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NAS CORPUS CHRISTI, TEXAS **CNATRA P-826 (New 01-16)**

FLIGHT TRAINING INSTRUCTION

BASIC FIGHTER MANEUVERING (BFM) ADVANCED NFO T-45C/VMTS

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250 LEXINGTON BLVD SUITE 102
CORPUS CHRISTI TX 78419-5041

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1. CNATRA P-826 (New 01-16) PAT, "FLIGHT TRAINING INSTRUCTION, BASIC FIGHTER MANEUVERING (BFM), ADVANCED NFO T-45C/VMTS" 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 Naval Flight Officer Training System (NFOTS) 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.

C. J. HAYDEN
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FLIGHT TRAINING INSTRUCTION

FOR

BASIC FIGHTER MANEUVERING (BFM)

ADVANCED STRIKE/FIGHTER NFO TRAINING SYSTEM

T-45C/VMTS

(P-826)

LIST OF EFFECTIVE PAGES

Dates of issue for original and changed pages are:
Original...0...11 Jan 16 (this will be the date issued)

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COVER	0		
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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.

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 engagements 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 effectively 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 forward to the wingline plus 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; e.g., 4,000 feet above the deck dictates that the aircraft will not exceed 40 degrees nose-low.

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

iv. If the "*Hard Deck*" is ever broken, then 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. AIR COMBAT MANEUVERING (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 do not have a thrust-to-weight ratio greater than one and thus bleed energy as they maneuver. Their energy package is finite. ACM is a series of tradeoffs and consists of 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 an 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.

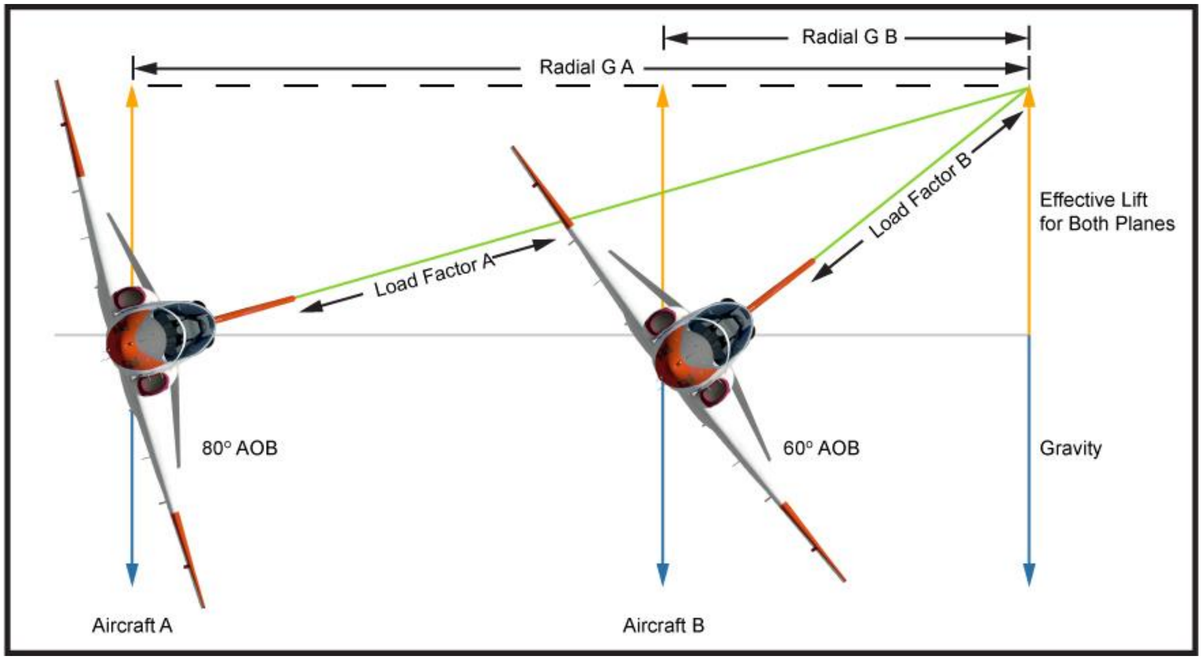


Figure 1-1 Horizontal Maneuvering

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 of the aircraft 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, resulting in an intermediate turn performance.

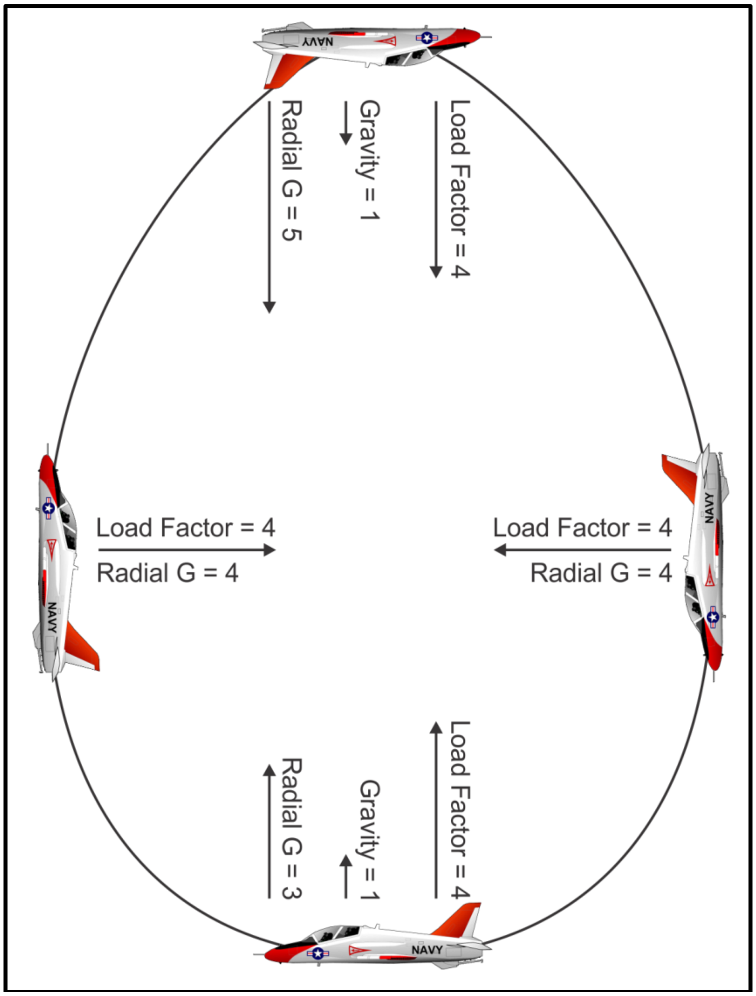


Figure 1-2 Vertical Maneuvering

3. **Energy Management and the 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 Potential Energy (PE), (represented by the aircraft's altitude), and its Kinetic Energy (KE), (represented by the aircraft's airspeed). 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 Military Rated Thrust (MRT) at 10,000' MSL.

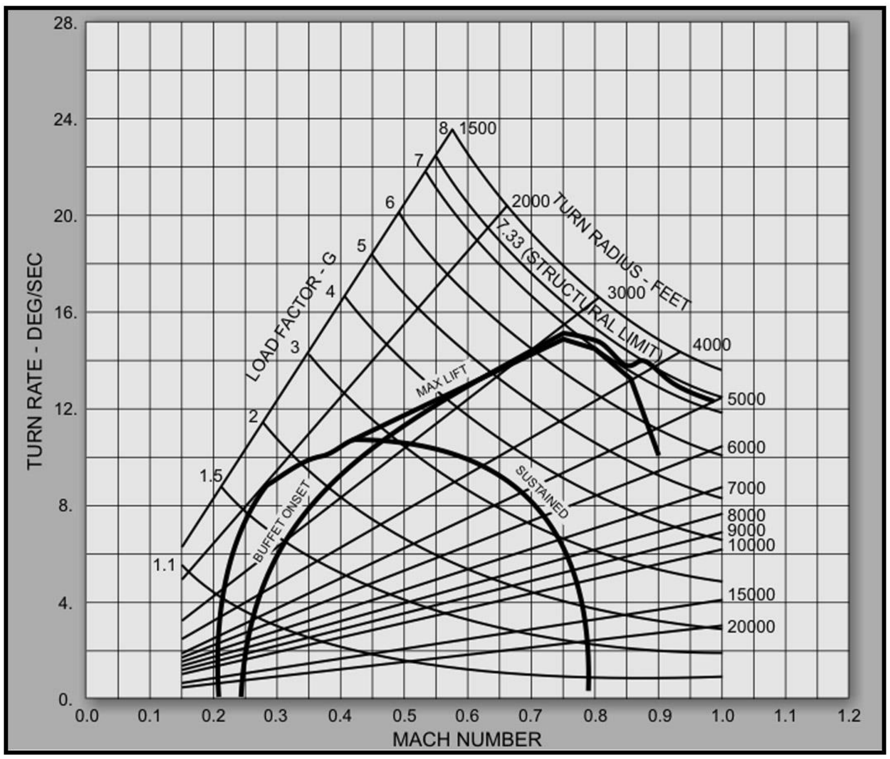


Figure 1-3 T-45C E-M Diagram (10,000 MSL)

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 angle of attack (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 that will be discussed 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 (V_C)." 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 the Corner airspeed. At any airspeed below Corner, pulling more than 24 units AOA, regardless of power setting, will cause an accelerated stall. Simply by easing the pull to below the lift limit, the aircraft will immediately recover from this stalled condition.

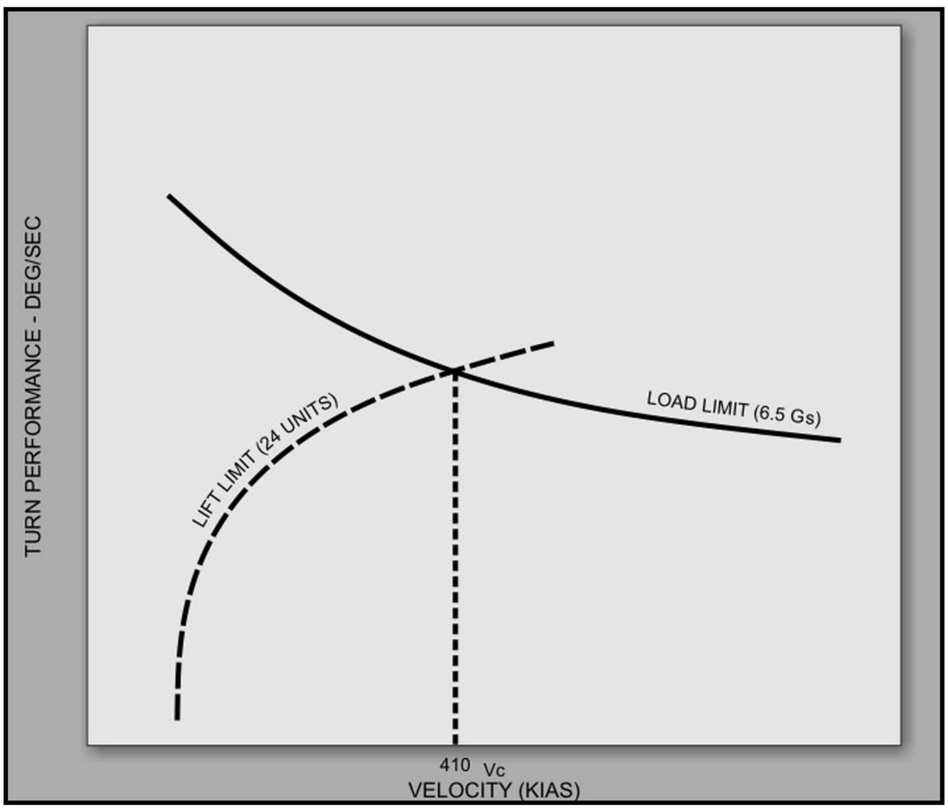


Figure 1-4 Lift Limit and Corner Airspeed

5. **Max G Available**

As depicted in Figure 1-5, there are an infinite number of G curves that parallel the G-limit (Load 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.

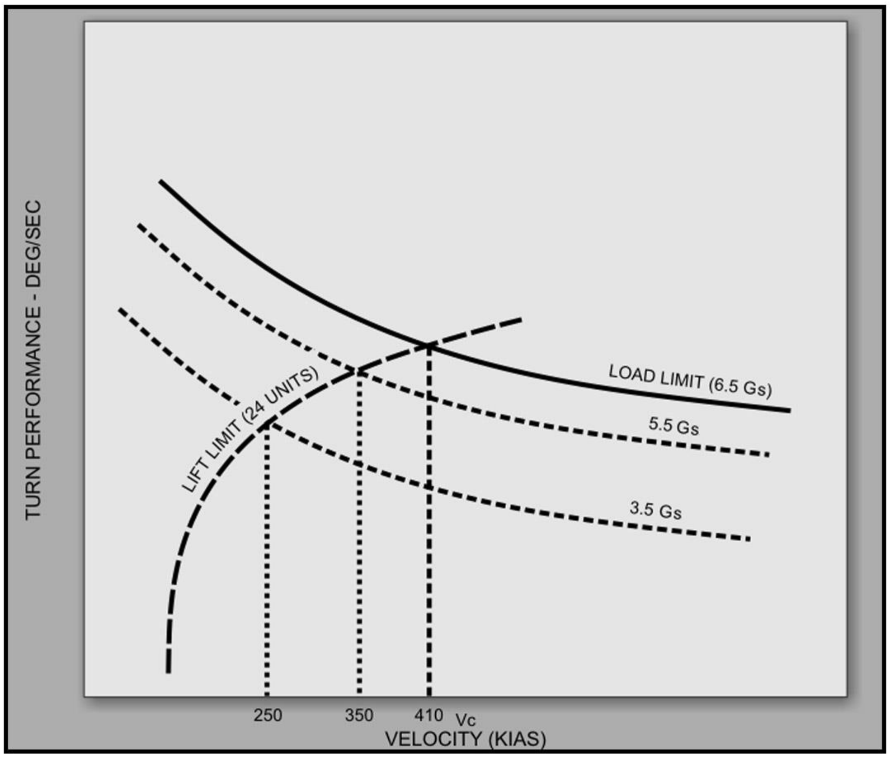


Figure 1-5 G Available

6. **Max Instantaneous Turn Performance**

The best turn performance at any given airspeed is defined by the intersection of 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, an AOA of 19-21 units is 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 with less energy being bled off during the turn. The maximum 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 (KE) or altitude (PE). 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 and usually plateaus across a range of airspeeds.

The $P_s = 0$ curve in the case of the T-45 occurs between 250 and 330 KIAS. 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.

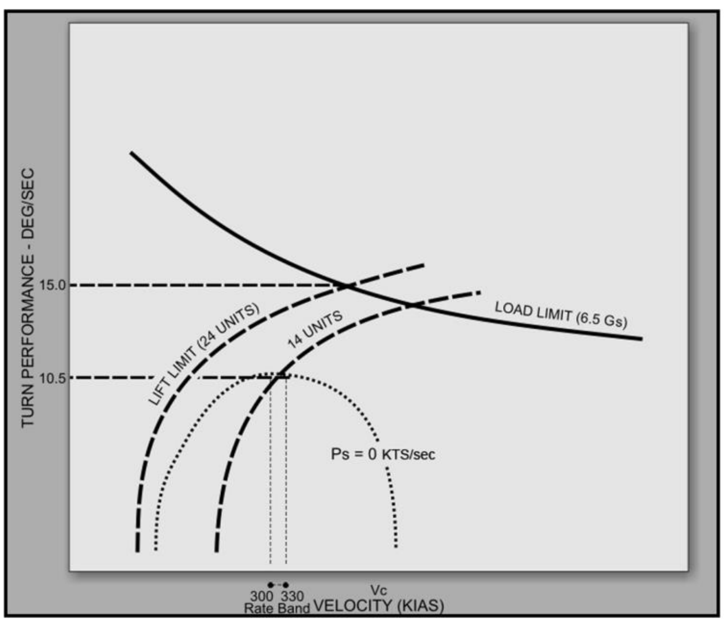


Figure 1-6 Turn Rate Band

The minimum turn radius for any given airspeed occurs along the Lift Limit curve. 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 (e.g., 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 KIAS 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.

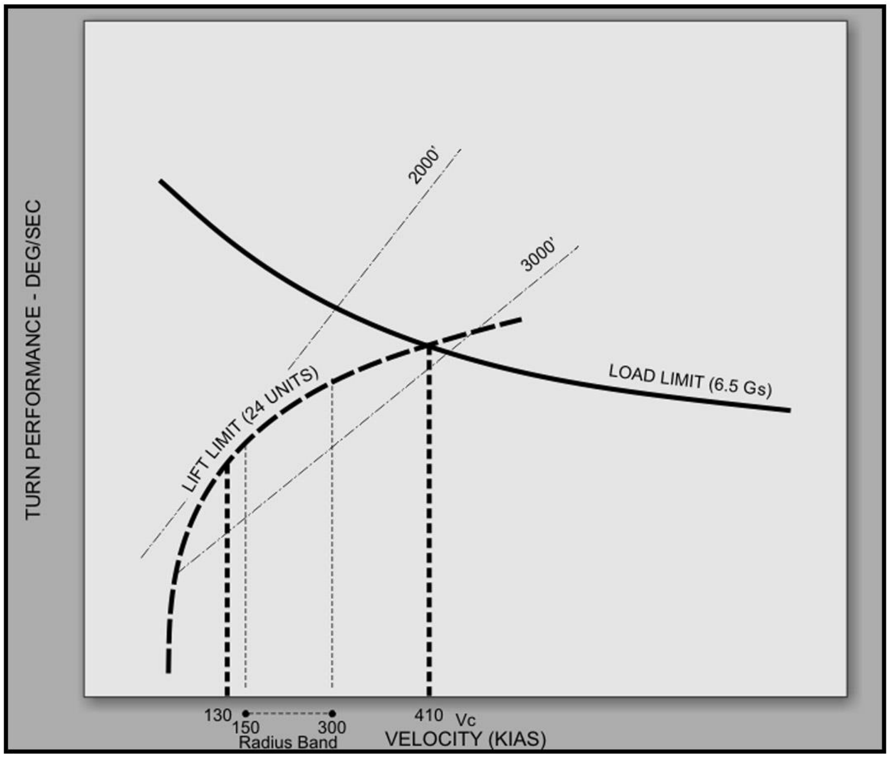


Figure 1-7 Turn Radius Band

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. Angles Off the Tail (AOT) – The angular position relative to the bandit's tail. AOT ranges from 0^o (bandit's tail) to 180^o (bandit's nose) and does not require any further amplification such as right or left 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 aircrew must be able to discern changes in range. Closure must be controlled in order to achieve or maintain a positional advantage.

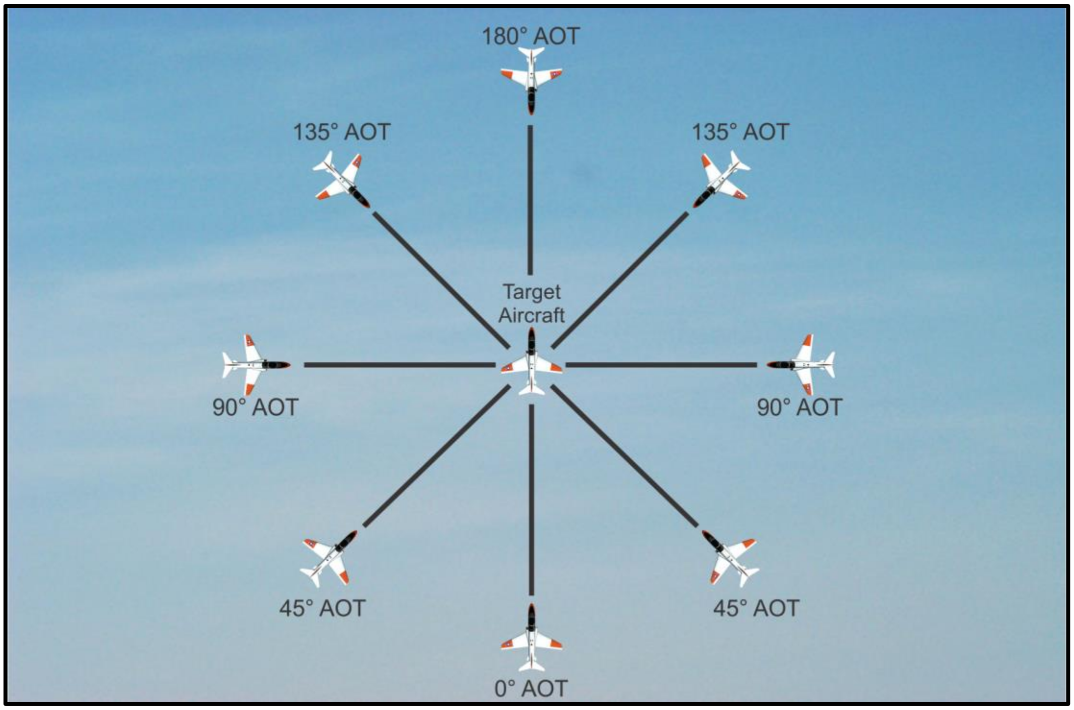


Figure 1-9 T-45C Angle-off the Tail (AOT)

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).

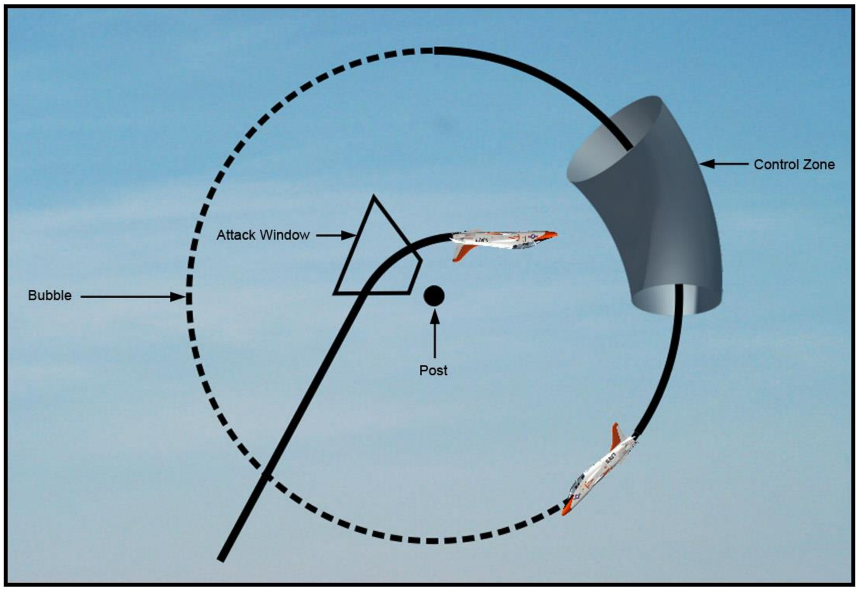


Figure 1-10 Bubble, Control Zone, and Attack Window

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. This results in the smallest turn radius and greatest turn rate for that given airspeed. This is significant because if we are defensive and the opponent is inside our bubble (assuming similar performing aircraft), we cannot deny the opponent 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, if the opponent is outside the bubble, we can pull the opponent back towards our nose to a 180 AOT (e.g., neutral pass).

The question then becomes, how do we determine if the opponent is inside our bubble? Sight picture is the key. If we are defensive and our opponent is outside our bubble, we can take away angles and pull our opponent’s aircraft forward on our canopy towards our nose. However, if our opponent stabilizes on our canopy and then starts to drift aft during our pull, our opponent has achieved bubble entry. On the other hand, if we are offensive and outside our opponent’s bubble, any pull our opponent makes will appear as target aspect change as our opponent denies us angles. Once we enter our opponent’s bubble, target aspect change will transition to a Line Of Sight (LOS) change. At this point, our opponent can no longer deny us angles. Bubble entry is one of the most important concepts of offensive and defensive BFM and will be discussed in greater detail later.

4. **Control Zone**

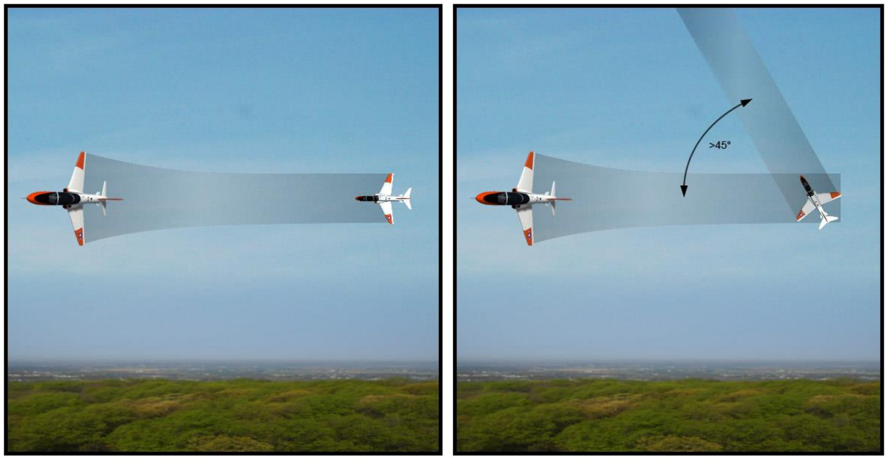
In the T-45C,the “Control Zone” is defined as an area that is roughly 2,000 feet to 4,000 feet behind the defensive aircraft. The near side of the control zone is roughly 20 degrees either side of flight path extending to 40 degrees either side of flight path on the far side. As the attacker, we strive to arrive in the defender's control zone with range, angles, and closure under control; as a defender, we try to deny control zone entry.

5. **Attack Window**

The “Attack Window” is a point in space where, if the attacking aircraft makes a maximum performance pull the attacker will arrive in the defenders control zone with range, angles, and closure under control. 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 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. 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) is best described as the geographic plane containing the aircraft's track. We will define out of plane maneuvering as any time own aircraft’s 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).



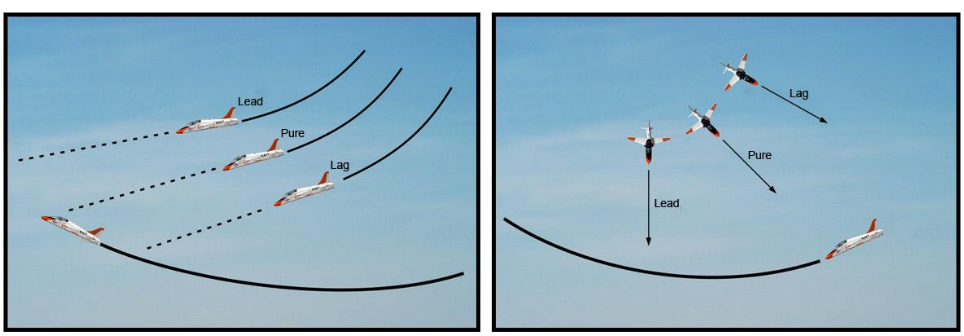
In-Plane **Out-of-Plane**

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

7. **Pursuit Curves**

The concept of pursuit geometry in the BFM environment is the basis of every tactical maneuver and cornerstone maneuver associated with any 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 OOP 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.



In-Plane **Out-of-Plane**

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

Lead Pursuit occurs when the nose or lift vector of your aircraft is placed in front of the opponent (Figure 1-13, left image). "Lead" is the proper 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 of your aircraft 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

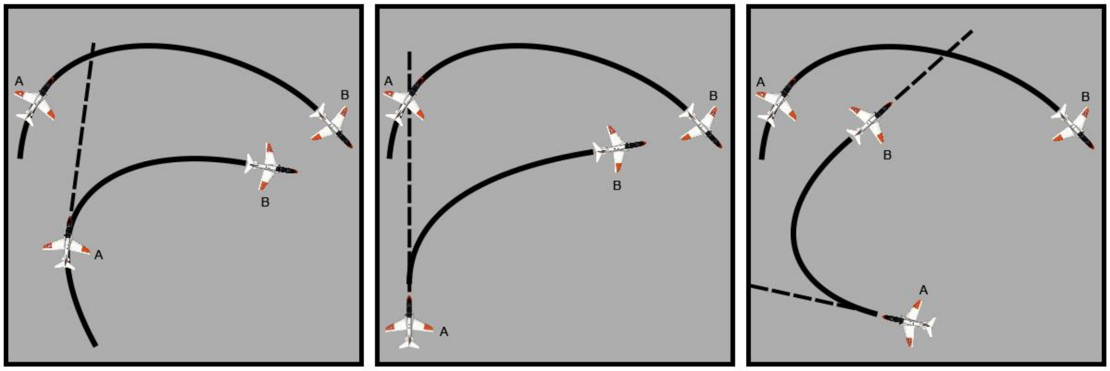
c. Increase closure (V_C)

Lag Pursuit occurs when the nose or lift vector of your aircraft 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)



Lead Pursuit **Pure Pursuit** **Lag Pursuit**

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 top priorities for training at VT-86 is for the SNFO to quickly recognize the engagement flow and to fight their 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 towards the same direction, for example both aircraft turn to the east, 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 this one-circle flow, the two aircraft are fighting nose-to-nose.

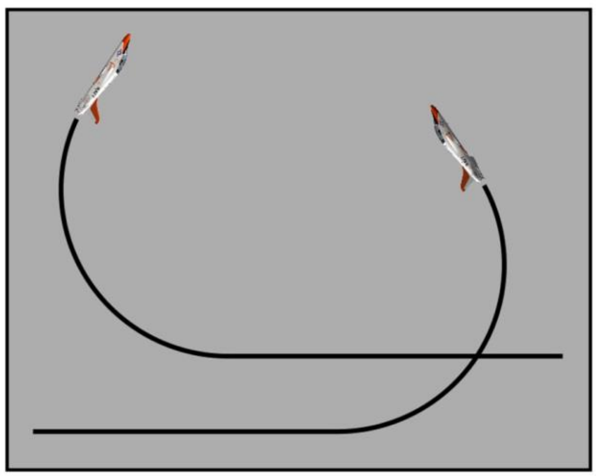


Figure 1-14 One-Circle Flow

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 T-45C at 19-21 units AOA. If we find ourselves in a one-circle fight in the T-45C, 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.

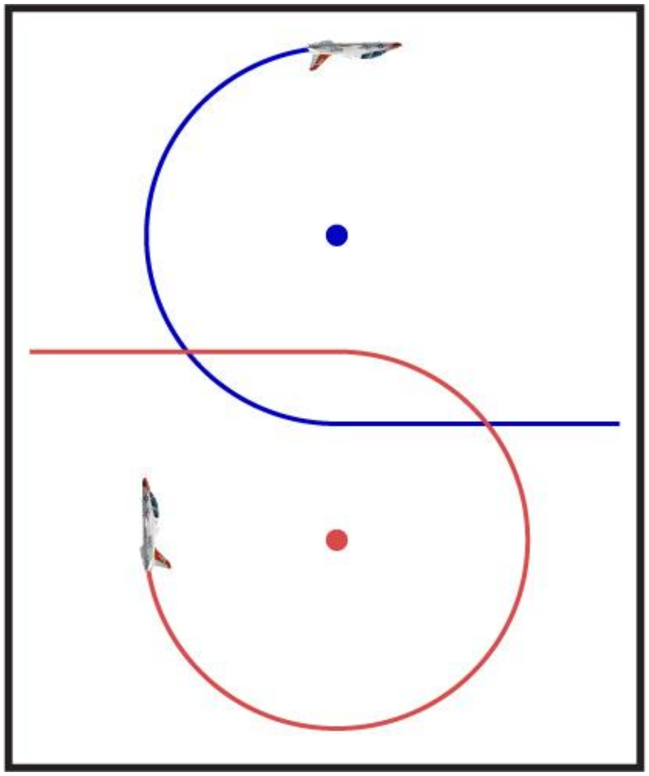


Figure 1-15 Two-Circle Flow

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 in the T-45C, the greatest achievable turn rate actually occurs at the corner airspeed of 410 KIAS. However, it is impossible to max perform at the corner airspeed 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, max perform until airspeed bleeds to 300 – 330 KIAS. Then, ease the pull to 14 units AOA 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**

OOP maneuvering is defined as any maneuvering in which our plane of motion is greater than 45 degrees above (nose-high) or below (nose-low) 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 often provides the added benefit of causing a delayed reaction from our opponent. If uncountered, an OOP also gives us the ability to cut across the circle and either gain or take away angles from our opponent. As a general rule, it is more beneficial for us to initiate OOP maneuvering. If however, 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 our opponent and us. To manage RAC, we have several tools at our disposal, some of which will be more effective than others depending on the actual situation. In the following discussion, we will discuss tools that have been utilized since the dawn of aerial combat. In today's ACM arena, several of these tools have become outdated as a result of advanced missile technology. However, we will still cover those methods, describe why they are no longer desirable or effective, and detail how to exploit those methods as BFM errors should our opponent mistakenly choose them. Finally, we will outline the possible consequences of not properly managing RAC.

13. **High Yo-Yo**

A High Yo-Yo is an offensive lag pursuit maneuver originally designed to prevent an overshoot by controlling excessive closure while preserving range. It is an out of plane maneuver intended to control excessive down range travel and ensure our aircraft does not overshoot the opponent’s flight path. As the fighter sees an overshoot developing, it should execute a quarter roll away from the bogey while simultaneously raising its nose to slow the closure on the defender’s flight path. This OOP maneuvering will place the nose of the fighter above the plane of attack and trade airspeed for altitude. The combination of OOP maneuvering and slower airspeed will reduce the fighter’s turn radius while aligning fuselages. The fighter’s slower airspeed will also reduce the closure rate allowing it to either maintain or increase range at their discretion. 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 the advent of modern missiles. This maneuver has several significant disadvantages today. The High Yo-Yo has the adverse effect of taking pressure off of the opponent thus increasing time-to-kill. Additionally, by maneuvering nose-high OOP, we decelerate out of our rate band during a two-circle fight. A better alternative would be to maintain rate numbers, accept the flight path overshoot, and allow the concept of misaligned turn circles to work to the advantage of the attacker. The latter option will bring the attacker into a rear quarter IR missile WEZ more quickly.

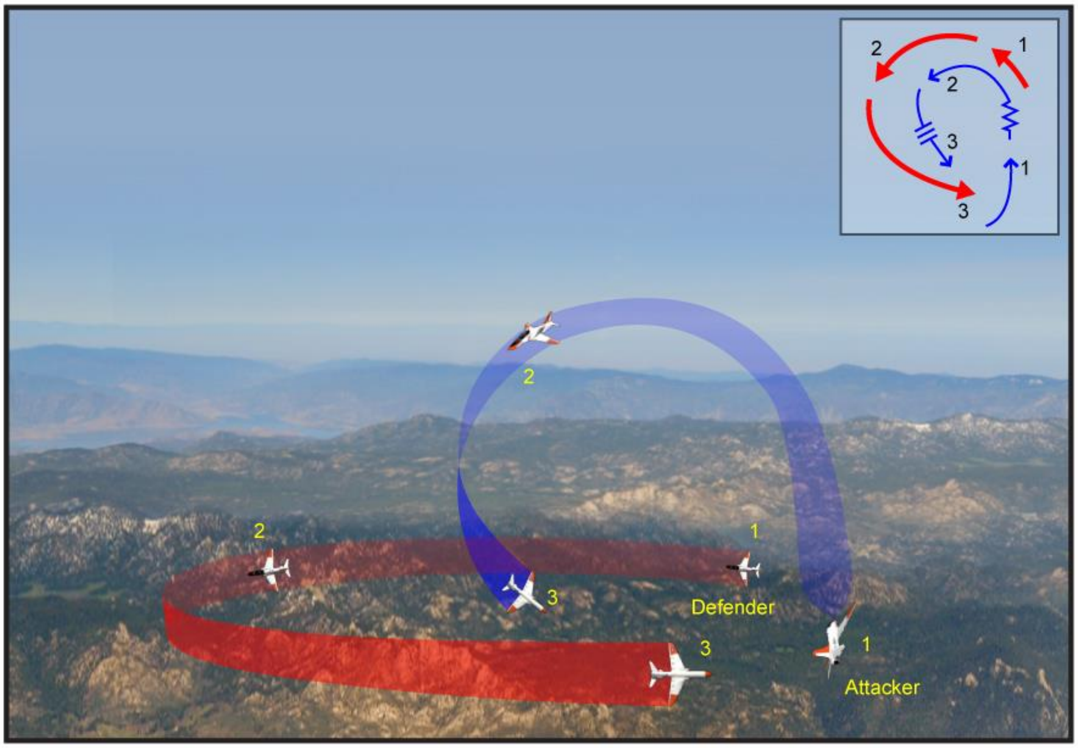


Figure 1-16 High Yo-Yo

As a defender, if the attacker mismanages RAC and mistakenly executes a High Yo-Yo, we need to immediately recognize the mistake. By taking its lift vector off, the opponent has taken sensor nose pressure off and allowed the defender (us) to regain precious energy. We should 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 pursuit. A Low Yo-Yo is usually employed when the attacker finds themselves confronted with 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 radius while simultaneously descending below the bandit's plane of motion (Figure 1-17). Depending on the degree of the nose-low maneuver, it is generally characterized as an OOP nose-low maneuver.

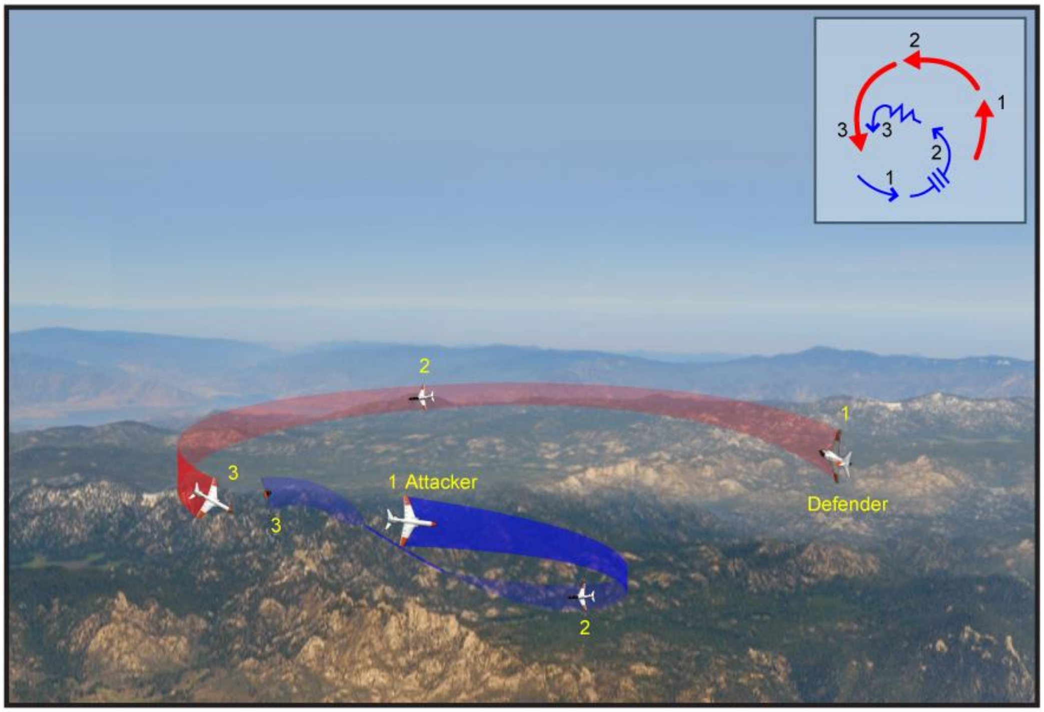


Figure 1-17 Low Yo-Yo

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 taking away the separation the attacker wishes to preserve. In modern warfare, separation is desirable for weapon employment.

As a defender, should our attacker execute a Low Yo-Yo, we need to recognize the mistake and match the attacker's nose-low attitude and match their pull in order to generate as much closure as possible reducing the range between aircraft. Collapsing the fight may seem counterintuitive to a defender. However, 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 executing a Low Yo-Yo. If poor offensive BFM results in the attacker being 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 properly countered, the Low Yo-Yo may work; but a savvy opponent will counter the maneuver nose-low and make the attacker pay for their 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 to a lag pursuit position. Normally, the displacement roll begins with an attempt by the attacker 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 by the attacker will depend on the amount of nose-to-tail separation that is desired.

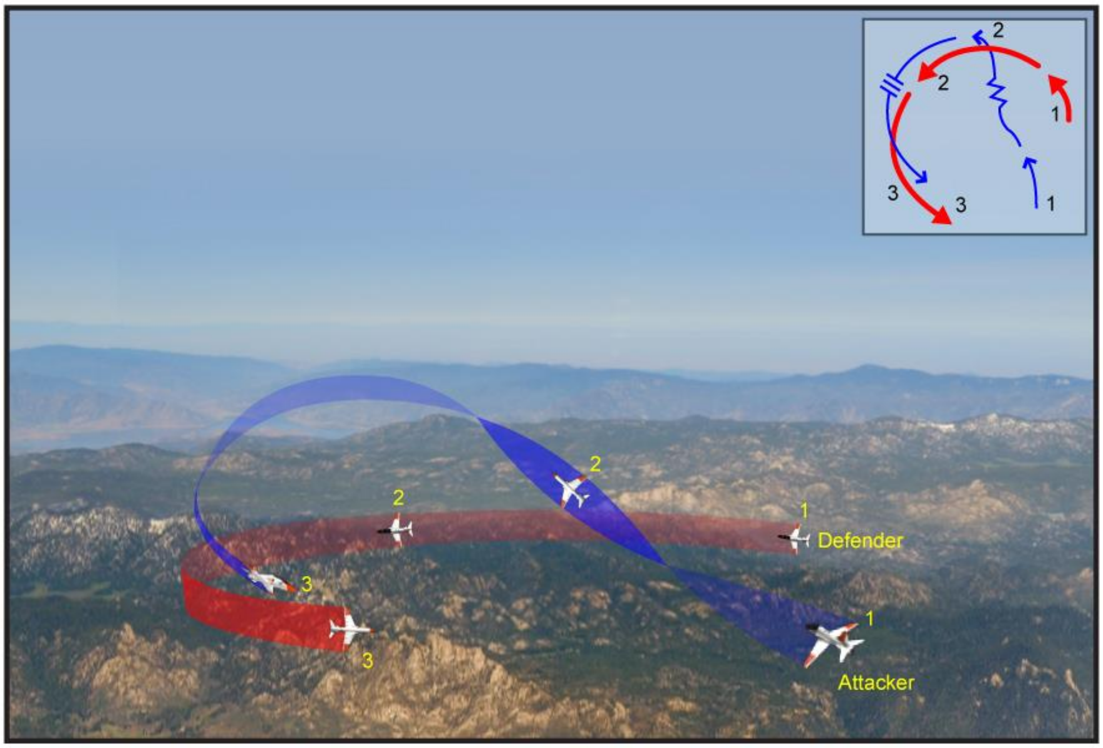


Figure 1-18 Displacement Roll

Like the High Yo-Yo, the Displacement Roll takes the pressure off the defender thus allowing them to regain energy. Thus 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 may result in an overshoot. There are two basic types of overshoot. They are the 3/9 line overshoot and the flight path overshoot. Although we sometimes refer to an in-close overshoot, this overshoot is actually a severe flight path overshoot.

17. **3/9 Line Overshoot**

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

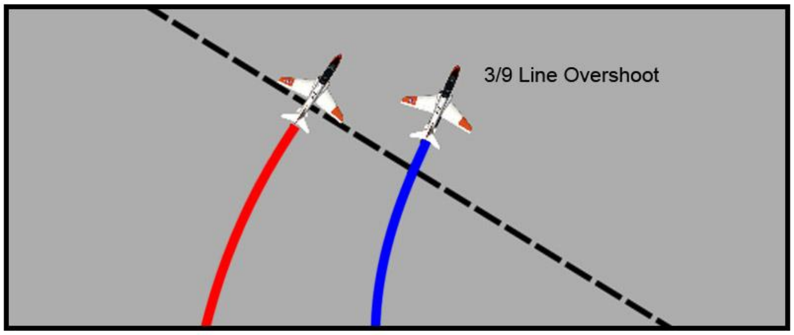


Figure 1-19 3/9 Line Overshoot

18. **Flight Path Overshoot**

A flight path overshoot occurs when the attacker accidently 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

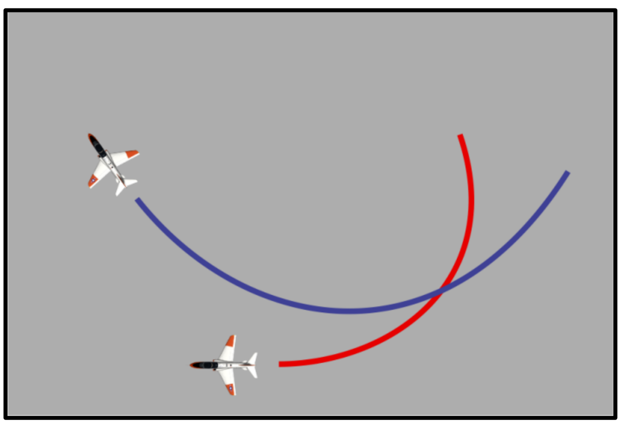


Figure 1-20 Flight Path Overshoot

19. **In-Close Overshoot**

An in-close overshoot occurs when the attacker crosses the defender's flight path inside the defender's control zone (< 2000 feet in the T-45C). 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). Before reversing, the defender should ensure the in-close overshoot meets the following criteria:

a. Inside the control zone (< 2000 feet in the T-45C)

b. High cross tracking rate

c. > 60 degrees angle off tail

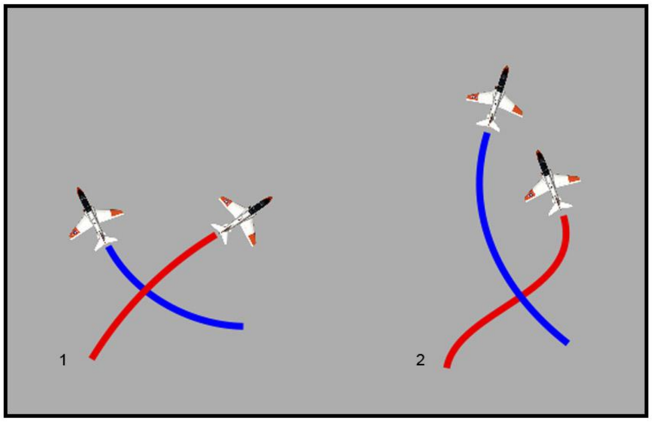


Figure 1-21 In-Close Overshoot, Reverse for Roll Reversal

If any one of three reversal criteria is not met, do not reverse. Instead, continue in the present direction of turn, increasing your survival time and wait for your Wingman to shoot the bandit. If all three reversal criteria are met, timing of the reversal 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).

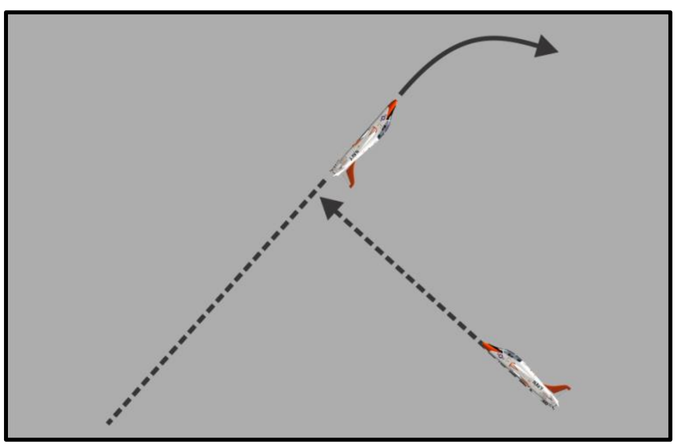


Figure 1-22 Reversal Timing

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 limit down range travel. The primary means of accomplishing this is by placing your lift vector in lag pursuit.

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 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. OOP maneuvering

d. Lift vector placement in lag pursuit of the opponent

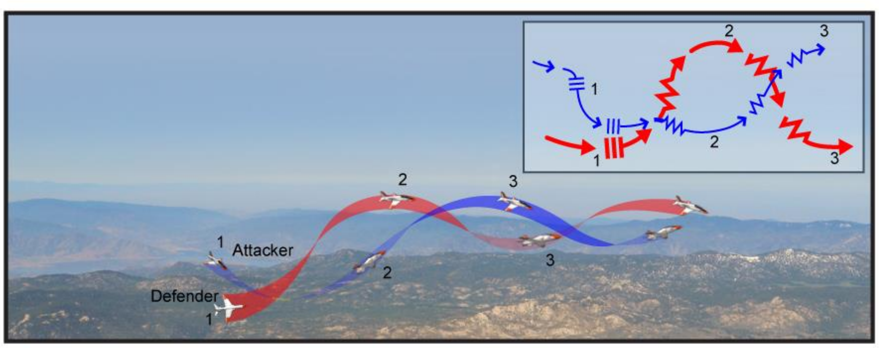


Figure 1-23 Flat Scissors

Disengaging from a Flat Scissors is difficult. Because both aircraft are generally operating at slow speeds in close proximity to each other, 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 also 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 may appear that the Rolling Scissors is two-circle flow, it is actually one-circle flow. This is better observed from a God's-eye view where the aircraft can be seen turning nose to nose with one aircraft being nose-high while the other is nose-low. Only after one aircraft obtains a slight positional advantage and the aircraft begins to align fuselages does the Roller become two-circle. Normally, by the time this occurs, the engagement 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 coupled with proper energy and lift vector control.

A key determinant in winning the Roller is the ability of one aircraft to get its nose up when at the bottom of a Roller before the opponent can get their 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 our 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 thus an offensive advantage. Likewise, if we are at the bottom of the Roller and cannot (or do not) transition to nose-high before the opponent has transitioned to nose-low, the opponent is gaining an angular advantage.

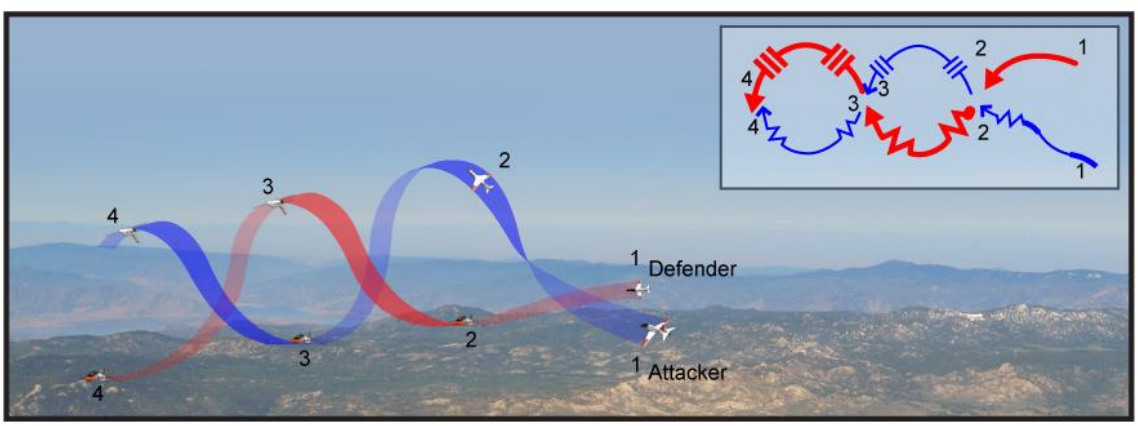


Figure 1-24 Rolling Scissors

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 to either align fuselages or pull for a shot; however, because each aircraft is typically inside the other's bubble, lead pursuit generally results in an increase in ones down range travel and being flushed out in front. There are generally only two times when one would pull lead in a Rolling Scissors:

a. To get inside the bubble when offensive and outside the opponent's bubble

b. When pulling for a nose-high shot

Generally, it is only desirable to pull lead going nose-high because with a nose-high overshoot, your opponent typically cannot reverse and take advantage of the overshoot. When nose-low, our 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 at the bottom. This may be an optical illusion due to the effects of radial G and the tactical egg. If most of the time your opponent appears in the forward part of your canopy, the fighter is offensive. The Rolling Scissors tends to degenerate in altitude as the fight progresses due to the bleed rates associated with the Rolling Scissors 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, and the fight will transition to 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 be the first to transition.

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.

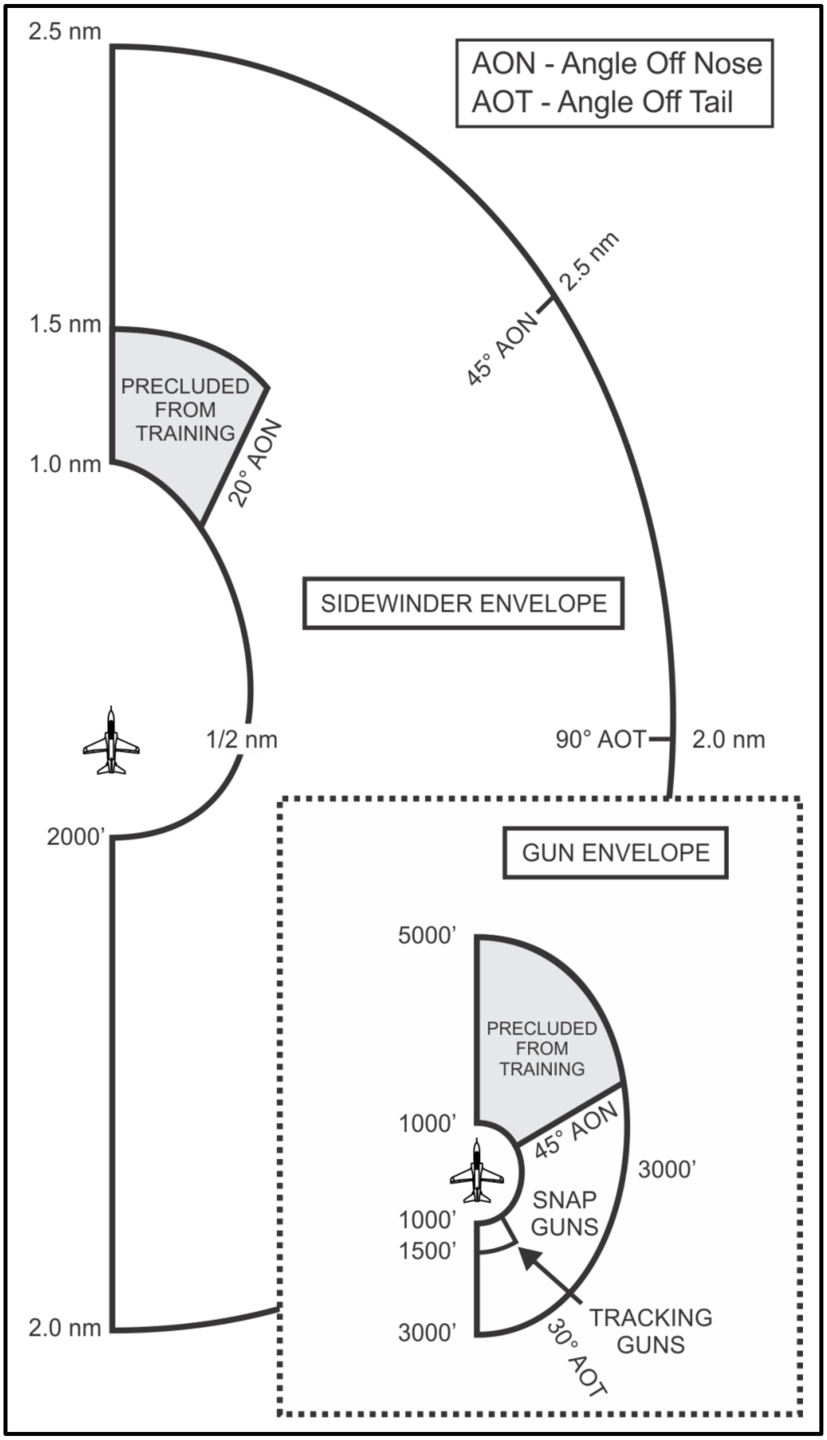


Figure 1-25 CNATRA Weapon Envelopes

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 for the shot to be considered valid.

a. IR Missile:

i. Shooter within CNATRA Sidewinder Envelope

ii. Target within HUD Field of View (FOV)

iii. Wingman (if one present) not within HUD FOV (shot de-confliction).

iv. ***Pull the trigger when steps 1, 2, and 3 met and weapons release authorized***.

b. Snap Gun Envelope:

i. Shooter within CNATRA snap gun envelope.

ii Pull trigger early (prior to canopy bow) 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 purposes we must call our shots. The called shot must be appropriate for the type of weapons envelope being employed. For example:

a. IR missile shot - “(fighter call sign)…Fox-2.”

b. Snap gun - “Trigger down, snap , overall assessment (e.g., missed high/missed low/looked good).”

c. Tracking gun - “Pipper’s on, tracking…pipper’s off.”

2. **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 (number of bullets) at target range. Bullet velocity at impact is affected by target range and closure; while bullet density is a function of target range (as it relates to bullet pattern dispersal), track crossing rate, and employment parameters of the shooting aircraft. Because of these factors, not all quadrants of the Gun Employment Envelope will achieve the same P_k. In fact, the quadrant that provides the highest P_k (forward quarter gun employment) is actually prohibited by training rules and CNATRA.

The next most lethal sector would be the tracking region from 0 degrees to 30 degrees AOT, within 1,500 feet of the target. This region has very little track crossing rate and requires minimal lead or maneuvering from the shooter, thus providing a high bullet density. The decreased range also provides the bullet with increased kinetic energy. Snapshots taken from the beam (30 degrees to 135 degrees AOT) are less lethal due to the high track crossing rates. These tracking rates increase the lead requirements, resulting in much lower bullet densities at target range.

3. **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 plane of the shooting aircraft. The Real Time Gun Sight (RTGS) pipper in the HUD is calculated by T-45C Global Positioning System/Inertial Navigation Assembly (GINA); it shows where a bullet will be after one second Time of Flight (TOF). If the pipper track can be lined up with the target's POM track, a successful gun-shot can be made so long as the range and lead parameters are also solved.

b. Range – This is the linear distance from the gun to the target. As an aid for solving range, set 31feet (T-45C wingspan) into the A/A stores page. This provides a 31 mil diameter pipper in the HUD FOV (1 mil = 1 foot at 1,000 feet 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-sight 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 along its projected flight path (lead pursuit) when firing; otherwise, the bullet will travel down range but be behind the target. The lead must be sufficient for the bullet and the target to arrive at the same location, at the same time.

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

Defending against a gun attack is an important concept in BFM. While an attacker attempts to solve for the parameter of POM, Range, and Lead, the defender attempts to disrupt that effort. By pulling harder it may increase the lead required, resulting in a miss with bullets late to target range arriving behind the defender. However, if all three parameters are solved, then Guns Defense (Guns "D") is the only option available for the defender. The Guns 'D' is designed to defeat the POM parameter. 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 defender's wingtip is on the attacker, a pull out of the attacker's plane-of-motion is required. The Guns 'D' can be performed as nose-high, nose-low, or with a wings level bunt described below.

a. Nose-high – There are several reasons why we might want or have to initiate a "Nose-high" Guns 'D'. Perhaps we are on the deck with no ability to go nose-low. Secondly, we may not want to initiate a slow speed, nose-low maneuver that would be fairly easy for an opponent to follow. On the other hand, if our opponent was coming from high-to-low, a nose-high maneuver would be extremely difficult for them to follow. However, for the most part, nose-high maneuvers are not difficult to follow and typically 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 simplify 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 thus displacement; gravity helps us 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, then maneuvering opposite their plane-of-motion could be advantageous. However, maintaining visual in a nose-low Guns 'D' is often 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 even establishing negative AOA to displace the aircraft opposite its lift vector. While it is an option, it is not necessarily recommended as it relies mainly on deception. The aircraft performance under negative G is much less effective and therefore provides much less displacement from POM.

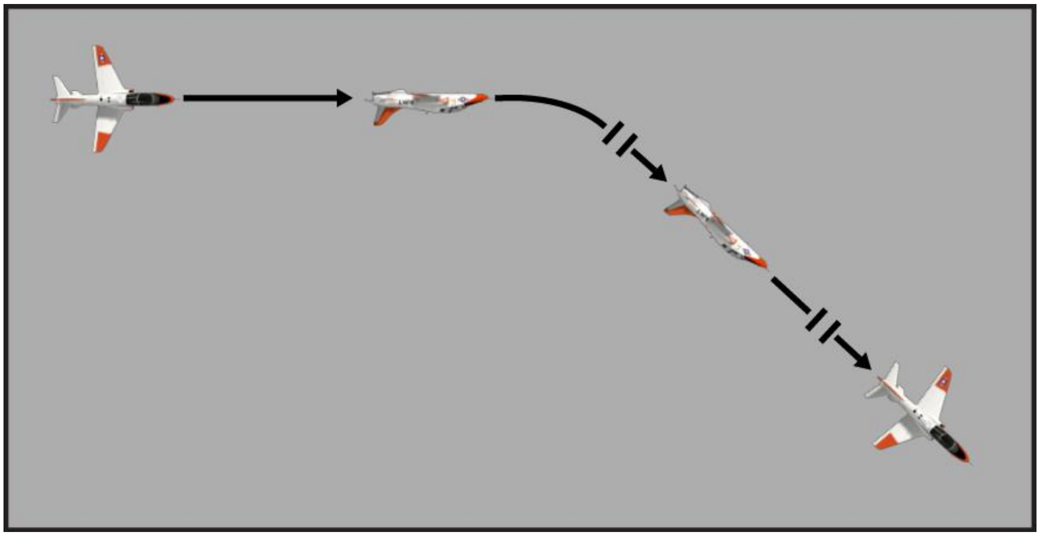


Figure 1-26 Wingtip On, Guns 'D' Low

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 during an engagement, the overarching goals remain the same:

Offensive Goals:

- Preserve lateral separation/turning room (Control RAC)
- Pressure the defender
- Maneuver to arrive in the control zone
- Employ weapons

Defensive Goals:

- Deny weapons employment opportunities
- Collapse the fight, denying angles/turning room
- Create fuselage misalignment
- Separate/Neutralize/Kill

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

- Maneuver to Survive: Recognition of "sensor nose" and responding with break turns or Guns 'D' as appropriate.
- Attacker outside the Bubble: Pull Attacker as Far Forward as Possible
    - Sensor nose-on = break turn (19-21 units AOA)
    - Sensor nose-off = hard turn (17 units AOA)
- Attacker Inside the Bubble: Decrease in Target Aspect = Increase in pull
- 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 for learning BFM, by 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 remains 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.

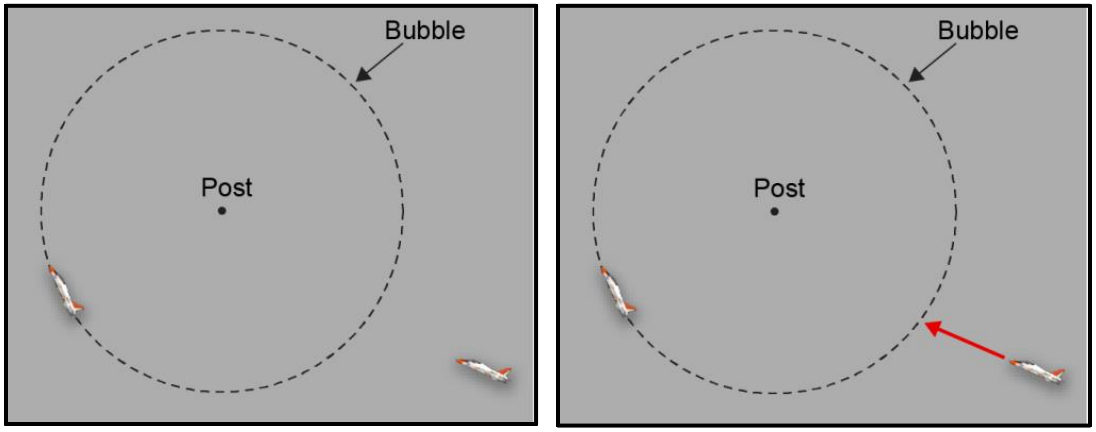


Figure 1-27 9K' Set Outside Bubble/Pure Pursuit for Bubble Entry

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

Once we have achieved bubble entry (target aspect change switches to line of sight change), work toward lag pursuit 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 AOA). Continue to pull as required until we can no longer hold that sight picture without bleeding below the rate band (300 to 330 KIAS).

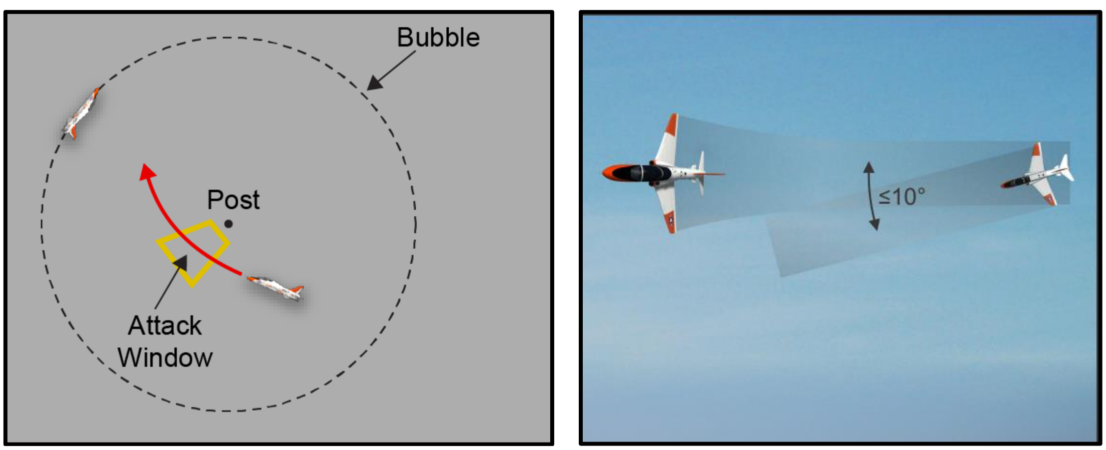


Figure 1-28 9K' Attack Window Entry Mech

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.

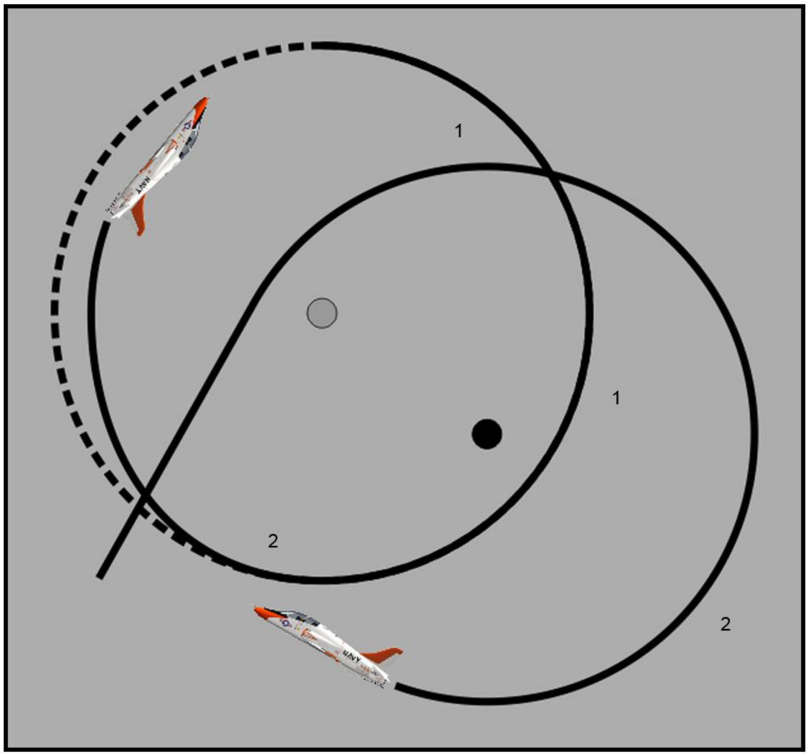


Figure 1-29 9K' Set Misaligned Turn Circles

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 level break turn 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 attempt to 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 our 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 their nose to regain airspeed. As the defender, we do not want to lower our 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 turn rate war, we would like to do so "level" (no increase or decrease in altitude) in order to preserve all of our options. However, if our opponent makes a mistake and drops the nose in an effort to execute a Low Yo-Yo, we will counter by also going nose-low and thus collapse the fight (reinforcing Defensive Goal #2).

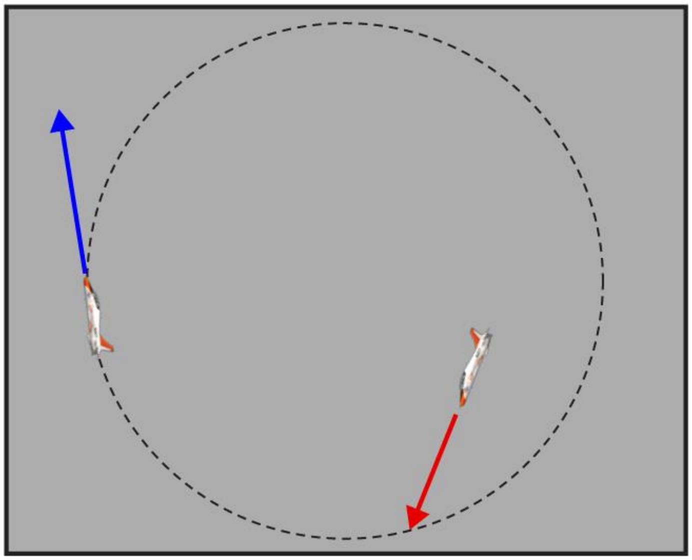


Figure 1-31 Match Attacker's Pull Inside the Bubble

9. **Misaligned Turn Circles**

Once established in the turn rate war, we will attempt to match the attacker's action by easing our pull when the attacker eases and tightening 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 thereby setting ourselves up for a high aspect pass. If we can position ourselves across the circle from our opponent and outside their bubble, we have gotten closer to the engagement being neutral. 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.

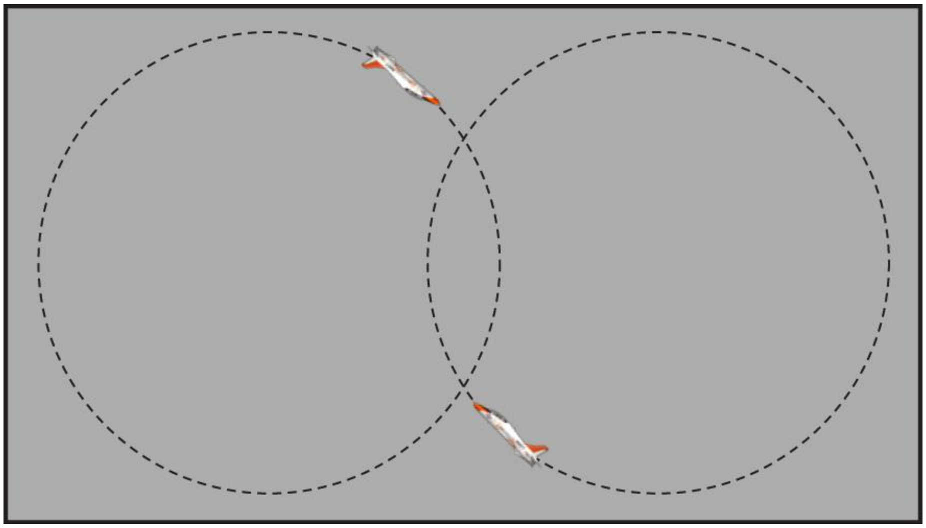


Figure 1-32 Successful Rate Management Back to Neutral Pass

10. **Bug**

To bug we need approximately 180 degree out (heading reciprocal) and 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).

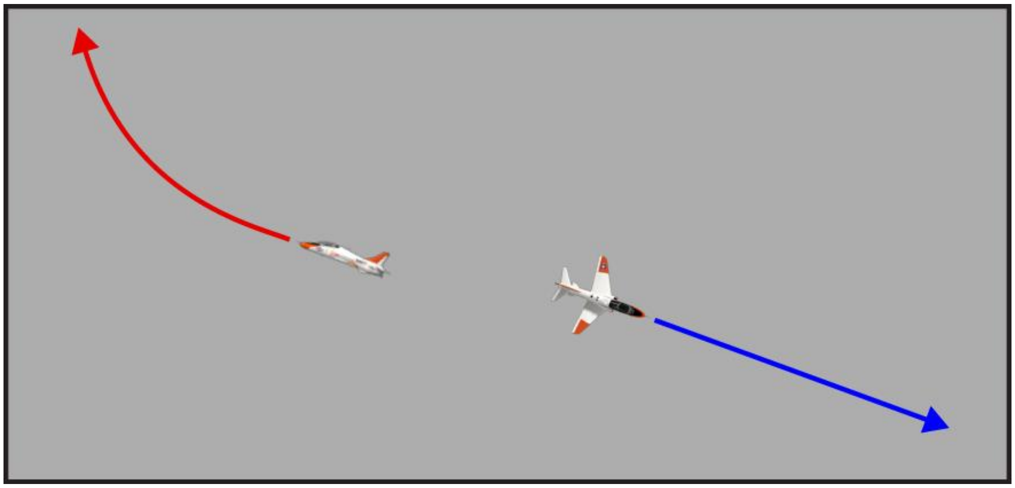


Figure 1-33 Bug if Possible, 180 Degrees Out

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-on and bubble entry again. When the attacker's sensor nose is on, execute the same break turn with flares as before. If at any time the attacker is approaching sensor nose-on 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.

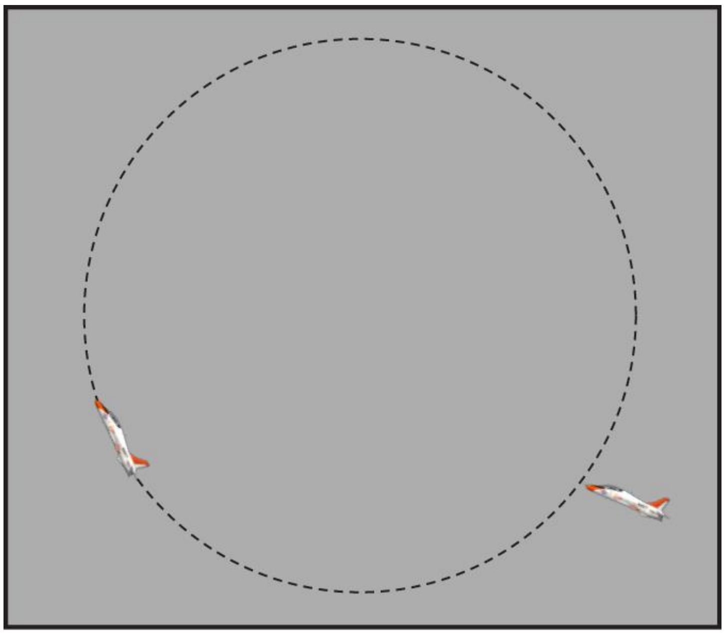


Figure 1-34 6K' Set, Just Outside the Bubble

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 using a 'Last Ditch' or 'Ditch' maneuver, altitude permitting. This is a Split 'S' type of nose-low maneuver in which our opponent rotates their lift vector out in front of us in an attempt to deny us their 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. When the defending aircraft begins to pass under the attacker's nose the attacking aircraft should start their ditch follow. A common error is for the defender to be late on the ditch follow. 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.

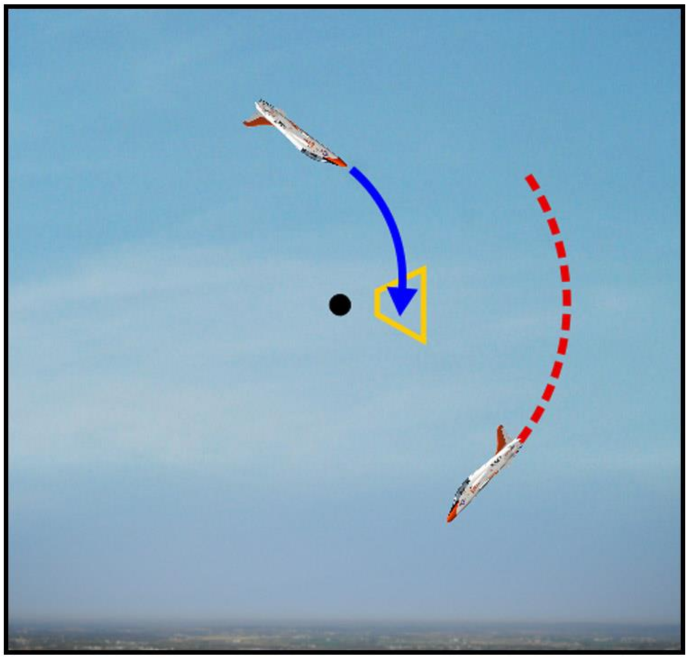


Figure 1-35 First Lag Towards Departure Point, then Ditch Follow

15. **Deck Transition**

As we approach the deck we have two options: a pure positional deck transition or an oblique, energy rate deck transition. 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 within 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) in order 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 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-on becomes a factor, we will redefine/Ditch (Axiom #4).

18. **Ditch**

With no other options available and assuming we have sufficient altitude (approximately 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 our 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-on again becomes a factor. We will ditch again if altitude permits. The hope is to create additional fuselage misalignment. However, we probably will not have the altitude to execute a second ditch in the T-45C.

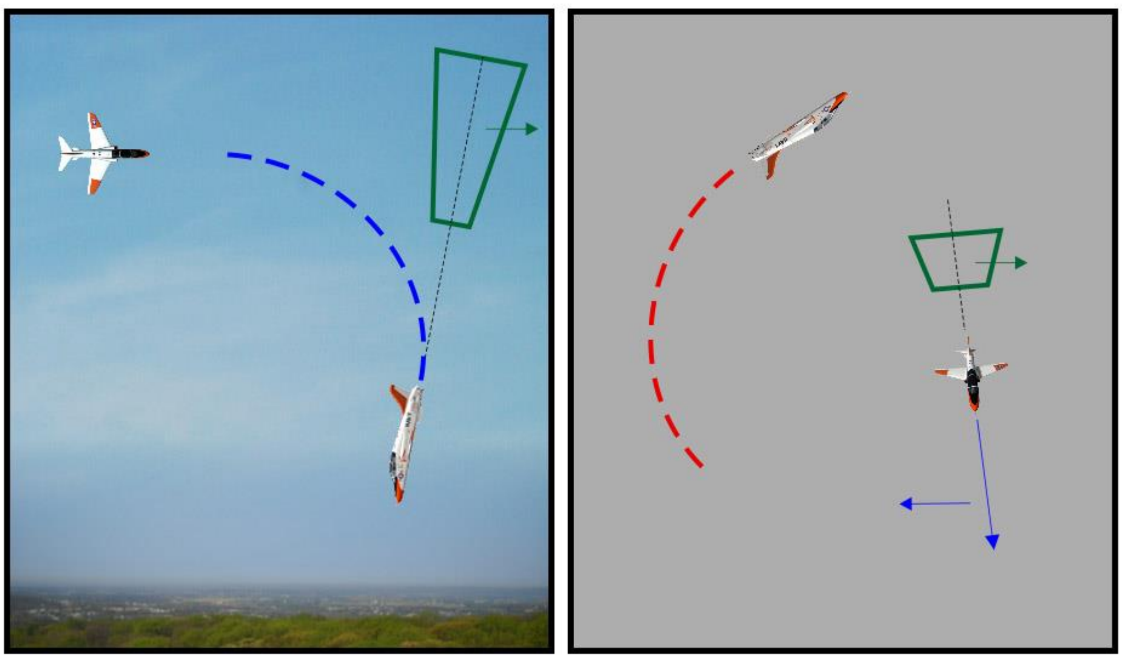


Figure 1-36 Ditch Mechanics, Deny Control Zone

19. Deck Transition

Once we find ourselves within 6,000 feet of the deck, we must start working towards 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 in a position where fuselages are still aligned (defensive), we will execute a positional deck transition, max performing our aircraft in order to take out angles. If we have enough altitude to go pure nose-low (> 6,000feet above the deck), the transition 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 AOA) in the oblique. During this process, if we find that the 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 gain back as much airspeed as possible by the time 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 (due to altitude constraints) so we will attempt to execute an "On Deck Reversal." Despite the fact that reversal criteria haven't been met, 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 lack 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 this 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.

– Nose-Low Altitude Above the Deck

If 5,000 feet above the deck, then max nose-low is 50^o.
If 4,000 feet above the deck, then max nose-low is 40^o.
If 3,000 feet above the deck, then max nose-low is 30^o.
If 2,000 feet above the deck, then max nose-low is 20^o.
If 1,000 feet above the deck, then max nose-low is 10^o.

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

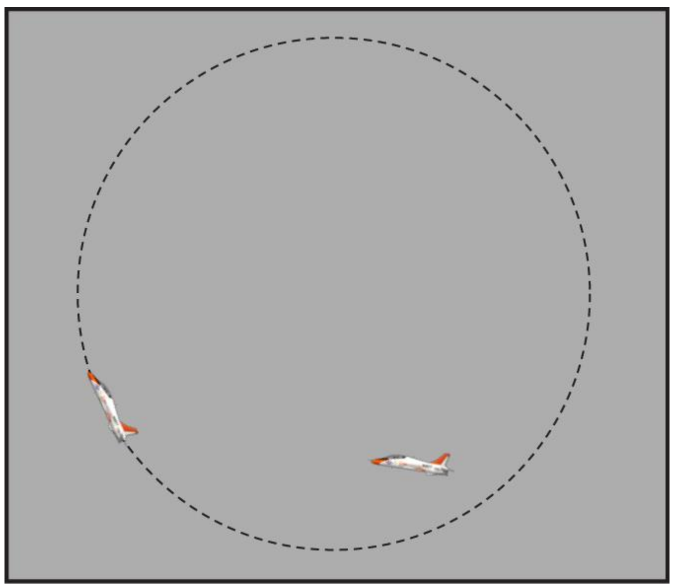


Figure 1-37 3K' Set, Inside the Bubble

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 events 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 in an attempt to deny us a weapons opportunity, cause us to overshoot, or scrape us off the deck. We should expect to arrive on the deck in some sort of weave, which is a cross between a Flat Scissors, and a Snapshot drill. Our first priority is to avoid the deck. Our second priority is to preserve the offensive advantage. The defender will try to maximize our closure thus forcing an overshoot.

We should mainly pull for lag pursuit and early turning (lead pursuit) only if we have sufficient nose to tail separation to align fuselages (approximately a minimum of 1,000 feet). This becomes the quintessential "knife fight," thus max performing our aircraft (19-21 units AOA) is the key to success. Finally, our last priority is weapon's employment. Any time our nose is going to pass through the defender, we should employ our gun (Figure 1-38).

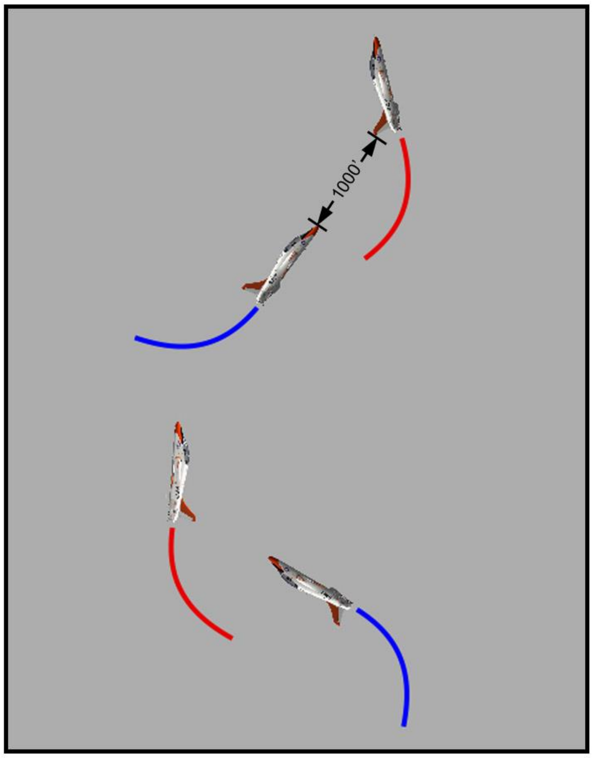


Figure 1-38 Finish the Fight, Maneuver to Weapons Employment

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, in all likelihood we will find ourselves on the deck, out of energy, with the attacker approaching a guns tracking solution.

24. **Guns Weave**

Never give up! Once we find ourselves on the deck, out of energy and our opponent pulling lead for a gun solution, we will need to initiate a reverse (Figure 1-39). Like the offensive discussion, our first priority is to avoid the deck. We should attempt to target 500' above the deck to give ourselves some buffer. In order to employ the gun, our opponent must solve POM, range, and lead. If we are on the deck, in-plane and in-phase with our attacker, two of the three of the necessary parameters are solved. At that point, the only variable we can affect is lead.

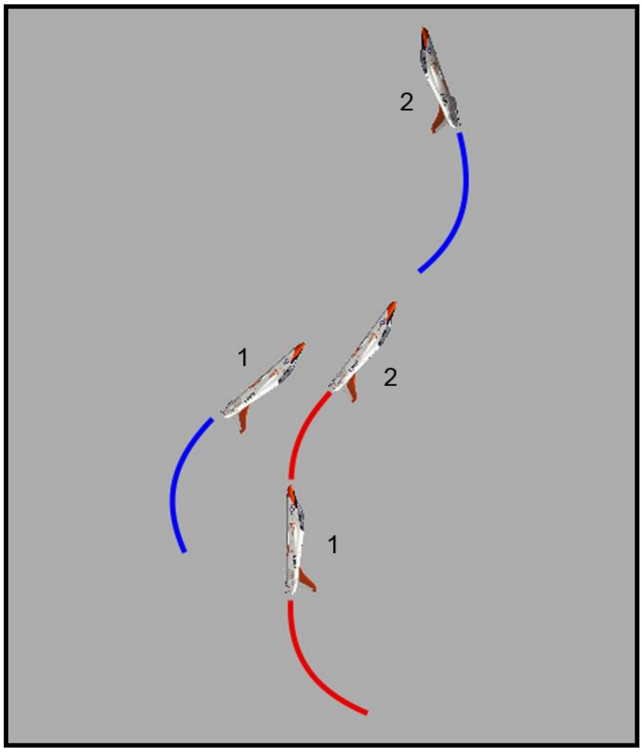


Figure 1-39 On Deck Reversal

Our opponent cannot shoot us nose-on; some sort of lead is required. With our attacker in phase and pulling for lead, we will target 150 KTS and max perform (19-21 units AOA) to maximize the attacker's closure. Just as the attacker is pulling nose-on, we will reverse, disrupting the lead solution. Once established in the opposite AOB turn, max perform our aircraft once again and look to reacquire the attacking aircraft at our 5 or 7 o'clock position. Repeat this process once again as the attacker attempts to pull for lead. As we max perform, our hope is that the attacker will have to lag in order to preserve the required nose-to-tail separation. It may take a couple of iterations, but ultimate goal is to get out of phase with the attacker. This will 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 immediately reverse. We continue maneuvering to survive until we scrape our attacker off on the deck, run the attacker out of fuel/bullets or optimally 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 subsequently 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 should be the expected 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 our strengths while simultaneously minimizing our opponent's strengths while exploiting their weaknesses. The other threat consideration is our opponent's 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 conservation 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 instead 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 possess 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.

Ultimately, 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 somewhere between one-circle and two-circle flow.

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 (e.g., switch from two-circle to one-circle flow). Doing so would play directly into our opponent's game plan. If our game plan is not working for us, perhaps the best course of action is for us to disengage prior to becoming defensive and live to fight another day. Conversely, 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 At which point we will once again attempt 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 where turning room exists but the altitude of the merge is within one turn diameter of the deck. In this situation, the lower aircraft can use that turning room, airspeed permitting. However, the higher 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 lower 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.

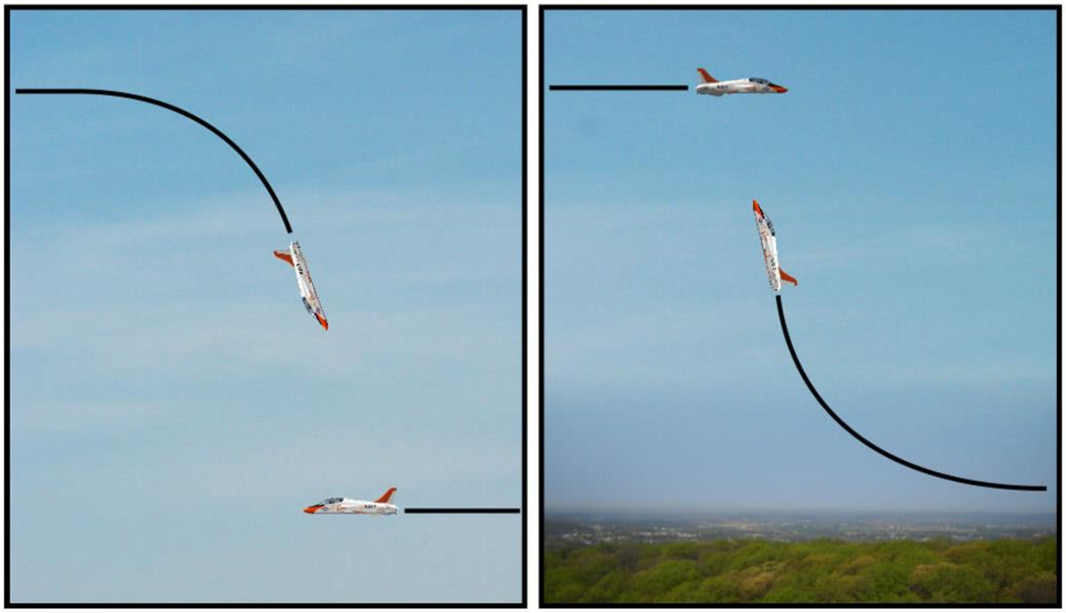


Figure 1-40 Exclusive Use Turning Room

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 turn 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 depending on the reaction of our opponent. If it appears our opponent is trying 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 in the Offensive Perch BFM section. We will put the opponent on our canopy bow and pull to keep them there. If our opponent chooses to max perform instead in an attempt to stop their 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, our first priority should be to avoid this type of merge at all costs.. If our opponent is coming up at us, we need to counter by opposing their nose and come down to meet them. However, we will strive to work up and behind the opponent, in an attempt 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 the situation as if we are defensive and react according to the Axioms of Defensive BFM, more specifically Axiom #3. If our opponent tries to early turn, we counter by max performing to minimize our altitude loss (Decrease in TA = Increase in Pull). If our opponent tries to extend through the merge in an attempt to gain altitude, we will extend as well in an effort to exit our opponent's bubble where we will then be able to pitch back in and deny the opponent angles.

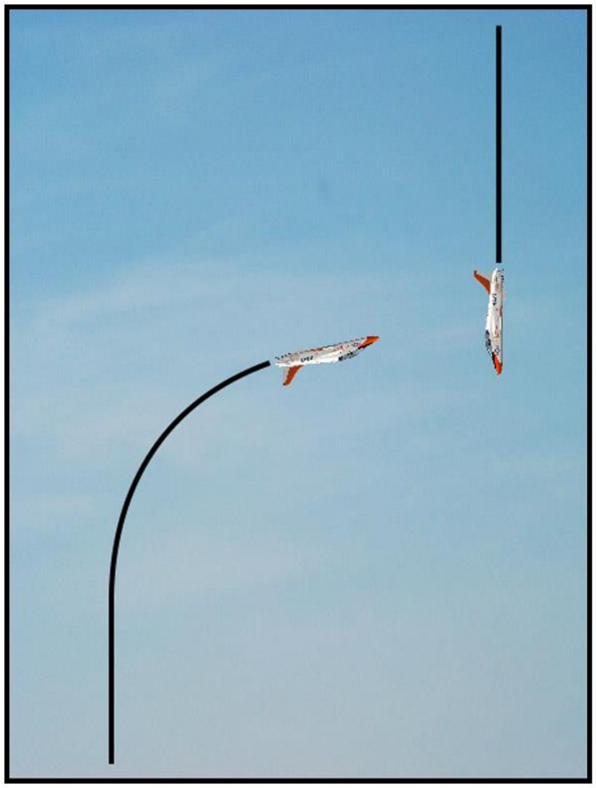


Figure 1-41 Vertical Merge

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 original 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 nose-low 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 where going up appears to be the only option. If our opponent decides to go up, we could immediately follow suit and go up. However, in doing so we must be aware that we will 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 instead, if we cross our opponent's tail and wait for bubble exit (Figure 1-42), an opportunity to gain angles exists. 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 chooses not honor our nose and instead comes back down, we gain un-countered angles. On the other hand, if the opponent honors our nose, we set up the vertical merge and take advantage as the nose-high aircraft.

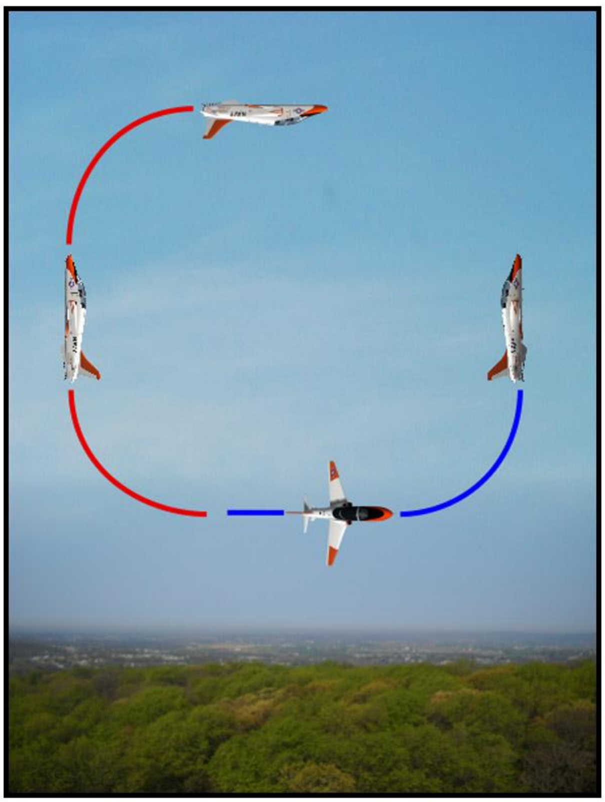


Figure 1-42 Nose-high Counter

This scenario can also be used when our opponent goes up but 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 in order to go up prior to our opponent coming back down. Of course, if we initiate a nose-high maneuver and our opponent chooses to execute 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 a First Move Option 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 to evaluate our opponent's first move in an effort to force our desired mindset and flow. For instance, if our original game plan was to force one-circle flow and we arbitrarily chose to go nose-high at the merge, our opponent might go nose-low and affect two-circle flow; not the flow we wanted. By going level initially, we can evaluate our opponent's first move, and subsequently 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 quickly evaluate our opponent's flow and counter when the proper sight picture develops.

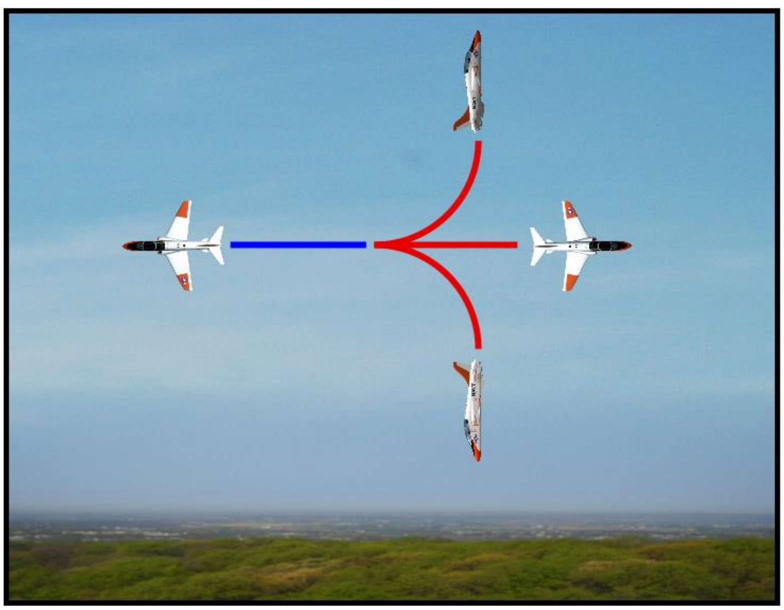


Figure 1-43 First Move Option, Level

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

Out-of-Plane maneuvering is defined as any maneuvering where 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 or nose-low OOP.

We initiate nose-high OOP maneuvers when we are willing to sacrifice kinetic 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 chooses instead to execute a 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. Should our opponent turn level and opts not counter nose-high, we can with proper lift vector placement 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.

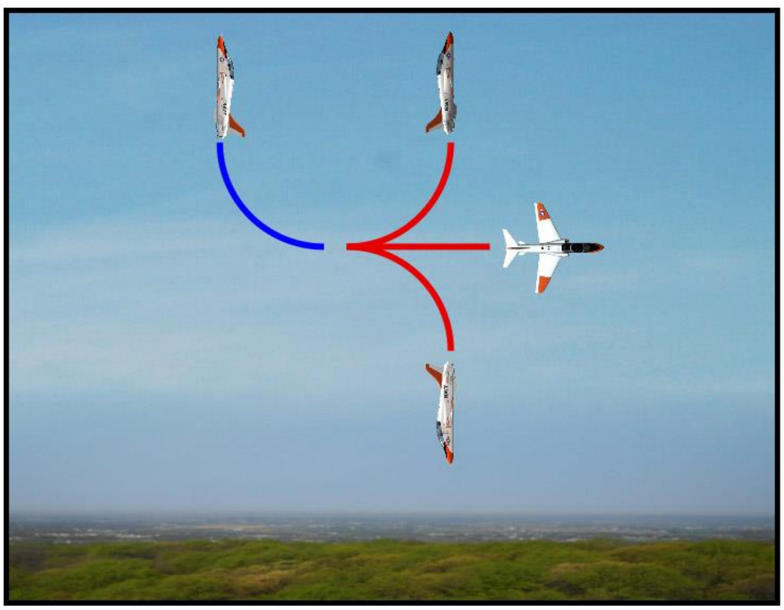


Figure 1-44 First Move Option, Nose-high

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.

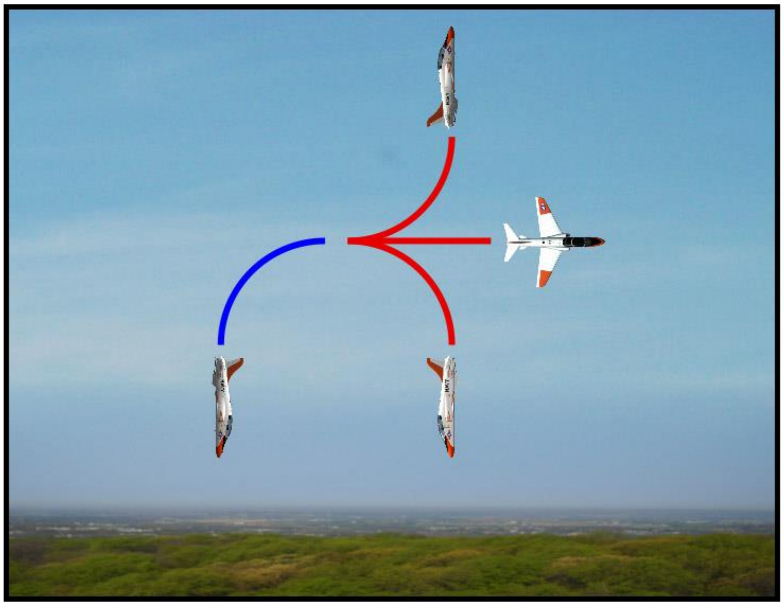


Figure 1-45 First Move Option, Nose-low

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 (350 KIAS) in an attempt to minimize turn radius, we may put ourselves at an kinetic 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 based on those sight cues. Almost immediately after the first merge, roles will be determined even though the advantage may be as little as 20 degrees. The aircraft to recognize the advantage or disadvantage first, and make the proper transition based on the sight picture is usually the one that prevails. The key to understanding this 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 of their perspectives.

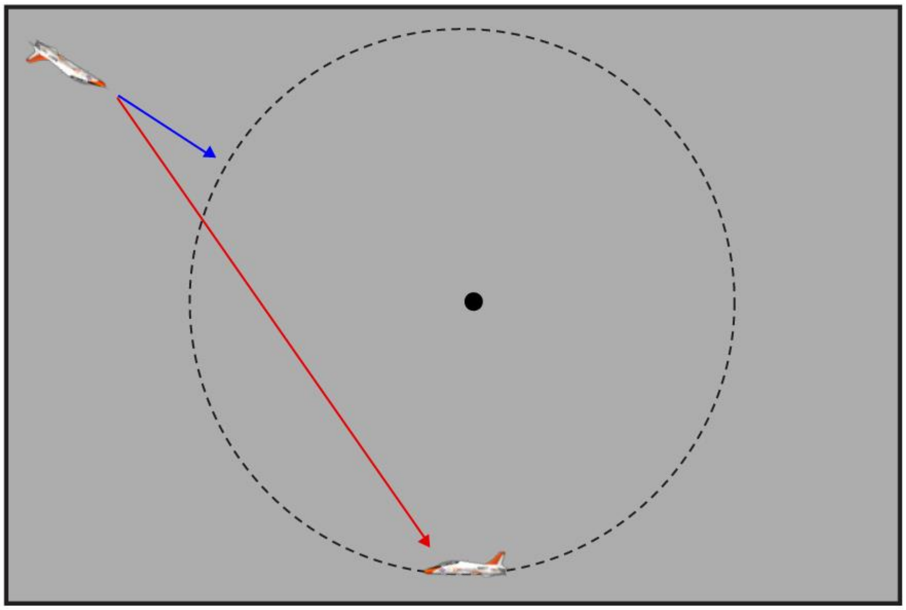


Figure 1-46 Offensive/Defensive BFM Transition

14. **Offensive with 30 Degree Bite**

From the offensive perspective, the first priority is to preserve lateral separation. Remember from our discussion of 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 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 the 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 the other aircraft 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 out, we cannot afford to give our opponent an angular advantage. Regardless if the angular advantage of our opponent 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 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, 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 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 characteristic, by providing 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.

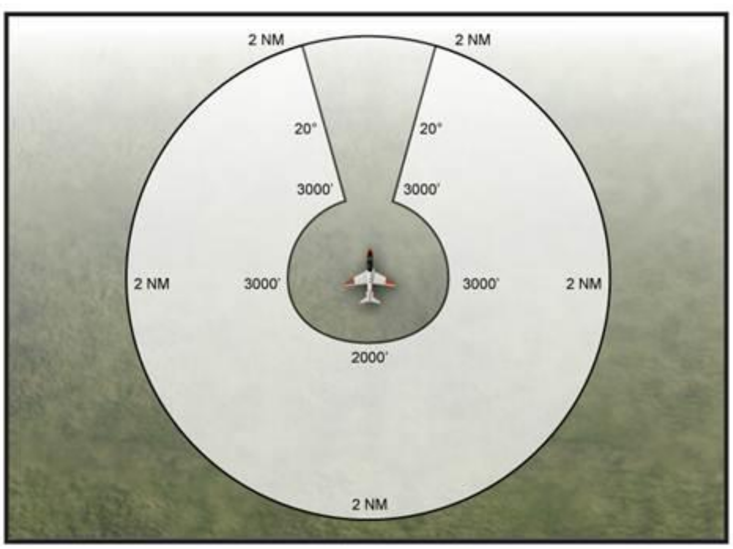


Figure 2-1 T-45 OFT/VMTS SRM (IR) Missile Envelope

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 SRM employment method will be in the rear quarter with a RADAR lock , whereby the seeker of the SRM is directed by the radar. This simulates AIM-9 employment modes.

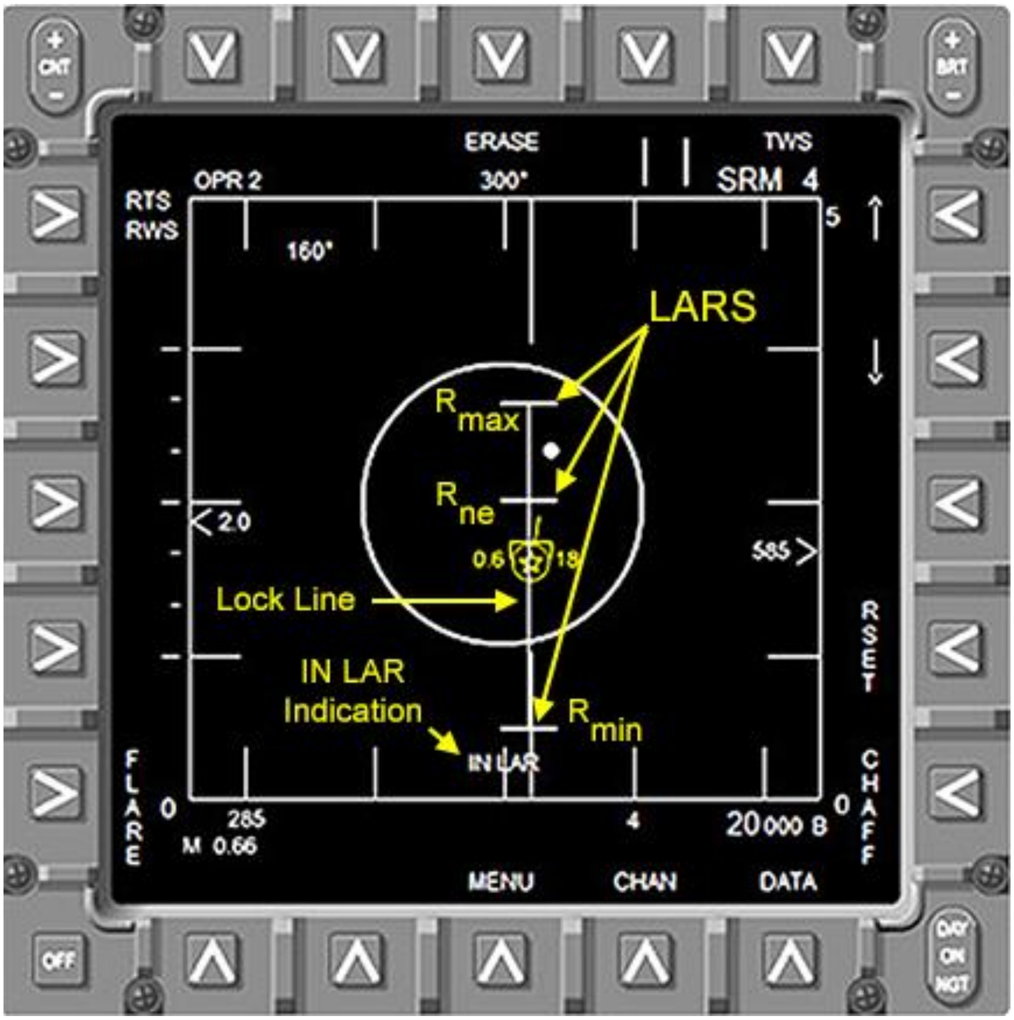


Figure 2-3 Rear Quarter SRM Employment with RADAR Lock

In the aircraft, RADAR indications of IN LAR are displayed (Figure 2-3). LAR stands for Launch Acceptability Region. The label "IN LAR" will appear immediately above the "MENU" button on the scope along with three horizontal bars on the lock line. These horizontal lines appear any time the RADAR is in A/A radar shot employment mode (TWS or STT). The bottom horizontal line is the closest you can shoot the target (labeled R_{min}). The weapon will not have enough time to arm itself if you shoot it inside of this range. The middle one (labeled R_{ne}) is a LAR that the enemy cannot escape. If you shoot the missile at this point regardless of what maneuver the bandit attempts, they cannot kinematically defeat the missile. The farthest LAR (labeled R_{max}) represents your max range shot. A small maneuver could defeat the missile kinematically depending on the scenario. Any simulated 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 used in BFM will be in the rear quarter without a RADAR lock. Training will emphasize visual recognition of the Rear Quarter (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

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. 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.

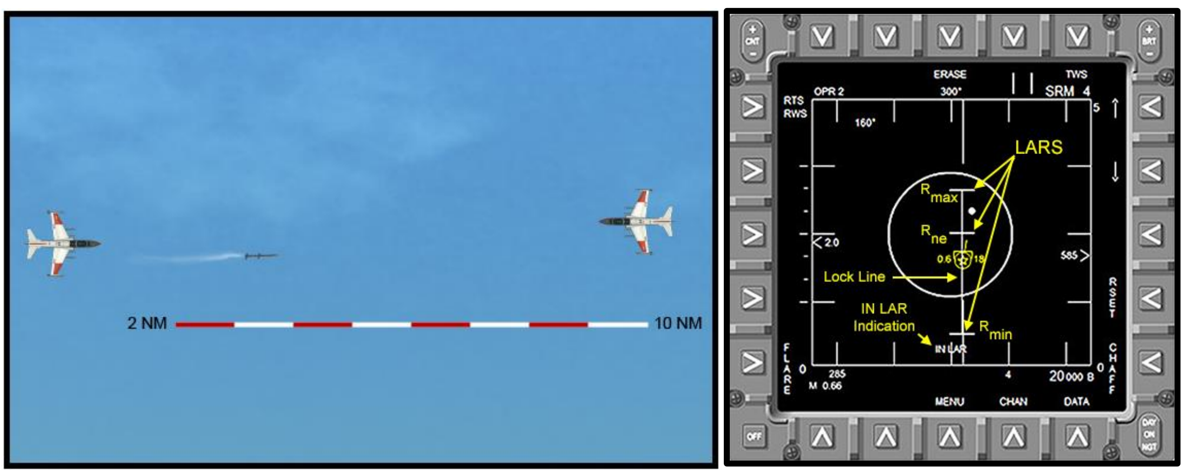


Figure 2-4 Forward Quarter SRM Employment with RADAR Lock

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 associated gun systems offered insufficient rates of fire. Additionally, multiple gun barrels in a single wing (Figure 2-5) negatively impacted aircraft balance should a gun became jammed.

Figure 2-5 F4U Corsair with Wing Cannons

Air cannons and their associated ammunition have undergone many changes, improvements, and innovations over the last half century, with nearly every ammunition size having been tried. While small calibers lack the destructive power of the higher calibers, the higher calibers incur a penalty of both weight and magazine 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 dispersion patterns. 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.

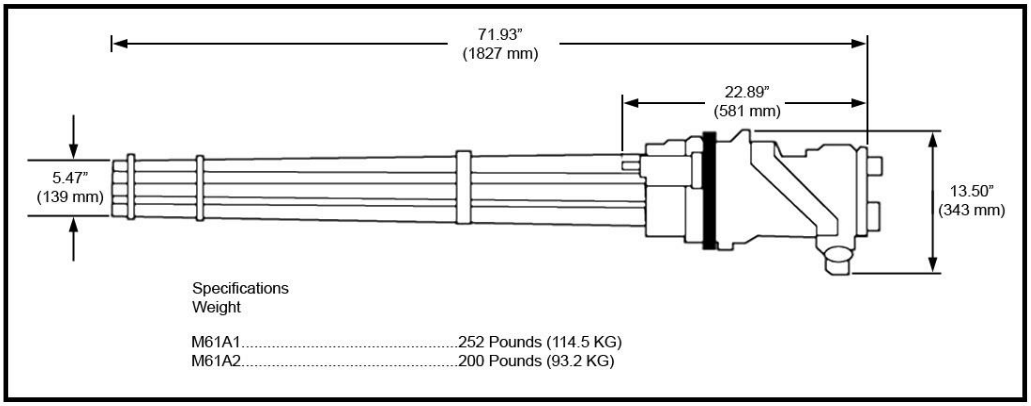


Figure 2-8 M61 Cannon Dimensions

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 considered the weapon of choice. A solid understanding of the T-45 gun symbology, operating 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 Air-to-ground (A/G) target data entry. However, the only A/A data that needs 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 Built In Test (BIT) is run, A/A data can be entered.

To enter the A/A data from the Multi-Function Color Display (MFCD):

a. Select MENU.

b. Select Stores (STRS).

c. Select A/A.

d. Select WSPN (Wingspan) (Figure 2-10).

– The previously entered wingspan stored in memory is displayed in the scratchpad.

e. Press ENT to accept the displayed wingspan.

f. If required, enter the desired bandit wingspan using the number keys on the Data Entry Panel (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.

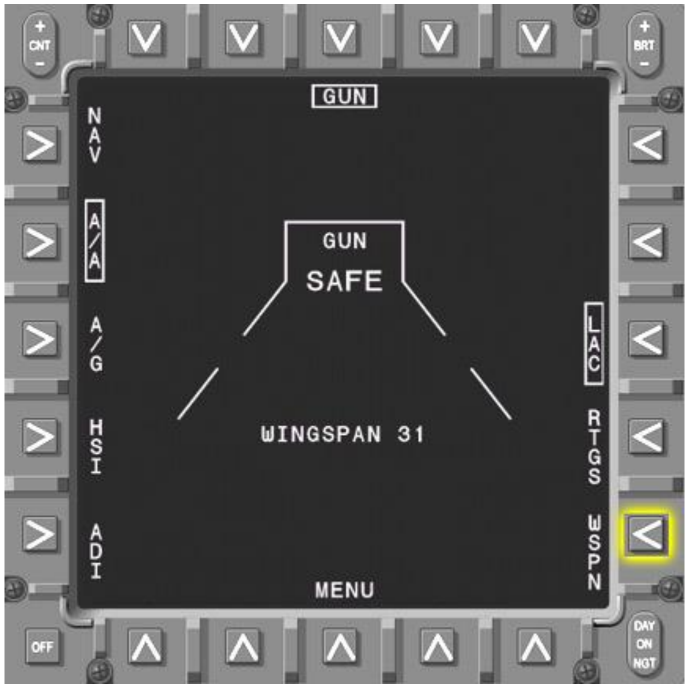


Figure 2-10 STRS Display on MFCD

2. **Gun Sub-Modes**

The A/A gun is selected by pressing the MODE button on the HUD DEP, or alternatively via the hands on throttle and stick (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. diameter equals the wingspan of the projected 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 sub-mode should only be used when the bandit is performing limited or mild maneuvers, or the RTGS mode is degraded. Because the bullet impact point is computed, the pipper should be placed over the bandit and held steady for at least one second prior to firing. The pipper indicates the bandit wingspan at 1,000 feet. Thus if the range to the bandit is more or less than that (bandit wingspan is less than or greater than the piper width), 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 Inertial Navigation System (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. Should any of those assumptions be 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. The student is required to have a thorough knowledge of the working area procedures. 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 any questions they may have. 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 POM, Range, and Lead as described in Section 103.6. Solving for these parameters is required for successful air-to-air gun employment. Resolution of POM, range, and lead are required for every successful gun employment. Aggressiveness is rewarded in BFM; SNFOs are encouraged to seek shot opportunities. A single snapshot may be the only shot opportunity that presents itself throughout an eight-merge engagement. The ability to recognize and capitalize 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 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 these 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 sometimes tragic mistakes.

1. **Administrative**

   a. Departure/spin and Compressor Stall/EGT/RPM. As the student you are responsible to brief Out of Control Flight (OCF) and engine stall EPs.

   b. Scheduled face-to-face brief. Each experience in 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**.

Flight Experience	Flight Currency	Additional Requirements
Pilot with <750 hours in T/C	1 flight within the previous 6 days 2 flights within the previous 14 days	1 flight shall be flown in a dynamic maneuvering hop in the T/M aircraft ACM will be conducted. Non-tactical aircraft do not satisfy flight requirements. Flights must occur on or before the 6th, 14th, 30th day.
Pilot with >750 hours in T/C	1 flight within the previous 14 days 2 flights within the previous 30 days	
NFO hours independent		

Figure 3-1 Currency Requirements

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 8,000 feet AGL.

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).

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

i. ***500 feet minimum 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 their weapons envelope. In the real world, know your adversary's capabilities.

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

iii. For head-on passes, maintain the established trend. If no trend established, give way to the right to create left-to-left pass.

iv. Broadcast your own intentions.

v. Converging flight paths:

(a). Nose-high goes high.

(b). 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 unable to remain nose-high (ballistic).

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

vi. Never intentionally maneuver to lose sight (***no 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.

vii. 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 both aircraft have lost sight the second aircraft to transmit blind shall deconflict via altitude.

viii. 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 safe separation. If the weather is hazy, the sun creates a halo effect when you are looking down with the sun at your back. If the bandit is in the halo area, they cannot see you.

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

x. Knock-it-off if both aircraft have lost sight.

7. **Brief CNATRA Weapons Envelopes**

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

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

c. Break off all gun attacks at 1,000 feet separation.

8. **Terrain Avoidance**

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

b. Offensive (high) aircraft will monitor the defensive (low) 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 of the possible impending deck, for safety and to continue the fight as appropriate.

9. **Termination of ACM**

a. ACM shall cease when "Knock-it-off" is called by anyone (all players echo the call) 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. Minimum 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 IMC.

ix. Loss of SA or any unsafe condition develops.

x. 85 KIAS and decelerating.

xi. Training objectives attained; usually determined by the Instructor.

xii. Approaching area border. During an engagement if both aircraft lose sight or project the flight might exit the training area boundary.

xiii. Training Rule violation.

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 on the aircraft. Here are some of the more common emergencies:

1. **OIL PRESS Warning**

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

2. **Compressor Stall**

The majority of compressor stalls in the T-45 occur 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 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 compressor 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 flat scissors ("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 will clear 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 and will 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 Instructor Pilot (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 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 both 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 (e.g., WX < Circling Mins), a plan to launch as singles with a subsequent 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 3-2). The Pensacola MOA (Military Operarating Area) 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 (e.g., 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 3-2 depicts W-155A.

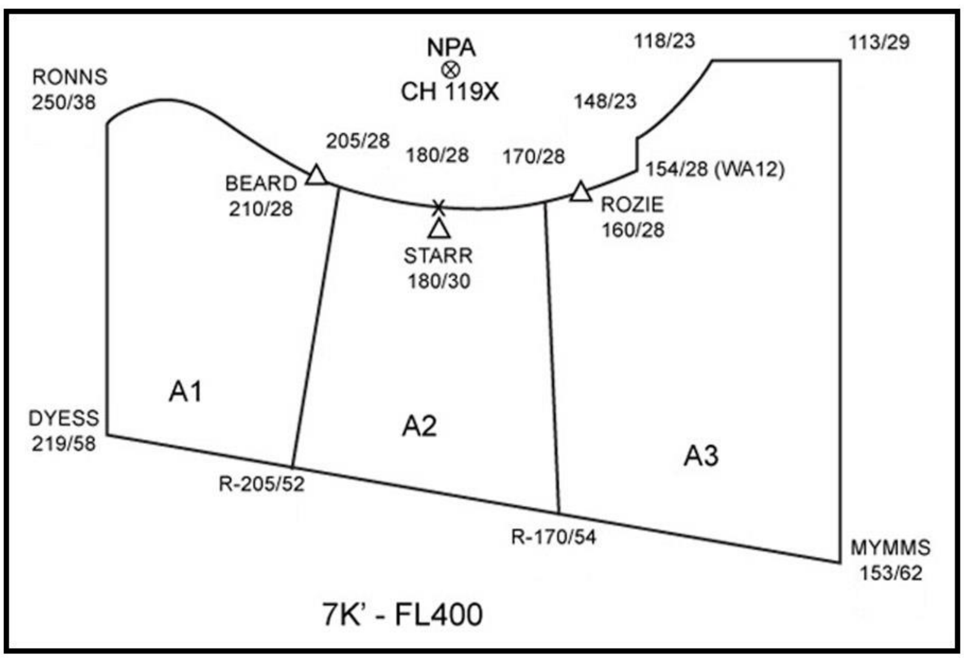

Figure 3-2 W-155A

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 (e.g., 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 a discrete frequency for the flight. 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 the discrete frequency, 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 3-3) 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.

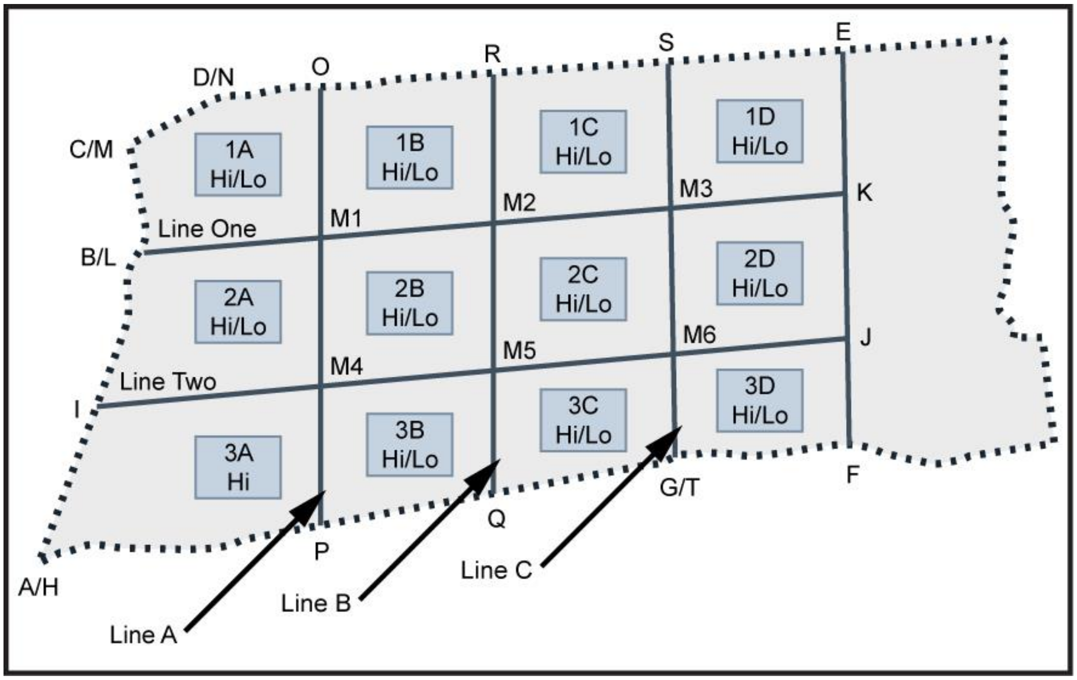

Figure 3-3 PNSS MOA

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 3-4) is the most common area used at VT-86 and is part of the Sequence 2 standard waypoint load.

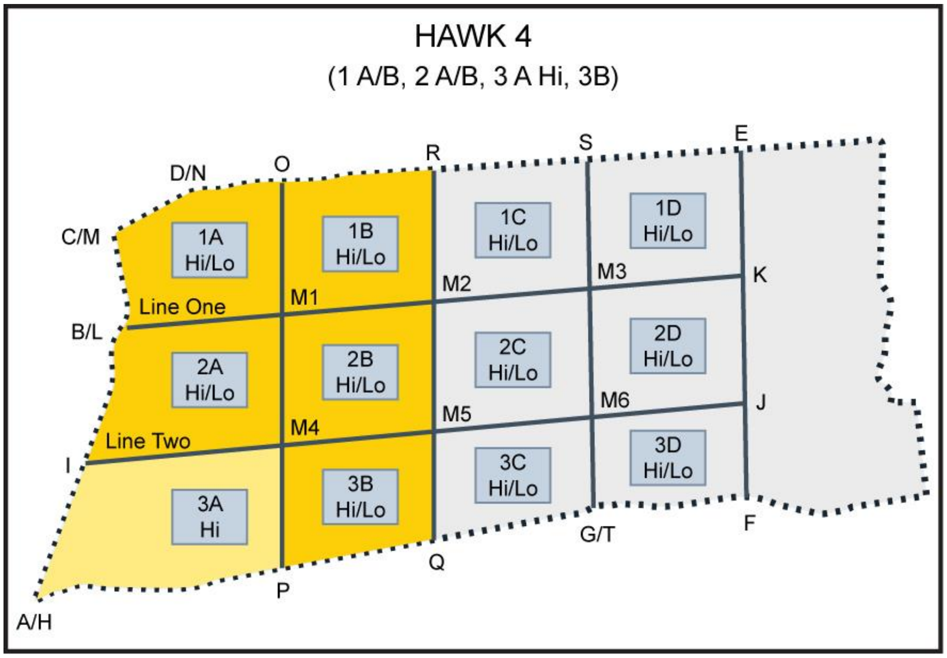

Figure 3-4 HAWK 4 Working Area

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 act as 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 used 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. Maintaining one's scale throughout the debrief 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 (e.g., faster aircraft are represented by longer arrows). Figure 3-5 represents the symbology typically used in a whiteboard debriefing.

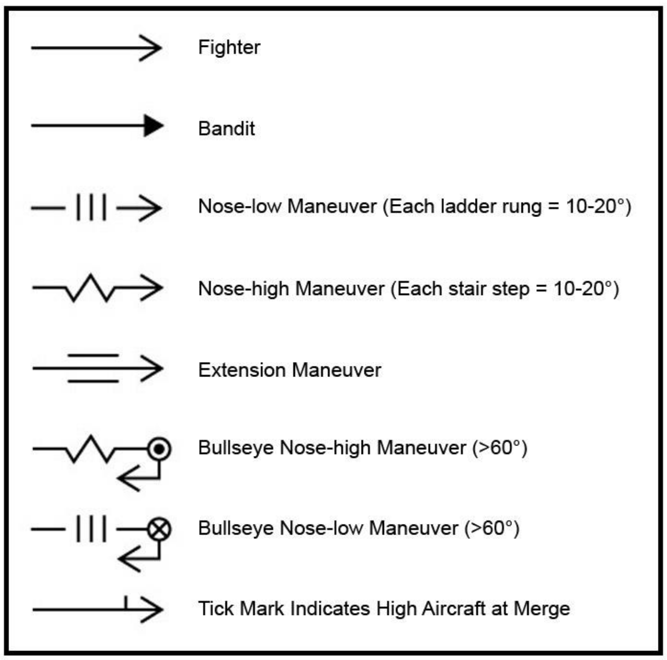

Figure 3-5 Whiteboard Debriefing

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 when using 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 velocity 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 primarily 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 they are 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 preceding debriefing tools. It can also be used to quickly debrief simple concepts that do not need to be demonstrated in a great deal of visual detail. This is a debriefing tool primarily limited to experienced aircrew that possess a solid BFM background and 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 this 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 the reconstruction is not accurate, especially if there is disagreement as to the actual conduct of an engagement, any analysis is premature. If all members of the flight do not agree as to what actually happened, it is unlikely that they will buy-in to the analysis. Likewise, should the reconstruction be inaccurate, any subsequent analysis may also 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 their validity as well as why the shot opportunity arose.

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 (TOF) (6 sec/NM after Witness X, play tape for TOF):

– No flares call during 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 TOF (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 Tactical Frequency (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) or 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. **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 Rules of 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 (KIO)- Term used to stop an entire multi-plane engagement/exercise. In the context of 1v1, used to end a specific engagement/exercise (e.g., 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 (Abeam)
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 3-6 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' high or low based on pilot' discretion. Once safely established on a flow heading, the PADS will be reset and the sequence will commence after another "*Speed and Angels*" call.

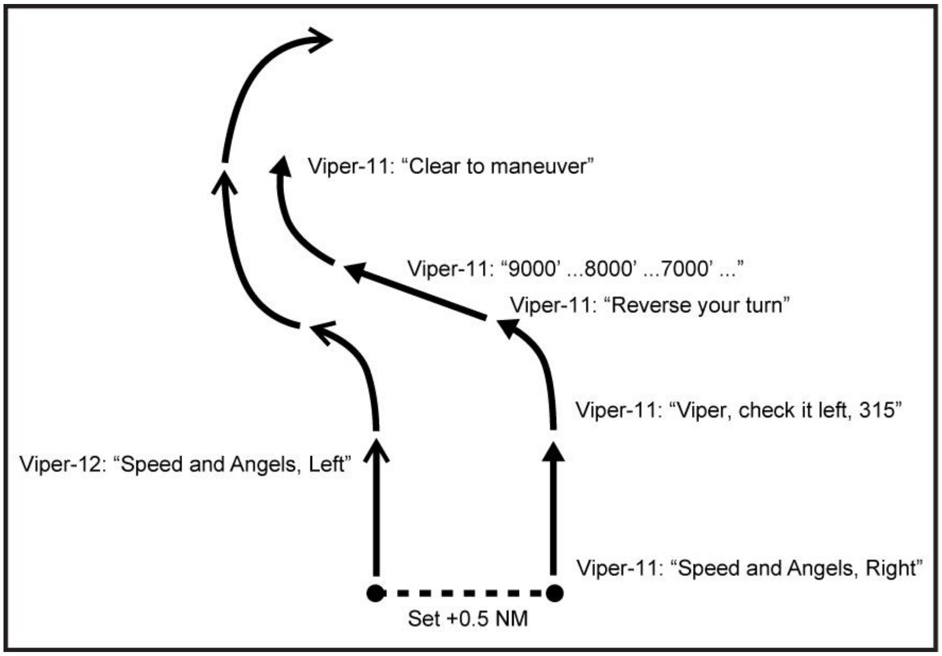

Figure 3-6 Perch Setup

7. **High Aspect Sets**

All High Aspect sets will utilize Butterfly Sets (Figure 3-7) 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: Abeam, 18K', 1.5 NM, and 300 KIAS. 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' high or low based on pilot's discretion. 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.

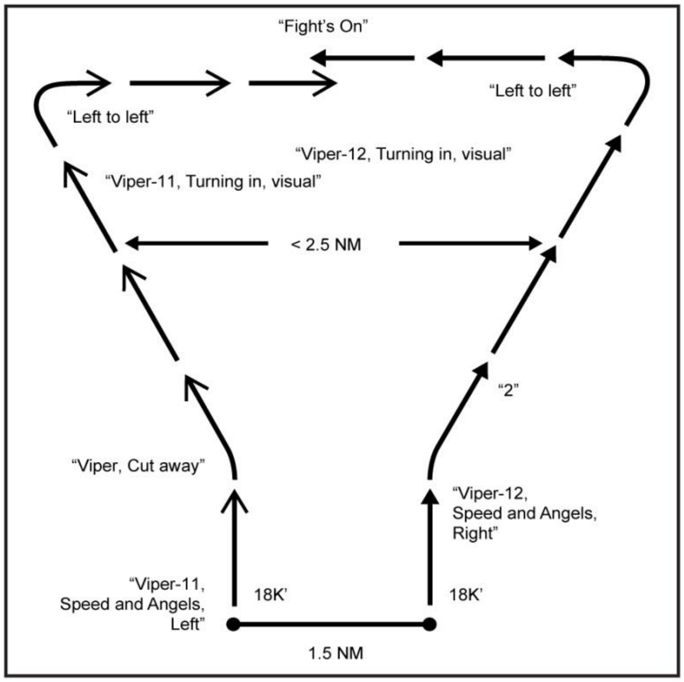

Figure 3-7 High Aspect Set

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. TOP GUN 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 provided during the execution phase is determined by the "type" of engagement (Figure 3-8).

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 3-8 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) Abeam/15K'/1.0 NM/300 KIAS

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

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

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

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

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

g. Performance Characteristics (DEMO)

i. Accelerated Stall

ii. High AOA/Deep Stall Investigation

iii. 70 Degrees Nose-High Departure

iv. Level vs. Unloaded Accelerations

v. Hard Turns vs. Energy Sustaining Turns

vi. G-Available Exercise

h. TACAN Rendezvous

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

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

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

c. 9K’ Perch (DEMO) – Abeam/18K'/2.0 NM/350 KIAS/

d. 6K’ Perch (MAX) – Abeam/18K'/1.5 NM/350 KIAS/

e. 3K’ Perch (MIN) – Abeam/18K'/1.0 NM/250 KIAS/

f. Repeat (as necessary/fuel permitting)

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

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

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

c. 9K’ Perch (DEMO) – Abeam/18K'/2.0 NM/350 KIAS/

d. 6K’ Perch (MAX) – Abeam/18K'/1.5 NM/350 KIAS/

e. 3K’ Perch (MIN) – Abeam/18K'/1.0 NM/250 KIAS/

f. Repeat (as necessary/fuel permitting)

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

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

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

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

      – MAX, MIN, AUTO, CREW Fights

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

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

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

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

      – 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**: Abeam/15K'/1.0NM/300KIAS

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 distance of a mile. At one nautical mile, the SNFO should be able to distinguish 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 Lead's 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 their 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 Lead 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 3-9 illustrates the Eyeball Calibration Exercise.

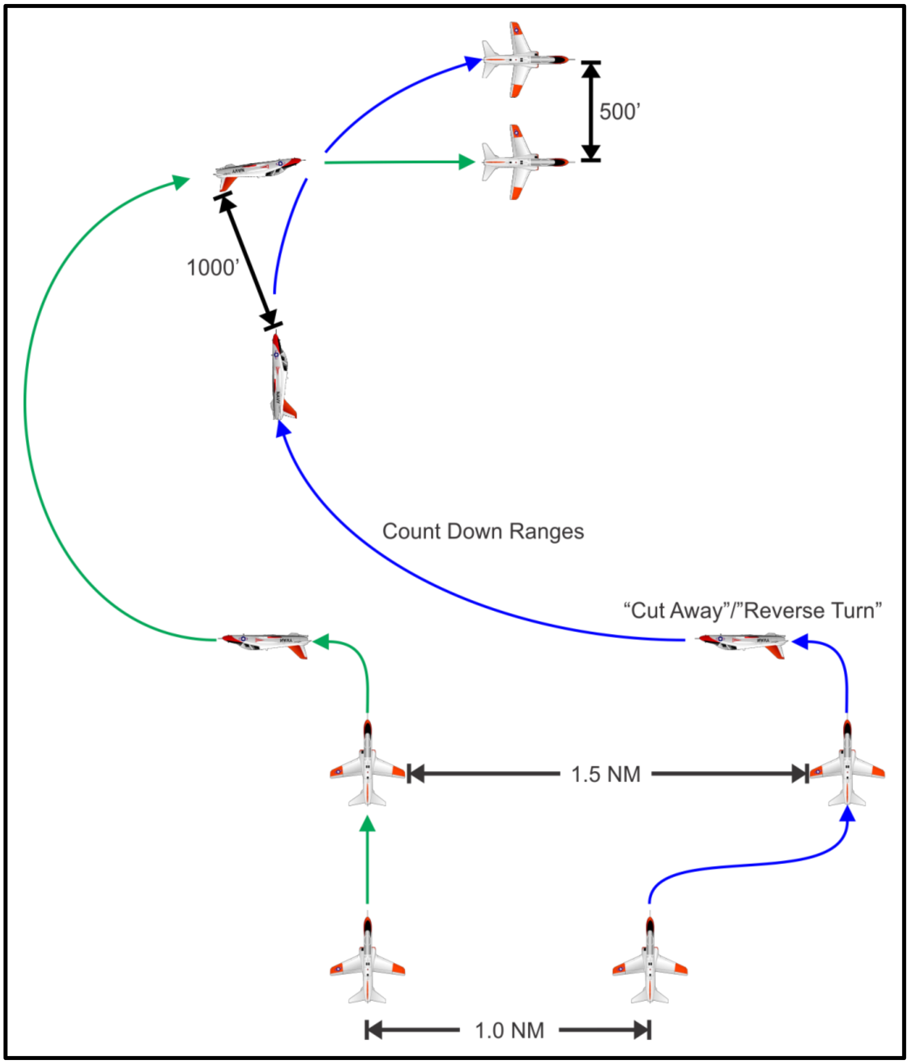

Figure 3-9 Eyeball Calibration Exercise

2. **Snapshot Drill**

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

The Snapshot Drill (SSD) is a cooperative maneuver designed to teach employment of the gun at high angle-off (Figure 3-9). 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/her 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 either the 10 or 2 o'clock position while the "shooter" solves 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 3-10. On the last Snapshot, the Lead IP will call, "*Turbo 11, In target/shooter, maneuver.*" As the shooter approaches the Snapshot envelope, the target SNFO will call for a "*Guns 'D'.*" At this command, the target IP will put a wingtip on the attacker and maneuver out of plane (either up or down) in an attempt 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.

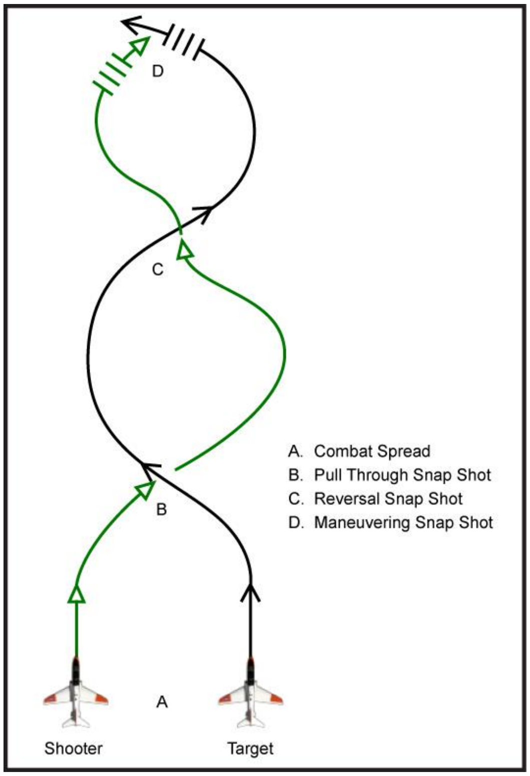

Figure 3-10 Snapshot Drill

b. Safety

If an unsafe situation develops, any member of the flight can call "*Skip it*," "*Terminate*" or "*Knock-it-Off*." If any of these calls are 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/her role, being the same as 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 T-45 aircraft as it relates to the E-M Diagram (Figure 3-11). The exercise will demonstrate timed accelerations and timed turns, as well as instantaneous "G" available at different airspeeds.

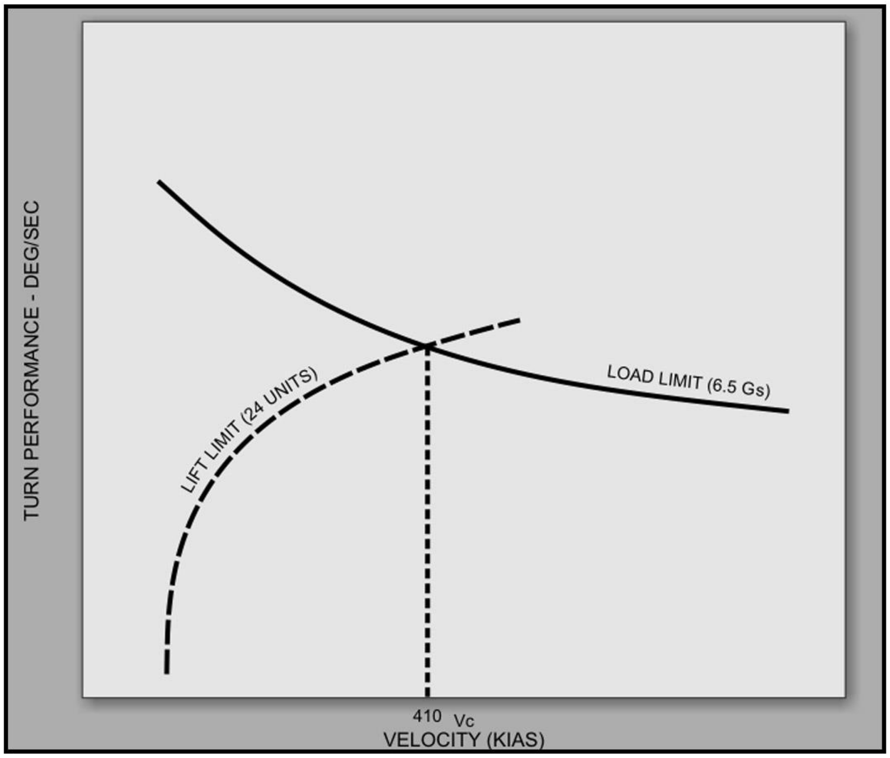

Figure 3-11 E-M Diagram

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 KIAS straight and level at MRT.

b. Timed acceleration from 250 to 300 KIAS 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.

e. Instantaneous "G" available at 250 KTS. At IP discretion, this will either be an approximately 90^{o} AOB turn applying full aft stick or straight and level with full aft stick.

f. Instantaneous "G" available at 350 KTS. This will be demonstrated in the same manner as the previous step.

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 find themselves in uncontrolled flight. Although it may seem 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 (e.g., expect rudder shakers at 21.5 units AOA etc.).

b. Knowing the Procedures**.** The recovery procedures must become second nature. The stall recovery and OCF 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.

OCF 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**

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 whether or not you are in a spin. If AOA is pegged at 0 units, airspeed is oscillating between 50 and 160 KIAS, and the turn needle is fully deflected, 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 the similar airspeed and turn needle indications as an inverted spin.

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 may add power. When the IP recovers from the last departure, your IP and you 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 may not experience all of the following indications of deep stall, nor will they be experienced them in any particular sequence. The indications of a deep stall are:

a. Increasingly heavier buffeting as stall deepens

b. Yaw rate zero or nearly so

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 the aircraft past 150 KIAS. The SNFO should notice that the rudder and aileron effectiveness remains adequate at 20 units AOA. 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 as well as the adverse yaw generated by aileron deflection.

The IP will continue to 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 using only the rudder; aileron will not be used to counter any roll tendencies. If the aircraft's AOB becomes 90 degrees or more, the IP will recover. If the IP is able to hold wings level with rudder, he/she will induce a departure using rudder by maintaining full back stick and inputting half rudder in one direction to achieve greater than 30 degrees AOB. The IP 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 and 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 associated 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, the higher G forces will 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. With all these parameters met, you can expect the aircraft to stall within the first 90 degrees of the turn. Because the onset of stall buffet is very clear, it provides good warning of the impending stall. Stall characteristics may include a wing drop, pitch oscillations, or the control stick reaching the full aft position.

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 demonstrating a low airspeed departure is to show 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 on the aircraft are negligible. At this point 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 during this maneuver. 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 and will not try to counter any oscillations as the nose falls through as the flight controls have become ineffective. Any deviations from neutral may aggravate the situation as airspeed increases. If performed correctly 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 be able to 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 reacting accordingly.

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

After returning the aircraft to level flight following each of the above maneuvers, check to ensure that the oil pressure is within normal limits by verifying that the OIL Warning light is NOT illuminated before adding power. 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.

Upon returning from flights during which departures have been conducted, a careful post-flight inspection of the aircraft will be made. Pay particular attention for popped rivets, loose or missing screws/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 AOB turn (Figure 3-12, 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 3-12, right side).

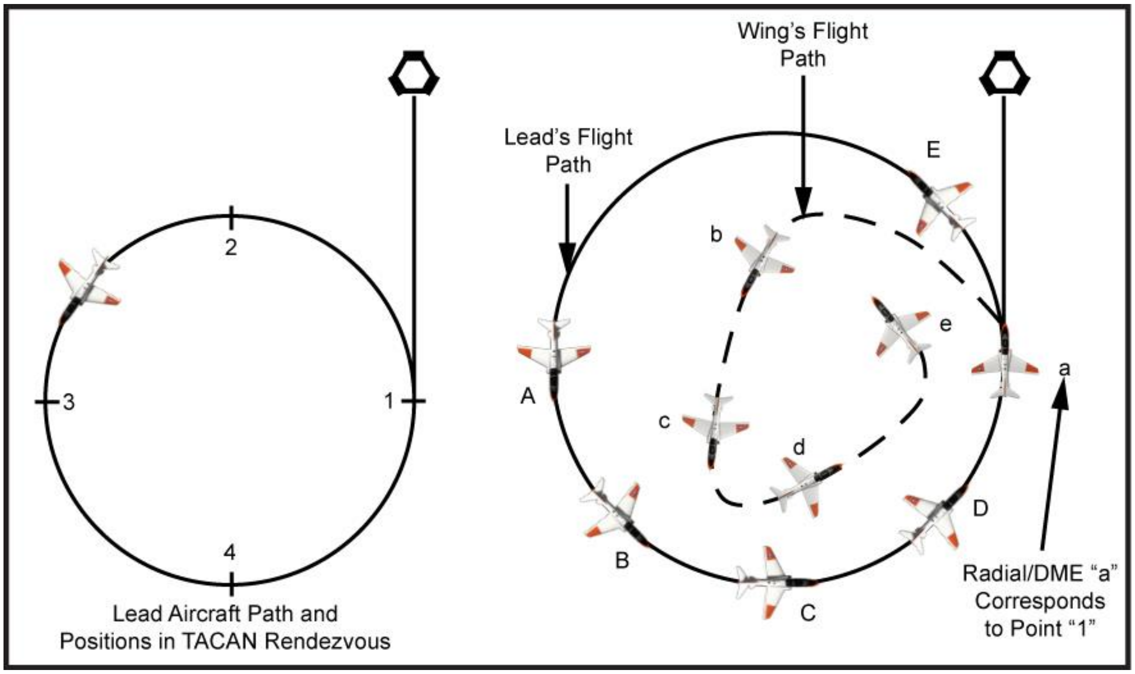

Figure 3-12 TACAN Rendezvous

In Figure 3-12, 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 at their discretion 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: Abeam/15K'/1.5 NM/ 300 KIAS (Fox-2/CTM = 40degrees AOT @ 6000')

The Flat 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. 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.

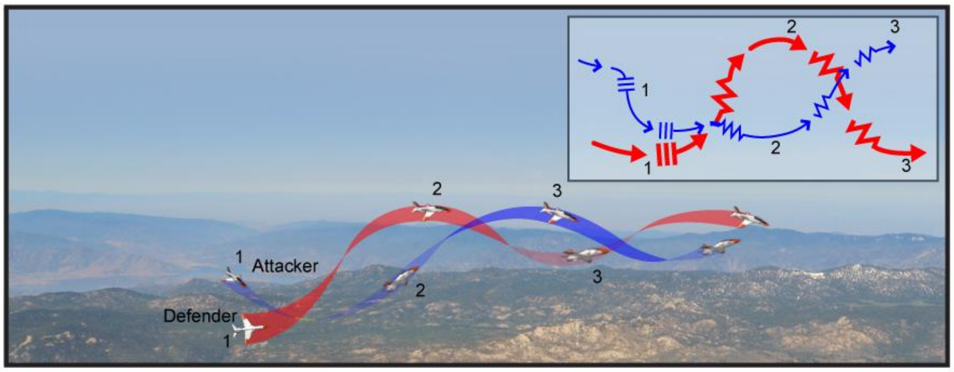

Figure 3-13 Flat Scissors Drill

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

The ultimate goal of the offensive aircraft in a Flat Scissors is to maneuver into a position where they can employ their gun. However, the primary responsibility is to maintain the offensive advantage. Because the Flat Scissors is a one-circle fight where the goal is to slow one's aircraft's down-range-travel more than the other aircraft, proper lift vector placement and reversal timing are essential. After each reversal, the SNFO will call for his IP to place the lift vector behind his/her opponent: "*Pull for his/her six*." After he/she 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, 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 should be 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/her six*" after each reversal. Additionally, the defender is always trying to keep the offensive aircraft out-of-phase and out-of-plane to deny them a high percentage gun tracking shot solution. 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 their 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: Abeam/15K'/1.5 NM/ 300 KIAS (Fox-2/CTM = 40degrees AOT @ 6000')

Like the Flat Scissors Drill, the Rolling Scissors Drill (Figure 3-14) 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/her six.*" The defender will pull their nose up in the reversal in order 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 their 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.

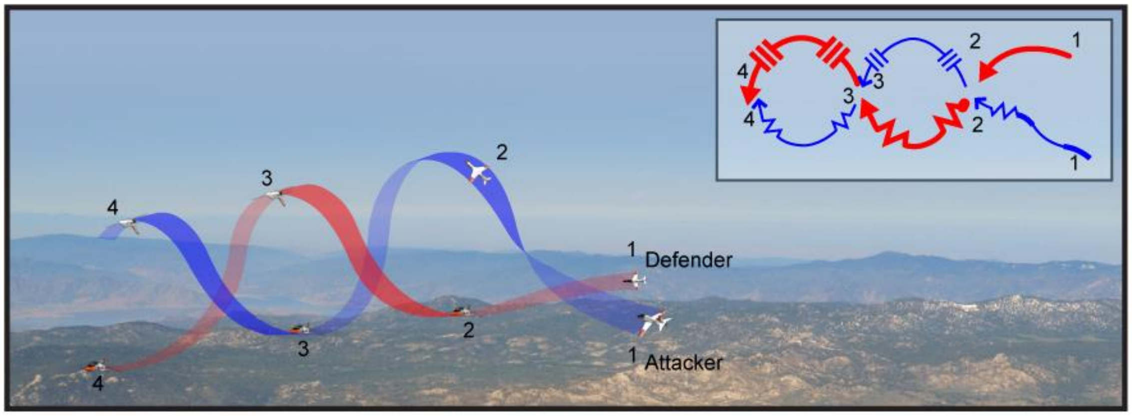

Figure 3-14 Rolling Scissors Drill

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 their being insufficient altitude to accomplish another 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 4001 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 4001. 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 (OOP 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. After the fight is initiated, 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 3-15, 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, they will shift their lift vector in front of the defender (lead pursuit) by aggressively going nose-low. This Low Yo-Yo (OOP 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 3-15, 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 3-15, 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.

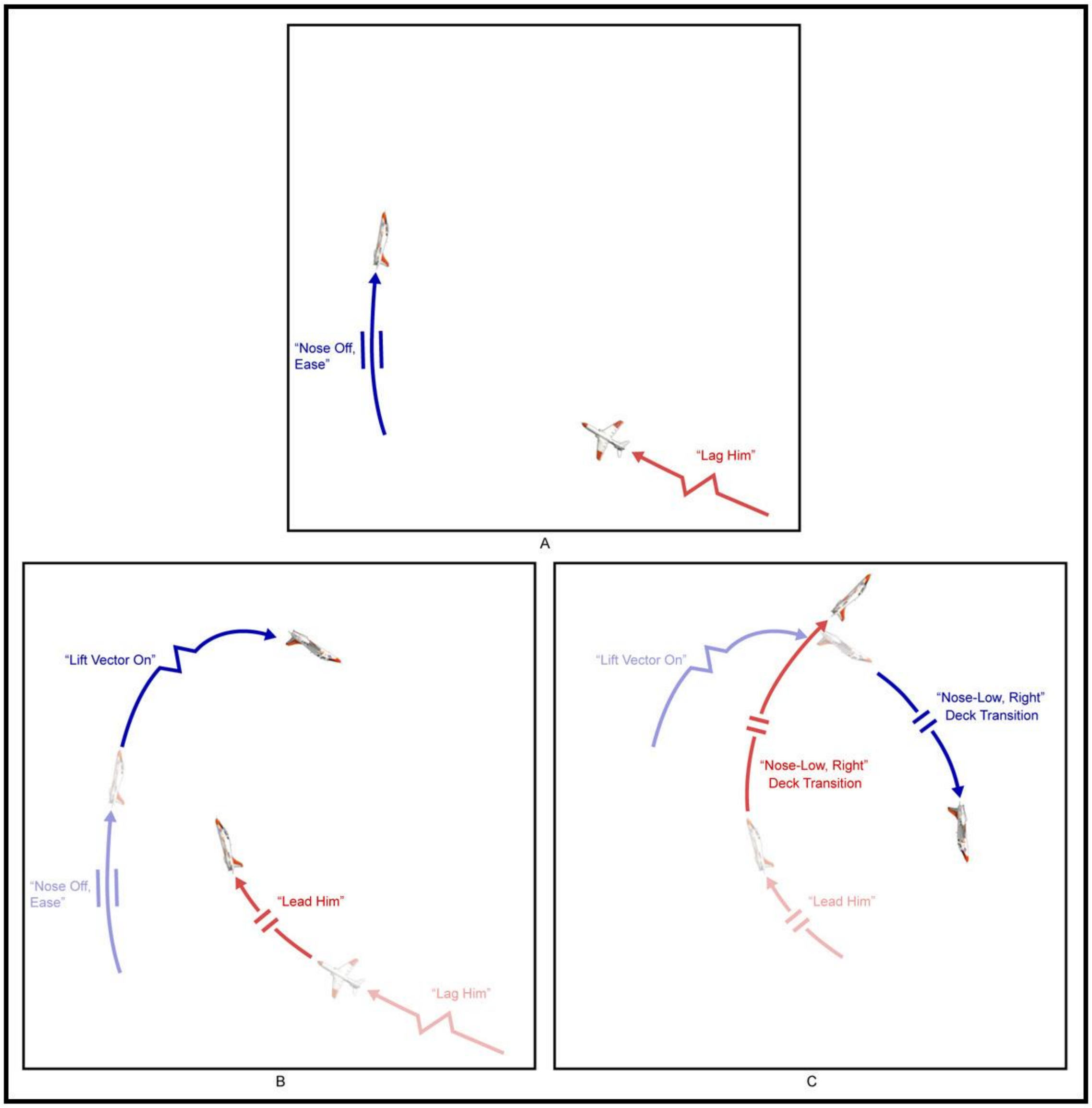

Figure 3-15 High-Low Yo-Yo Defense

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 3-16, 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 3-16, B).

Recognizing the in-close overshoot, the defensive student will capitalize on this reversal opportunity and call "*Reverse, pull for his six*" (Figure 3-16, 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.

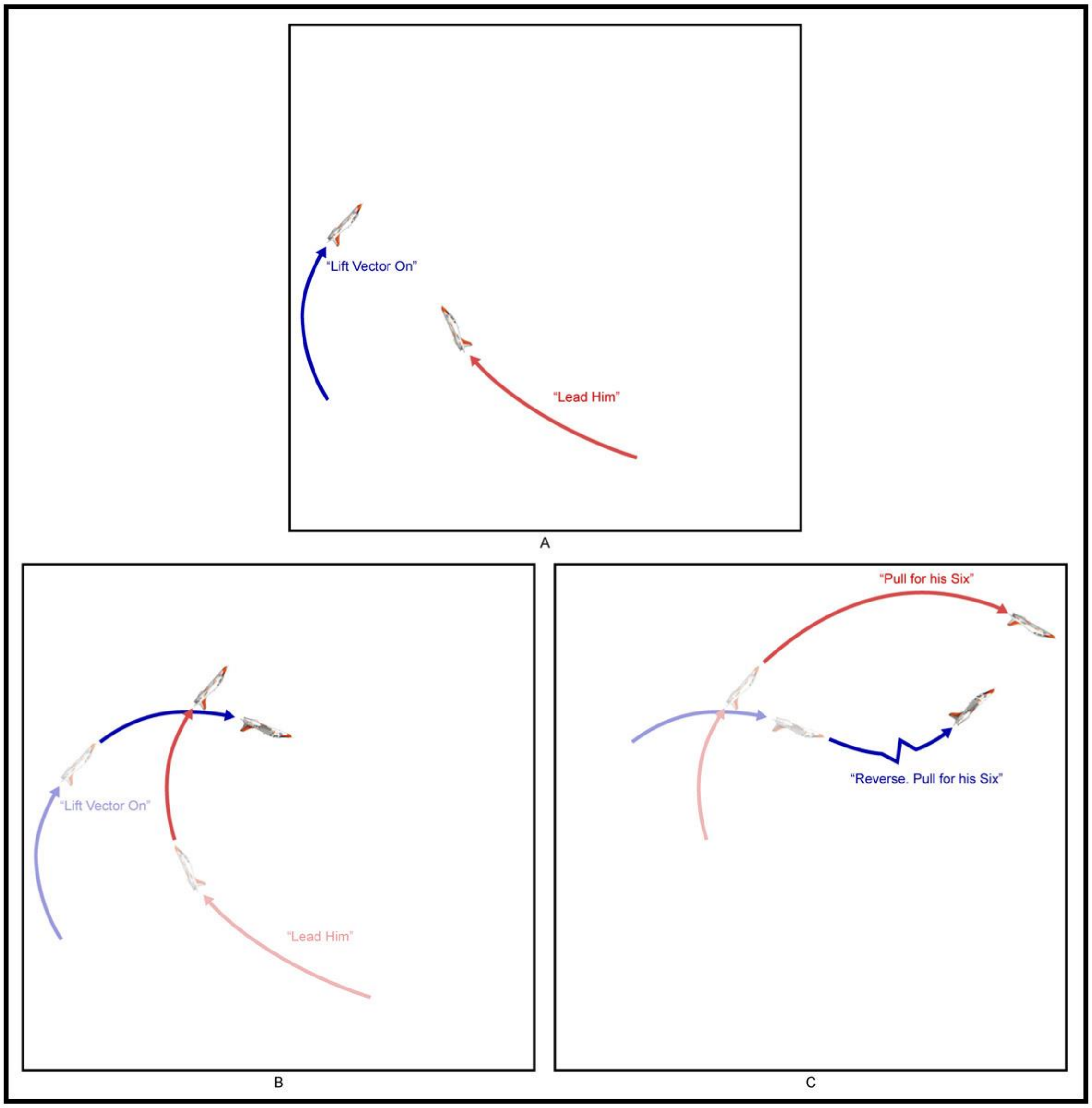

Figure 3-16 In-Close Overshoot Defense

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 3-17, 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 POM, range and lead 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 3-17, B). Upon hearing this command, the pilot will execute a last ditch OOP Guns 'D' as described earlier in this chapter. Follow-on BFM considerations and maneuvering are the same as for the Yo-Yo Defense (Figure 3-17, C).

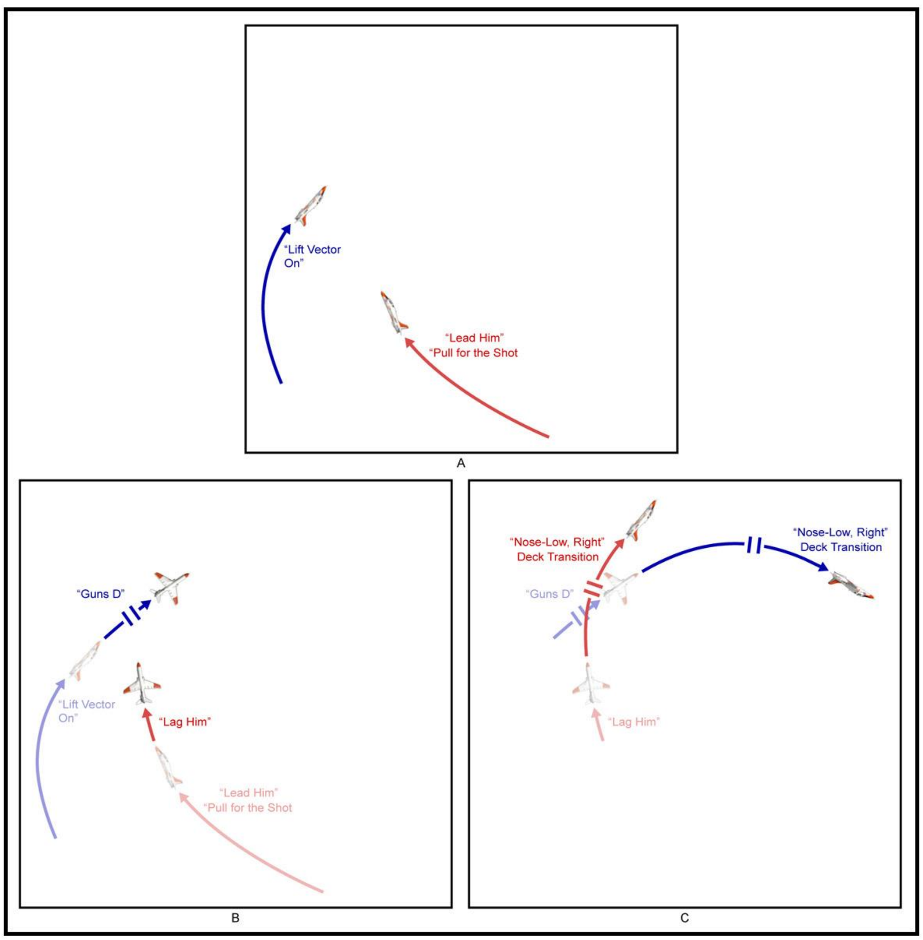

Figure 3-17 Valid Attack to Guns 'D'

20. SNFO Responsibilities

Figures 3-18, 3-19, and 3-20 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 3-18 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 3-19 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 3-20 Valid Attack to Guns 'D' SNFO Required Comms

21. **Offensive/Defensive Perch BFM**

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

On the BFM 4002 and BFM 4003 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 3-21). SNFOs will be exposed to either the offensive or defensive scenario on BFM 4002 with the alternate scenario being demonstrated on BFM 4003. 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

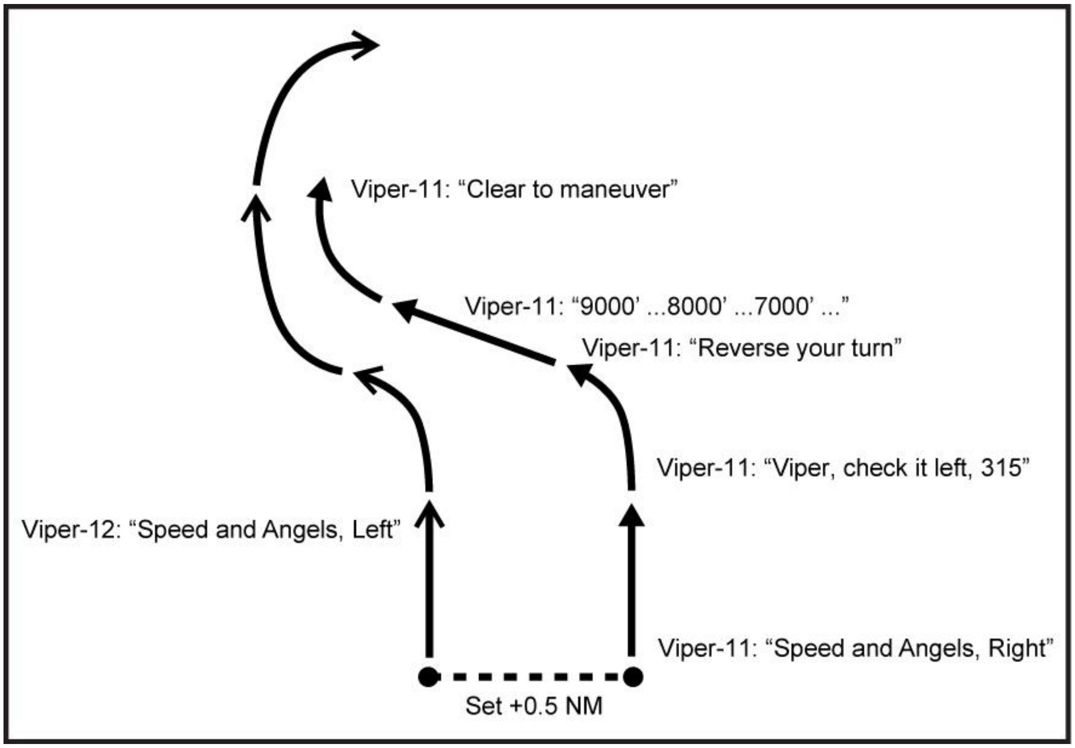

Figure 3-21 Offensive Defensive Perch Set

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

– Offensive Perch

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

(a). Bubble Entry

(b). Attack Window Entry Mech

(c). Rate War/Misaligned Turn Circles

(d). Second Bubble Entry

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

(a). Bubble Entry

(b). Attack Window Entry Mech

(c). Ditch Follow, Timing/Mechanics

(d). Deck Transition

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

(a). Attack Window Entry Mech

(b). Ditch Follow, 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, e.g., Flat/Rolling Scissors, weapons employment, etc., SNFOs will recognize and direct appropriate follow-on BFM.

– Defensive Perch

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

(a). Break Turn

(b). Bubble Entry

(c). Misaligned Turn Circles/Rate War

(d). Second Bubble Entry

(e). Bug

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

(a). Break Turn

(b). Bubble Entry

(c). Ditch, Timing/Mechanics

(d). Deck Transition

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

(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 opportunity 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 it is determined 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, e.g., 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 3-22, 3-23, and 3-24.

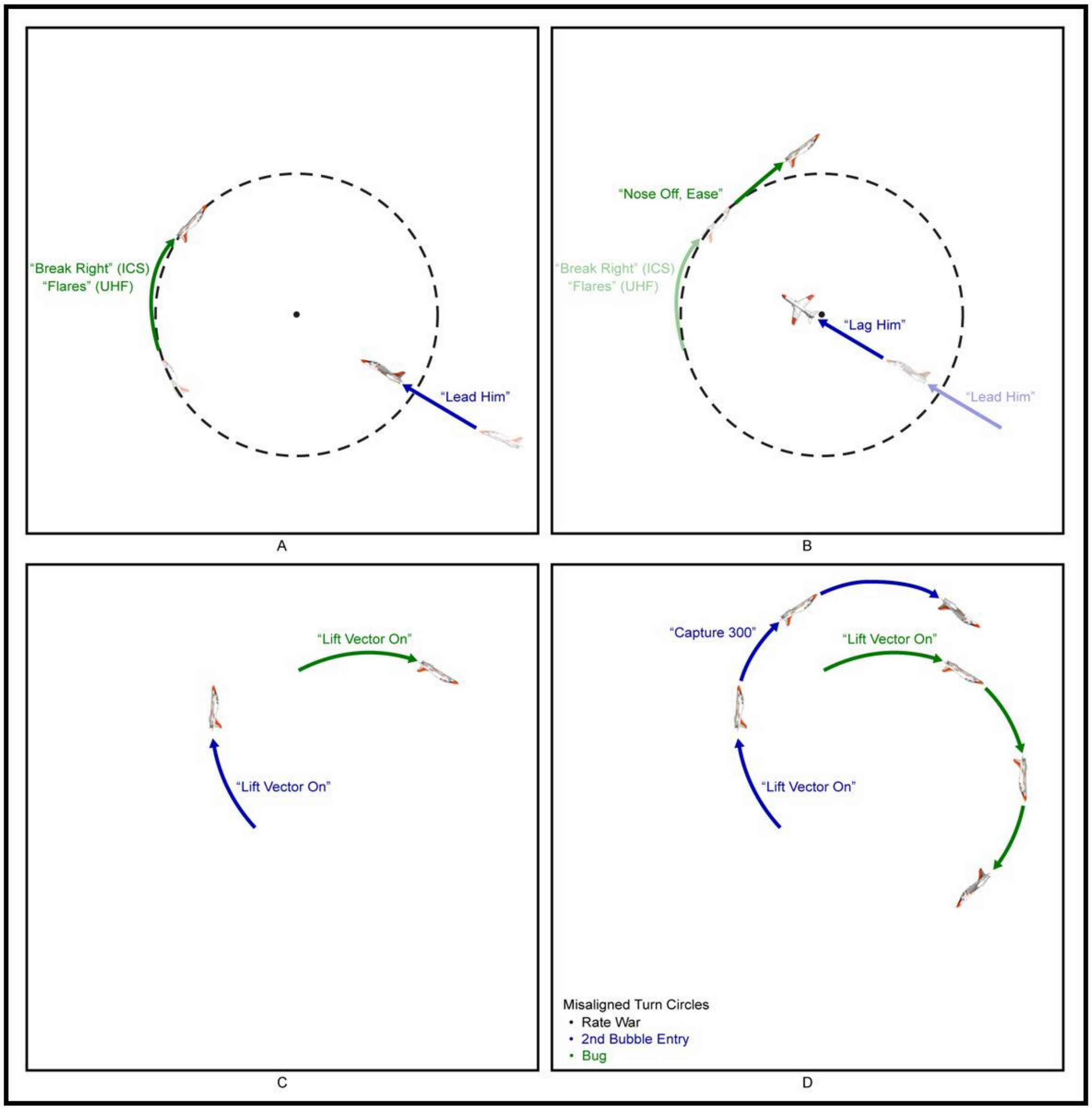

Figure 3-22 9,000' Perch

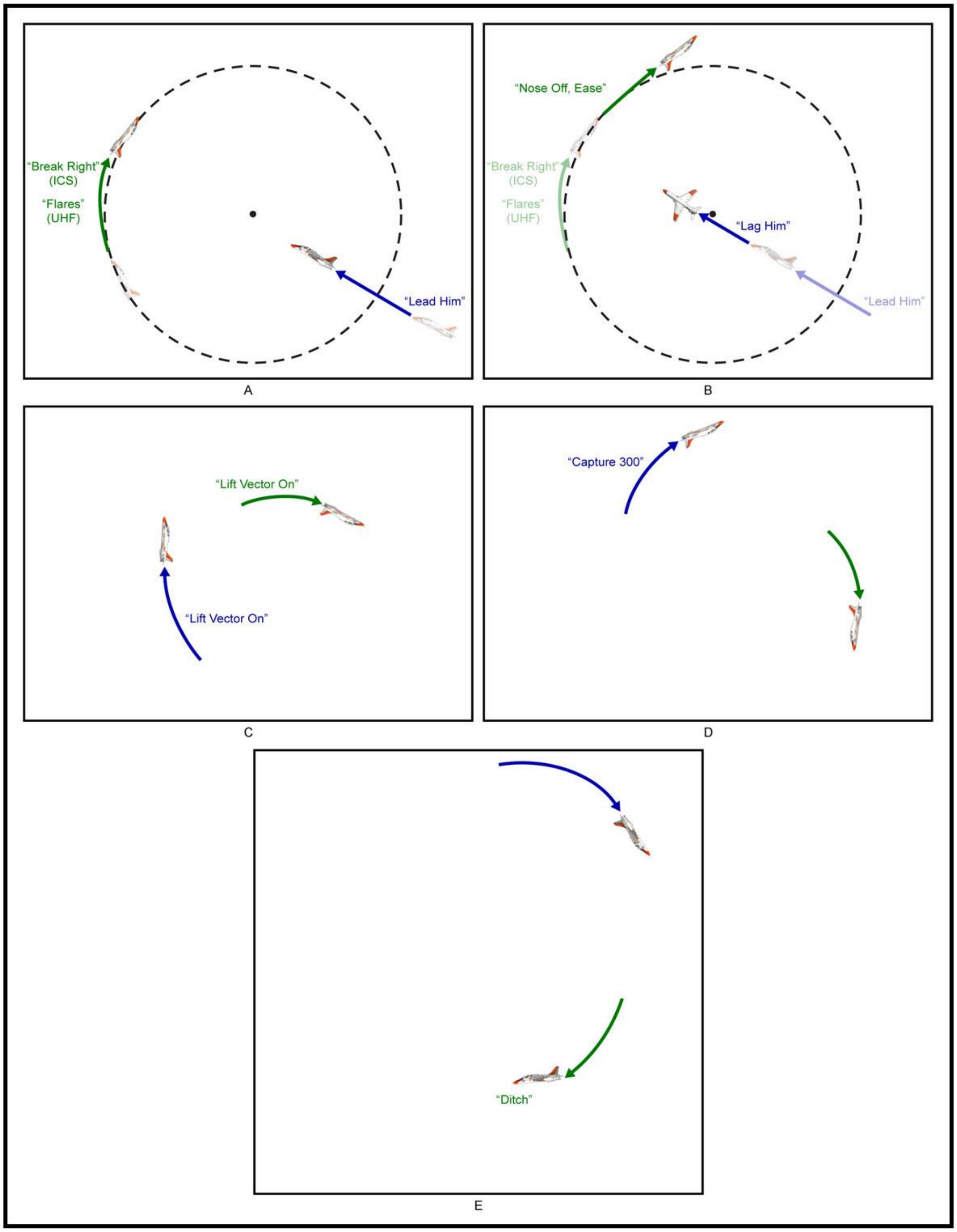

Figure 3-23 6,000' Perch

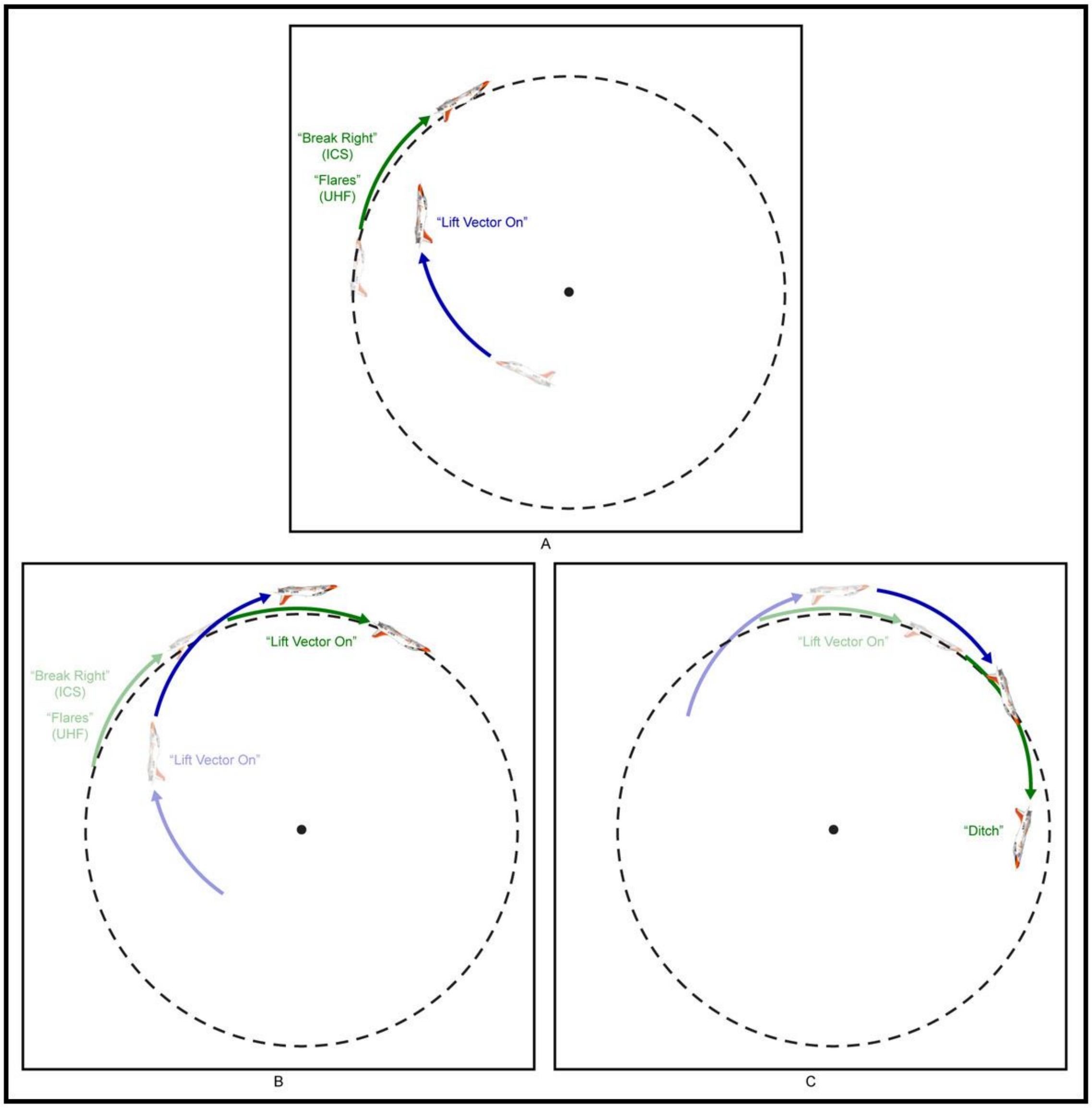

Figure 3-24 3,000' Perch

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: through a demonstration of the types of flow available and 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. 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 upon 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 4004, 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 4004 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 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 superior turn performance 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 ours, we would want to limit the amount of separation between aircraft during an engagement. In this case, one-circle flow would be the flow of choice.

ii. Two-Circle: If we have a superior weapons system/loadout compared to 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 (1Circle: "*max perform, pull for his six;*" 2Circle: "*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 4003 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 (e.g., 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 AOA). Recognition of sensor nose-off and responding with "*Hard Left/Right*" (17 units AOA).

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 AOA 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 such as snapshot scenario, guns weave, Flat Scissors or Rolling Scissors in order 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.

9. **“Guns ‘D’”**

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

10. **“Hard Left/Right”**

This call is used by the SNFO to initiate a hard turn (17 units AOA) in order to take away angles when defensive, his opponent is outside the bubble, and not in a WEZ with “sensor nose” as 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 (e.g., 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 AOA), 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.

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APPENDIX A
LIST OF ACRONYMS

A/A	Air-to-Air
ACM	Air Combat Maneuvering
A/G	Air-to-Ground
AGL	Above Ground Level
AOA	Angle Of Attack
AOB	Angle Of Bank
AON	Angles Off the Nose
AOT	Angles Off the Tail
BAR	Basic Airwork Recognition
BDC	Battle Damage Checks
BFM	Basic Fighter Maneuvers
BIT	Built In Test
BVR	Beyond Visual Range
DEP	Data Entry Panel
ECS	Environmental Control System
EGT	Exhaust Gas Temperature
E-M	Energy Maneuvering
EP	Emergency Procedure
FOV	Field Of View
FPT	First Pilot Time
GINA	Global Positioning System/Inertial Navigation Assembly
HOTAS	Hands on Throttle and Stick

HUD	Heads Up Display
ICO	In-Close Overshoot
IFR	Instrument Flight Rules
IMC	Instrument Meteorological Conditions
INFO	Instructor Naval Flight Officer
INS	Inertial Navigation System
IP	Instructor Pilot
IR	Infrared
KE	Kinetic Energy
KIO	Knock-It-Off
LAC	Lead-Angle Computing
LAR	Launch Acceptability Region
LCOS	Lead Computed Optical Sights
LOS	Line Of Sight
MFCD	Multi-Function Color Display
MOA	Military Operating Area
MRT	Military Rated Thrust
MSL	Mean Sea Level
OCA	Offensive Counter Air
OCF	Out of Control Flight
OOP	Out of Plane
PADS	Position, Altitude, Distance, Speed
PE	Potential Energy

POM	Plane of Motion
RAC	Range, Angle-Off, and Closure Rate
ROE	Rules of Engagement
RPM	Revolutions per Minute
RQ LAR	Rear Quarter LAR
RTB	Return to Base
RTGS	Real Time Gun Sight
SA	Situational Awareness
SNFO	Student Naval Flight Officer
SOF	Safety of Flight
SRM	Short Range Missile
SSD	Snapshot Drill
STOVL	Short Takeoff Vertical Landing
TA	Target Aspect
TAS	True Airspeed
TE	Total Energy
TOF	Time of Flight
T/M	Type/Model
VAGD	Valid Attack to Guns 'D'
V_C	Corner Airspeed; Closure Airspeed
VMC	Visual Meteorological Conditions
WEFT	Wing, Engine, Fuel, Tail
WEZ	Weapons Engagement Zone

WSPN Wingspan

WVR Within Visual Range