fly the F-14A Tomcat (Figure B-16) is the IRIAF, with 44 in their inventory, 25 of which are believed operational.

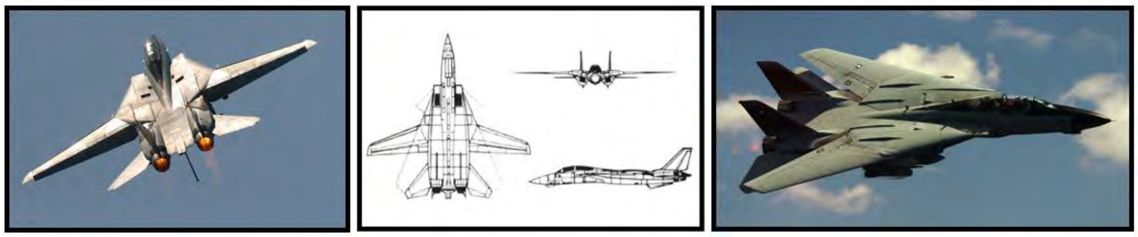

Figure B-16 F-14A Tomcat

Length	62 feet
Wingspan	64 feet
Wings	High-mounted, variable, swept-back, and tapered with curved tips
Engines	Two turbofans in fuselage; diagonally shaped, box-like air intakes alongside the fuselage; dual spaced exhausts
Fuselage	Box-like from the air intakes to the rear section; pointed nose; bubble canopy
Tail	Twin swept-back, tapered tail fins; mid-mounted horizontal stabilizers on the fuselage; swept-back, and tapered; fins beneath engines extend forward to horizontal stabilizers
Similar Aircraft	F-15 Eagle, Su-24 FENCER, Tornado, Su-27 FLANKER, MiG-29 FULCRUM

16. **Mirage 2000**

The Mirage 2000 (Figure B-17) is a single engine, multi-role aircraft sold in many variants, including a two-seat strike version. With the exception of the Mirage F1, the Mirage series, and aircraft based on them are very similar in physical appearance.

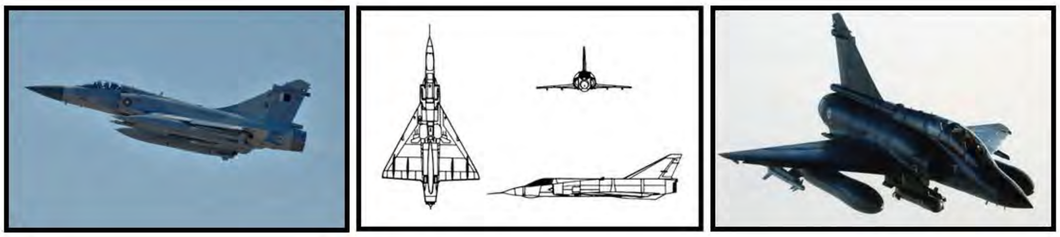

Figure B-17 Mirage 2000

Length	50 feet, 3 inches
Wingspan	29 feet, 5 inches
Wings	Low-mounted, delta with clipped tips
Engines	One turbofan mounted in the fuselage; semicircular air intakes alongside the fuselage forward of wings; large, single exhaust protrudes past the tail
Fuselage	Tube-shaped with pointed nose and bubble canopy
Tail	No horizontal stabilizers; fin is swept-back and tapered with a clipped tip
Similar Aircraft	Mirage III/5 (difficult to distinguish); Kfir, Viggen

17. **MiG-21 (NATO reporting name FISHBED)**

The MiG-21 (Figure B-18) (NATO reporting name "FISHBED") is the most widely produced jet fighter aircraft in the world. First produced in 1959, the aircraft has had continuous capability updates. The newest versions possess BVR missiles and Helmet Mounted Sights (HMS). Production ended in 1989 at 11,496.

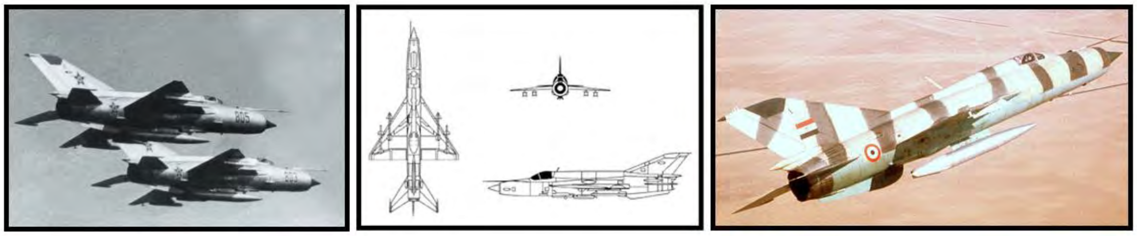

Figure B-18 MiG-21

Length	51 feet, 8 inches
Wingspan	23 feet, 5 inches
Wing	Mid-mounted, delta wing with small square tips
Engine	One, with round air intake in the nose; single exhaust
Fuselage	Long, tubular body with blunt nose and cone intake; dorsal spine flush with the canopy
Tail	Fin swept-back and tapered with square tip; horizontal stabilizers mid-mounted on the body, swept-back, and tapered with square tips; belly fin under tail
Similar Aircraft	Su 17/22 Fitter, Mirage III/5, A-4 Skyhawk; F-5 Tiger II

18. **MiG 29 Series (NATO reporting name "FULCRUM")**

The MiG-29 (Figure B-19) (NATO reporting name "FULCRUM") is a single or two seat fighter. It has evolved into a true multi-role fighter comparable to the F/A-18C/D.

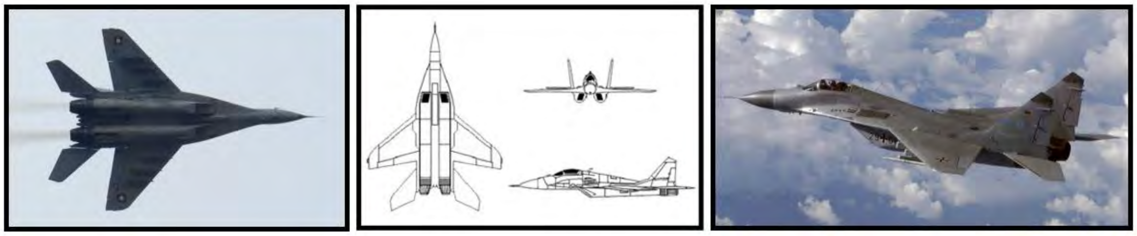

Figure B-19 MiG-29

Length	50 ft 10 in (15.6 m)
Wingspan	33 ft 7 in (10.26 m)
Wings	Swept-backed, tapered with square tips; LEXs are wide and curved down to the front; LEX begins even with front of canopy
Engines	Two; two slanted, rectangular intakes being at cockpit; two widely spaced exhausts
Fuselage	Tapered, wedge shaped body, widens at air intakes and tapers to exhausts; pointed nose; bubble canopy
Tail	Two swept-back, outward canted, tapered fins with slanted tips; stabilators extend well past exhausts
Similar Aircraft	F/A-18 Hornet, F-16 Fighting Falcon, F-15 Eagle, Su-27 FLANKER

19. **Su-27/30 Series (NATO reporting name FLANKER)**

With 12 air-to-air hard points, the Su-27 series (Figure B-20) (NATO reporting name "FLANKER") is the premier, Chinese and Russian-built multi-role fighter. The single seat Su-27 fighter evolved into the two seat Su-30 strike aircraft.

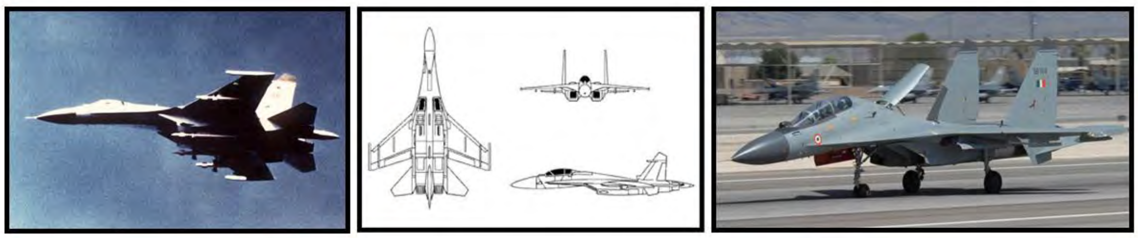

Figure B-20 Su-27/30 Series

Length	69 feet
Wingspan	47 feet, 6 inches
Wings	Mid-mounted, semi-delta with square tips; LEX extends to cockpit; missile rails on tips
Engines	Two with square, diagonally-cut air intakes mounted under the wings well aft of canopy
Fuselage	Rectangular from air intakes to the tail; pointed nose and bubble canopy; spike between exhausts
Tail	Fins are swept-back, tapered with slanted tips, no cant, mounted outboard engines; stabilators are mid-mounted, swept, tapered and do not extend far past exhausts
Similar Aircraft	F-15 Eagle, F-14 Tomcat, MiG-29 FULCRUM