

BASIC FIGHTER MANEUVERING (1v1)



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HOW TO USE THIS DOCUMENT

This is your textbook for the Basic Fighter Maneuvering (BFM) stage of your Jet Pilot Training and is the source document for all procedures related to BFM. In addition, it includes suggested techniques for performing each maneuver and making corrections.

Use this to prepare for and afterward to review lessons and flights. This information will help you effectively prepare for lessons: know all the procedures in the assigned section(s), review the glossary, and be prepared to ask your instructor about anything that remains unclear. Then you can devote your attention to flying the T-45. After a flight, review the materials to reinforce your understanding and to clarify any difficult maneuvers or procedures.

INTRODUCTION

When the P-80s came along in the 1940s, it was believed to mark the end of dog fighting. The P-80 outfit in Okinawa in 1947, however, was dog fighting on a daily basis. Thirty years later, air-to-air missiles arrived on the scene prior to the Vietnam conflict and “the powers that be” declared dog fighting obsolete. Organic internal cannons were removed from the modern fighters of the time since the experts were certain that Beyond Visual Range (BVR) missiles would eliminate the possibility of a within visual range (WVR) engagement. Nevertheless, the aircrews fighting over Vietnam frequently found themselves in the WVR arena unable to employ their missiles, with no gun for close combat, and without the training needed to be successful in the 1v1 Air Combat arena. The days of Midway and Vietnam are well past, yet in the world of modern aerial combat, electronic attack is the great equalizer. While we (and our enemies!) continue to improve our BVR capabilities, a combination of electronic attack, theater rules of engagement (ROE), switchology failures, or a momentary lack of attention to the prescribed air-to-air timelines may ultimately bring us face to face with the enemy in a 1v1 engagement.

COMBAT LESSONS LEARNED

Despite operating in an era of all-aspect, BVR missiles, things do not always go as planned. Radars have problems, missiles are not always reliable, and pilots sometimes make mistakes. Any one of these scenarios may allow the enemy to close WVR. For that brief moment when the decision is made to engage an opponent, we are involved in a 1v1 engagement. Strike-fighter aircrew *must* be proficient at 1v1 air combat to minimize time-to-kill and ensure they leave merges victorious.

Develops Fundamental Tactical Skills – BFM training accomplishes much more than preparing strike-fighter aircrew to be lethal at a merge with live, hostile aircraft. BFM training is a method of teaching aircrews the fundamental skills of maneuvering aircraft to the edge of its operating envelope, assessing the relationship between two maneuvering aircraft, and developing an increased state of situational awareness for flight leads and wingmen alike. In addition, it helps to breed and develop the aggression necessary to win in modern air combat. The result of thorough BFM knowledge can be evident in all phases of flight and must not be overstated.

Enhances Credibility – Particularly important while progressing through the USN Strike-Fighter Weapons and Tactics (SFWT) program or the USMC program.

It is incumbent upon every strike-fighter aircrew to have a sound understanding of 1v1 Air Combat in order to be successful. The 1v1 BFM discussion will use a building block approach. We will progress from the basics behind maneuvering the aircraft, to weapons systems capabilities and limitations, ultimately applying concepts specific to Perch and High Aspect BFM.

TRAINING RULES

The following training rules apply to all BFM training and shall be strictly observed. These rules include those found in OPNAVINST 3710.7. Because you will hear these rules before each flight, their meaning may become just "words". For the most part, they will be the same rules you hear in the fleet. It is important to note that these rules were developed over a long period and each is based not only on common sense but also on situations where pilots were guilty of making serious and even tragic mistakes.

ADMIN

1. BRIEF DEPARTURE/SPIN, COMPRESSOR STALL PROCEDURES, AND CURRENCY – All in flight have flown: 1 in 6 and 2 in 14 (<750 hrs), or 1 in 14 and 2 in 30 (>750 hrs)
2. FACE-TO-FACE BRIEF OF ALL MANEUVERS FOR ALL PARTICIPANTS.
3. ACM WILL BE CONDUCTED IN AN AUTHORIZED AREA ONLY FROM 30 MIN AFTER SUNRISE TO 30 MIN PRIOR TO SUNSET.
4. ACM WX MINS:
 - a. 5 miles visibility with a defined horizon.
 - b. 11K' between broken/overcast layers.
 - c. 1 NM horizontally and 2K' vertically from all clouds.
 - d. ACM may be conducted above broken/overcast layer provided the highest layer is below 7K' AGL for solo events and 8K'AGL for dual events. The flight lead will then establish the hard deck 5K' above that layer and all A/C will acknowledge the new hard deck.
5. HARD DECK SHALL BE 10,000 FT AGL MIMIMUM.
6. SOFT SHALL BE 5,000 FT ABOVE THE HARD DECK.
 - a. No sustained low speed/high AOA maneuvering (less than 120 knots AND more than 24 units) below the soft deck.
7. ALL AIRCRAFT MUST HAVE OPERABLE UHF AND ICS (MULTI-CREW) AND MONITOR GUARD.
8. CONFIGURATION CHANGES OTHER THAN SPEED BRAKES ARE NOT AUTHORIZED.
9. "G" AWARENESS MANEUVER REQUIRED PRIOR TO ACM.

COLLISION AVOIDANCE

10. MAINTAIN A 500' BUBBLE AROUND ALL AIRCRAFT.
11. ALWAYS ASSUME THE OTHER AIRCRAFT DOES NOT SEE YOU.
12. MAINTAIN THE ESTABLISHED TREND ON HEAD TO HEAD PASSES. WHEN NO TREND EXISTS, EACH AIRCRAFT SHALL GIVE WAY TO THE RIGHT FOR A LEFT-TO-LEFT PASS. TRANSMIT YOUR OWN INTENTIONS.

13. LOW AIRCRAFT IN A HORIZONTAL SCISSORS IS RESPONSIBLE FOR SAFE SEPARATION. NOSE HIGH GOES HIGH, NOSE LOW HAS COLLISION AVOIDANCE RESPONSIBILITY. TRANSMIT YOUR OWN INTENTIONS.
14. NEVER INTENTIONALLY MANEUVER TO LOSE SIGHT (NO BLIND LEAD TURNS).
15. IF LOST SIGHT, TRANSMIT "BLIND" AND REMAIN PREDICTABLE. OTHER AIRCRAFT SHALL ACKNOWLEDGE WITH "CONTINUE" OR "KNOCK-IT-OFF" AS APPROPRIATE, PROVIDING DIRECTIVE COMM AS NECESSARY FOR SAFETY OF FLIGHT. ONCE SIGHT IS REGAINED, TRANSMIT "TALLY."
16. UP-SUN AIRCRAFT IS RESPONSIBLE FOR COLLISION AVOIDANCE. IF DOWN-SUN AIRCRAFT LOSES SIGHT, BREAK OFF THE ATTACK, TURN AWAY FROM PREDICTED COLLISION BEARING AND BROADCAST "BLIND, SUN." UP-SUN AIRCRAFT SHALL ACKNOWLEDGE WITH EITHER "CONTINUE" OR "KNOCK-IT-OFF" CALL.
17. BREAK OFF ALL GUN ATTACKS AT 1,000', NO FORWARD QUARTER GUN ATTACKS (45 deg of target nose). CNATRA WEAPONS ENVELOPES APPLY.

TERRAIN AVOIDANCE:

18. IN A DESCENDING FIGHT, THE OFFENSIVE (HIGH) AIRCRAFT SHALL MONITOR THE DEFENSIVE (LOW) AIRCRAFT'S ALTITUDE, ATTITUDE AND AIRSPEED AND BREAK OFF THE ATTACK PRIOR TO PUSHING THE DEFENSIVE AIRCRAFT THROUGH THE HARD DECK.

TERMINATION

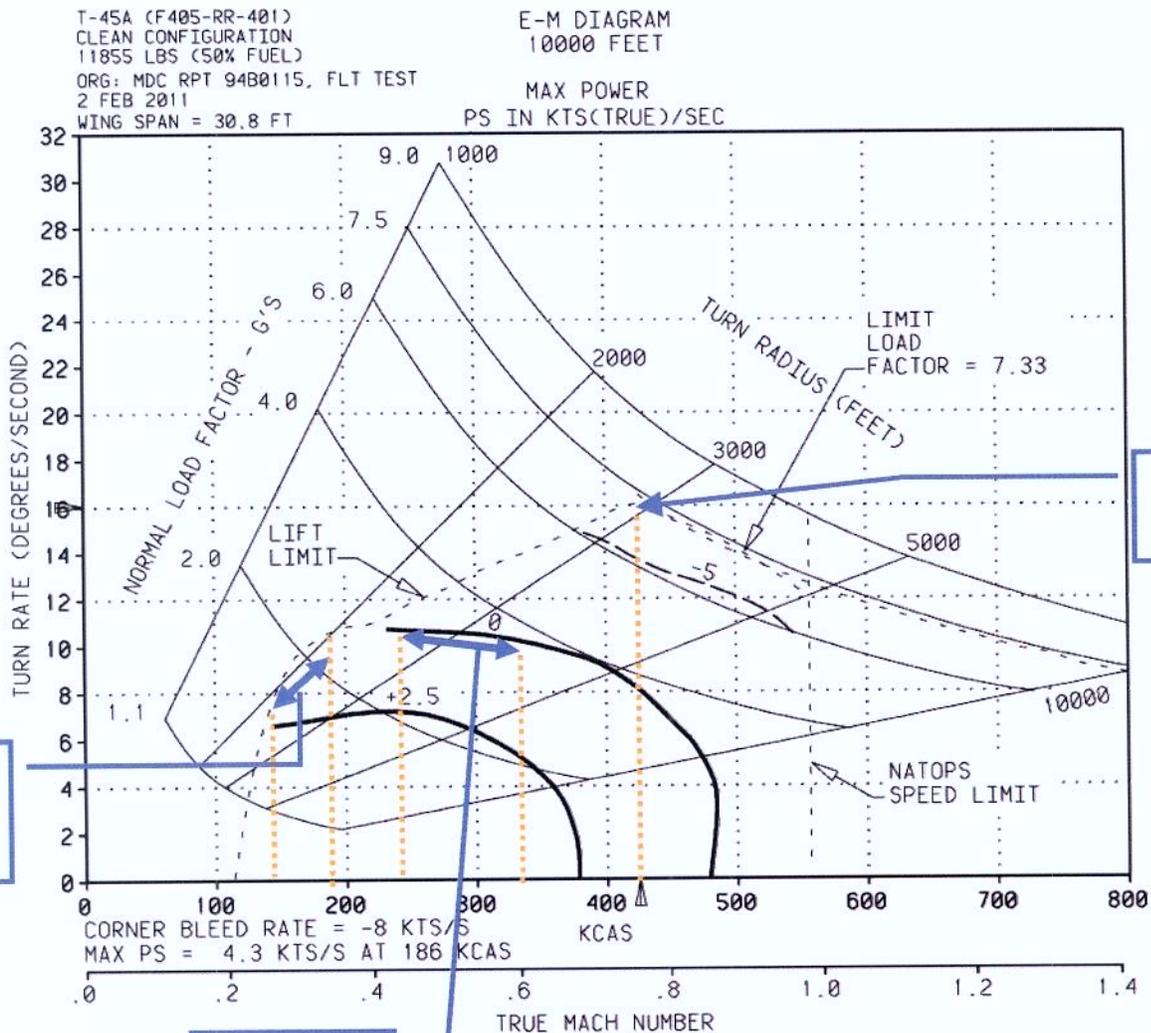
19. ANYONE CAN CALL A "KNOCK-IT-OFF." EACH AIRCRAFT SHALL TERMINATE THE ENGAGEMENT, MANEUVER TO SAFETY AND ACKNOWLEDGE WITH THEIR OWN "KNOCK-IT-OFF." WATCH OUT FOR THE MID-AIR POTENTIAL FOLLOWING A "KNOCK-IT-OFF".
20. KNOCK-IT-OFF FOR ANY OF THE FOLLOWING:
 - a. Any training rule is violated.
 - b. Interloper (unbriefed A/C) enters the engagement area.
 - c. Any OCF flight situation develops.
 - d. G-LOC experienced or suspected. (Aircrew shall RTB).
 - e. Radio failure/loss of ICS. An aircraft rocking wings is an automatic "knock-It-off."
 - f. Bingo fuel state is reached
 - g. Dangerous situation/loss of situational awareness/inadvertent IMC/possible overstress.
 - h. Training objectives have been reached.
 - i. Engaged aircraft crosses the border of the authorized training area.

MANEUVERING

The measure of success in 1v1 Air Combat is simple. "It is to kill or be killed". In order to be successful, we must maneuver our aircraft into a position in which we can employ our weapons systems while denying our enemy the ability to employ his. We will begin with the first part of the equation, maneuvering the aircraft.

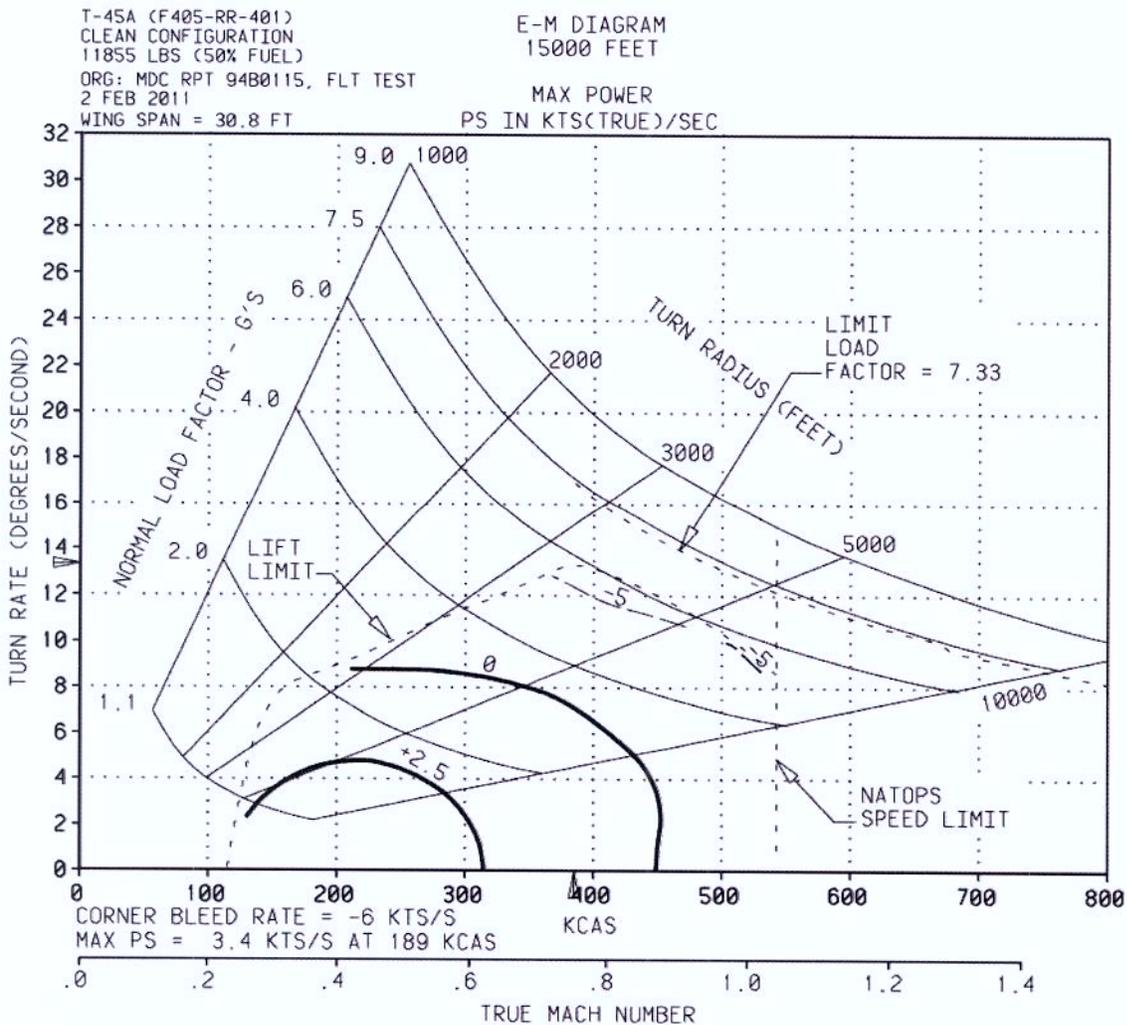
ENERGY MANEUVERABILITY PERFORMANCE NUMBERS

Before discussing the maneuvers to use in order to achieve a positional advantage, you must be familiar with the performance of your own machine throughout the flight envelope. Two of the most important source documents when familiarizing yourself with the full performance capabilities of the T-45 are Chapter 11 of NATOPS, and the Energy-Maneuvering (E-M) diagram. Chapter 11 of NATOPS defines maneuvering characteristics and details the maneuvering limits that can prevent aircrew from departing controlled flight. The E-M diagram outlines aircraft turn performance during a level turn in the horizontal plane. It also allows us to define our tactical maneuvering options and reference airspeeds, as well as the structural and lift limit of our platform. Although engagements rarely remain level, understanding the principals behind the E-M diagram allows you to make smart tactical decisions based on energy states.



We are not going to build an E-M diagram in this chapter, but we are going to identify the main ideas and extract the most important information so as to arm you with the basic foundational knowledge to execute BFM. Each diagram is specific for aircraft, configuration, and altitude, all of which can be found in the periphery of the diagram. Make sure to always read this information first so as to compare apples with apples.

For example, let's take a look at what happens to T-45 performance as we increase altitude by as little as 5,000 ft. The E-M diagram below is for a T-45 at **15,000 ft**. During a lift-limit level pull, our minimum radius has increased by 600ft (1900ft to 2500ft) and our max sustained Turn Rate ($P_s=0$ line) has decreased by 2.5deg per second (11 deg/s to 8.5deg/s). Translation? A T-45 in a max performance turn at 10,000ft will out-rate another T-45 at 15,000ft so much that the lower jet (in thicker air) will generate a 75 degree advantage in only 30 seconds (2.5deg advantage x 30s)!



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

T-45 Performance Numbers

Max Performance:

- *Pitch*
 - Airspeed above corner airspeed: load limit pull, 7.33Gs (above 5,000ft).
 - Airspeed below corner airspeed: lift limit pull, 19-21 units (rumble of buffet) pull. A lift limit pull is closer to 24 units, however due to stab stall 19-21 units may be the max achievable pull at higher airspeeds .
- *Roll (Max rate of 160-170deg/s at 350-400kts)*
 - Unload while utilizing coordinated stick and rudder. The slower the speed the more rudder deflection you will be able to achieve due to lessened aerodynamic loads. Due to this, the use of rudder at slower speeds becomes more beneficial in achieving maximum roll rates.
- *Acceleration* – Unload to 0G with MRT selected

Corner Bleed Rate: 8kts/s

- The rate at which the aircraft will decelerate in a max performance pull at corner airspeed.

Compromise Performance: Good turn performance without the bleed rates associated with maximum performance.

- *Load Limit Pull* - Ease pull by 1-2Gs
- *Lift Limit Pull*- Target 17 units (light buffet)

Corner Airspeed: 410 KCAS

- Yields the aircraft's best instantaneous turn performance but also the highest bleed rates.

Best Sustained Turn Rate: 240-330 KCAS

This band is found where the: Specific Power (Ps) curve = 0, i.e. the aircraft is sustaining energy. At the lower end of the rate band the aircraft yields a small advantage in turn rate (.5deg higher at 240kt compared to 330kts). However the aircraft's ability to trade airspeed for angles (energy excursion) is reduced below 300kts, furthermore at slower airspeeds the aircraft becomes more difficult to handle being more prone to stall/pitch buck. Therefore, initially targeting the upper portion of the rate band (300-330kts) until an airspeed excursion is necessary is prudent in most cases.

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

Minimum Vertical Airspeed: 300kts

- This number will vary based on altitude and proficiency. Each pilot needs to determine their own minimum vertical airspeed based on these factors. As a technique, targeting a light nibble pull will optimize the execution of a minimum airspeed vertical loop. In general 300kts is good target airspeed.

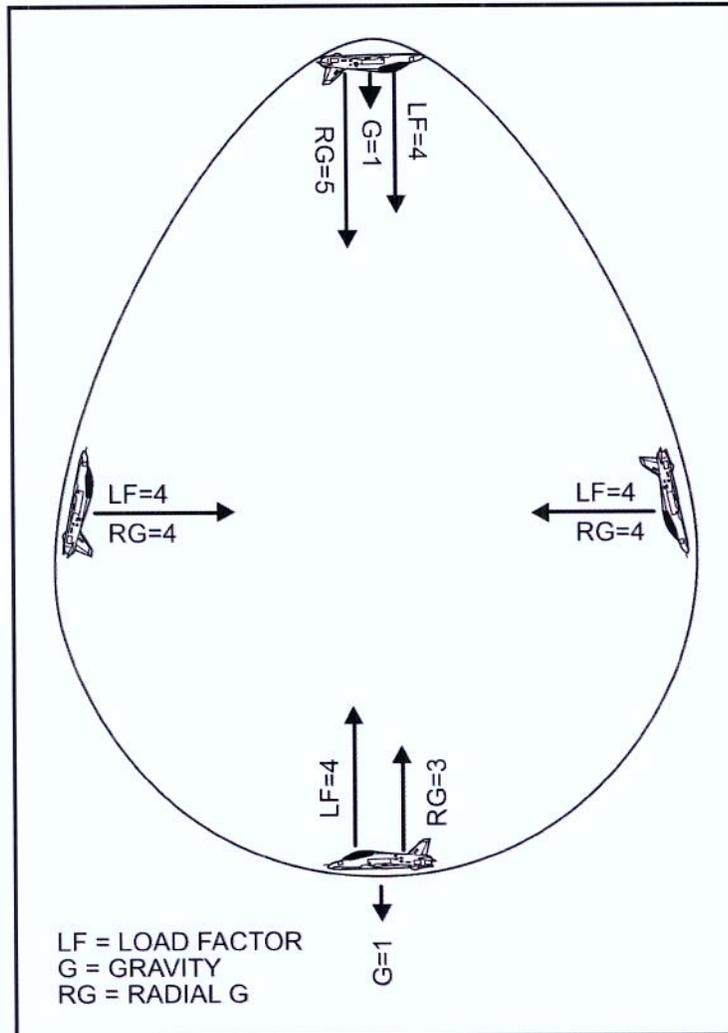
Tactical Vertical Airspeed: 350kts

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

Understanding the performance characteristics of our aircraft will enable us to fly our aircraft more effectively. However, as we are maneuvering to gain a positional advantage, so is our enemy. It is important to understand the adversary's maneuvering capabilities versus ours. In the training command that is greatly simplified as we fly the same aircraft. The variable is going to be the "man in the box". The pilot that best understands the capabilities of his aircraft and the principals of BFM will win the fight.

VERTICAL MANEUVERING

Remember, the E-M diagrams only depict an aircraft's turn performance in a level turn. The moment the maneuvering takes on a vertical component, we can no longer reference solely E-M diagrams to accurately represent the aircraft's turn performance. The effects of gravity must be considered as well. Gravity will have an effect on turn rate, radius, and the bleed rates associated with the maneuver.



Nose High Maneuver

The diagram on the preceding page illustrates the affects of gravity on vertical turn performance. The load factor (LF) is illustrated with a constant G force of 4, and is controlled by the pilot. Gravity (G) equals the affect of gravity on the aircraft. Finally the Radial G (RG) is the combination of G and LF and denotes total performance.

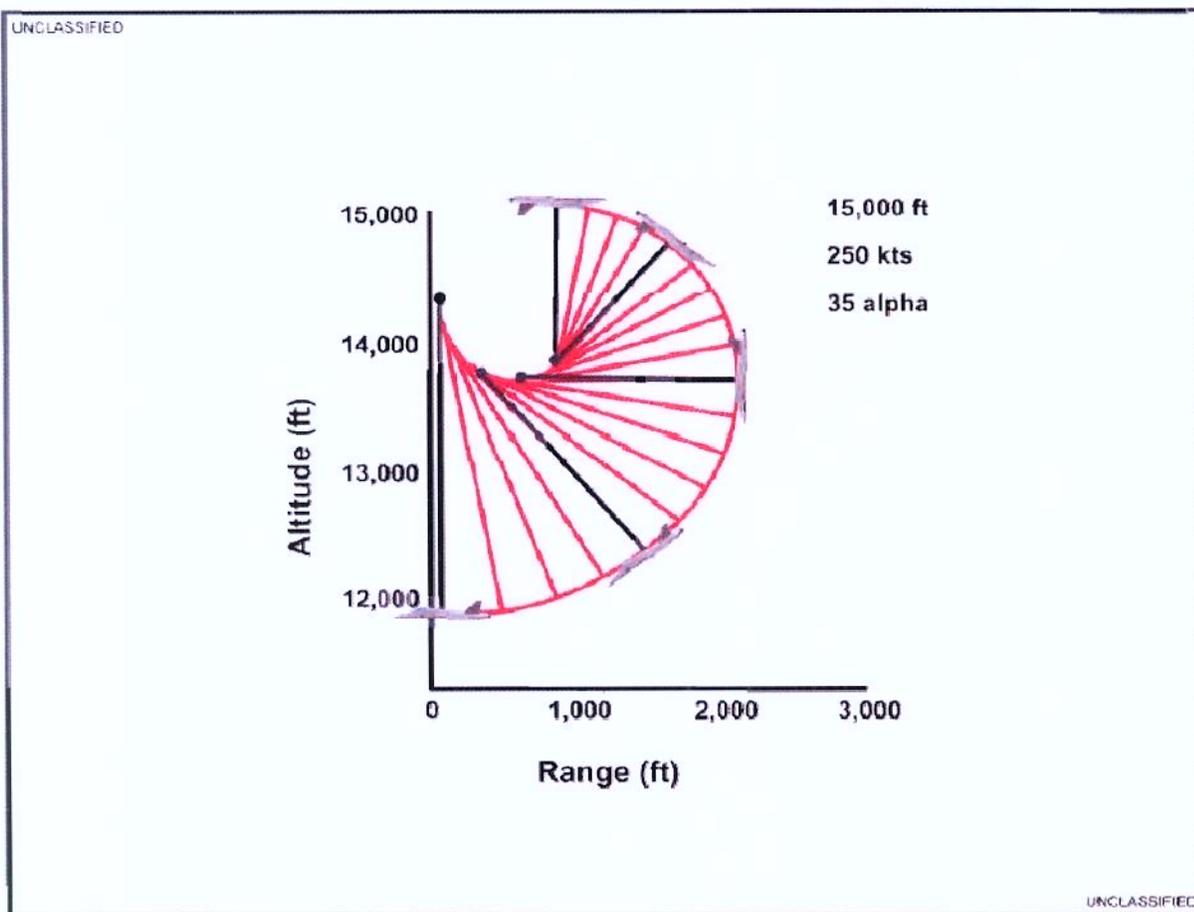
Gravity can positively affect the turn rate and turn radius performance of an aircraft during a nose high maneuver. The diagram shows a T-45 executing a pure nose high loop. The pilot executing the maneuver maintains a constant 4G pull, but the aircraft overall performance (RG) must account for 1 unit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

to turn through more degrees per unit of time (greater turn rate). When the aircraft is bullseye nose high or nose low, the effects of gravity are effectively zeroed out and a 4G pull results in 4RG of aircraft performance.

Nose Low Maneuver

While gravity can assist the aircraft turn performance as it maneuvers nose high, a combination of power, AOA control and gravity can adversely affect turn performance as the aircraft begins to maneuver nose low. The T-45 does not bleed energy in an extreme nose low maneuver. The aircraft will accelerate when extreme nose low despite max performing when at MRT. Finally, an aggressive nose low maneuver at airspeeds in excess of 350kts creates a greater probability of the pilot succumbing to Gravity Induced Loss of Consciousness (GLOC) without proper body positioning or executing the anti-G straining maneuver.

While performing a nose low maneuver, the effects of gravity on turn rate and radius are reversed from the nose high maneuver. If the aircraft maintains constant G, the turn rate will decrease and the turn radius will get larger throughout the maneuver. Although we are utilizing an example of an F/A-18 (with approximately half the nose-low turn radius of the T-45), the concept applies to all aircraft. The diagram below shows an F/A-18 executing a nose low maneuver. The F/A-18 is max performing on the lift limit at MRT. Due to the change in radius, the aircraft's post will shift from its original position. This lateral separation between the posts needs to be accounted for when timing the nose low maneuver, as is the case during the slow speed merge discussion in High Aspect Basic Fighter Maneuvers (HABFM). If the pilot executes a pull that is above or below the lift limit the turn radius will grow even larger.



Slow Speed Vertical Reversal

Typically, slow speed (less than 150kts) vertical reversals are used during BFM when reversing from a nose-high to a nose-low pitch attitude in minimal time and radius. Maintain the throttle at MRT and ensure you keep the nose tracking past vertical (bullseye nose high) outside 70deg of vertical. It is paramount that you keep a light nibble pull. If you pull too hard or don't keep the nose tracking back to the horizon a departure may occur. Although the jet is quite controllable during this parabolic maneuver at slow airspeeds, it does not mean the aircraft will not depart. If the aircraft ever starts to move in a direction that was not commanded, immediately neutralize the controls, reduce the throttle to idle and follow NATOPS out-of-control-flight (OCF) procedures. Also, remember that NATOPS states that we need the throttle at idle at altitudes above 15,000ft MSL and airspeeds below 85kts.

Deck transition Rule of Thumb (i.e “the 10% rule”).

The deck transition rule of thumb provides a conservative flight path profile to transition from a nose low attitude to level flight on the deck. We will discuss when to use the rule of thumb later on in the reading. With practice and experience you will be able to perform a more aggressive transition, but the below “gates” will provide a good starting point.

Deck transition Rule of Thumb gates

<u>Nose low</u>	<u>Altitude Above the deck</u>
40°	4,000ft
30°	3,000ft
20°	2,000ft
10°	1,000ft

1v1 Concepts and Definitions

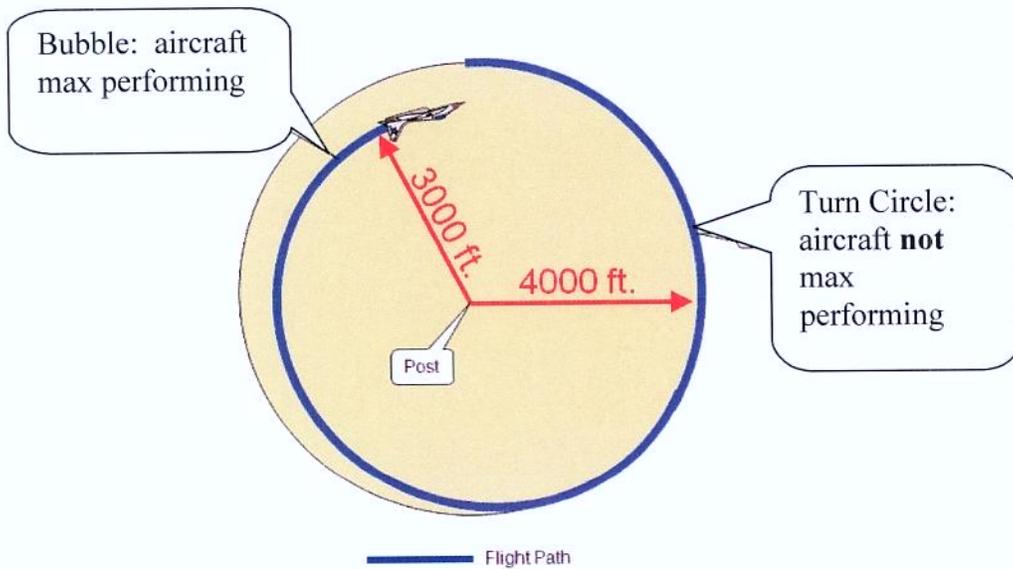
BFM concepts have been in development since the first time two aircraft found themselves in the same piece of sky and one guy decided: *“I want to go kill him!”*

In order to achieve a victory, we must maneuver our aircraft into a position in which we can employ our weapons systems while denying our enemy the ability to employ his. We covered concepts of maneuvering the aircraft and some basic maneuvers. The glue that puts them together will be the concepts of 1v1 BFM. Combining the concepts with the cues in the cockpit will dictate when to maneuver the aircraft and employ a weapon.

- **Sensor Nose** - Sensor nose is defined as nose on in the T-45. In the fleet, due to radar and other advanced aircraft “sensors”, sensor nose may be greater than 45deg off the actual nose position of the offender. Although the T-45 lacks those systems, we will reference sensor nose during defensive BFM discussions.
- **Flight Path** - The imaginary arc that an aircraft scribes in the sky. The aircraft's velocity, G, and LV placement determine the geometry of the flight path. The smoke from an aircraft's engine is an excellent indication of an aircraft's flight path.
- **3/9 Line** - An imaginary plane extending from wingtip to wingtip, perpendicular to the flight path. Positional advantage is generally defined by the position relative to the 3/9 line.
- **Turning Room** - Any separation that exists between two aircraft. Exclusive-use turning room is turning room that is available to only one of the aircraft in the engagement due to energy states or the deck.
- **Turn Circle** - The actual turn an aircraft is scribing based on current turn performance.

- *Bubble* - The actual turn an aircraft is scribing based on a maximum performance turn. The visual cues in BFM are based on entering the aircraft's bubble. The average bubble for a T-45 is 3,000 feet.
- *Post* - The center point of the turn circle. The post does not define pursuit curves.
- *Plane-of-Motion* - The two-dimensional plane in which the turn circle lies. When an aircraft is at a high-energy state or executing a symmetrical pull in the vertical, its POM is a close approximation of the plane of symmetry (POS), or the plane in which the LV lies. When at lower energy states (i.e., a 130kt level 60 degree AOB turn), POM may be more difficult to determine.

Turn Circle / Bubble

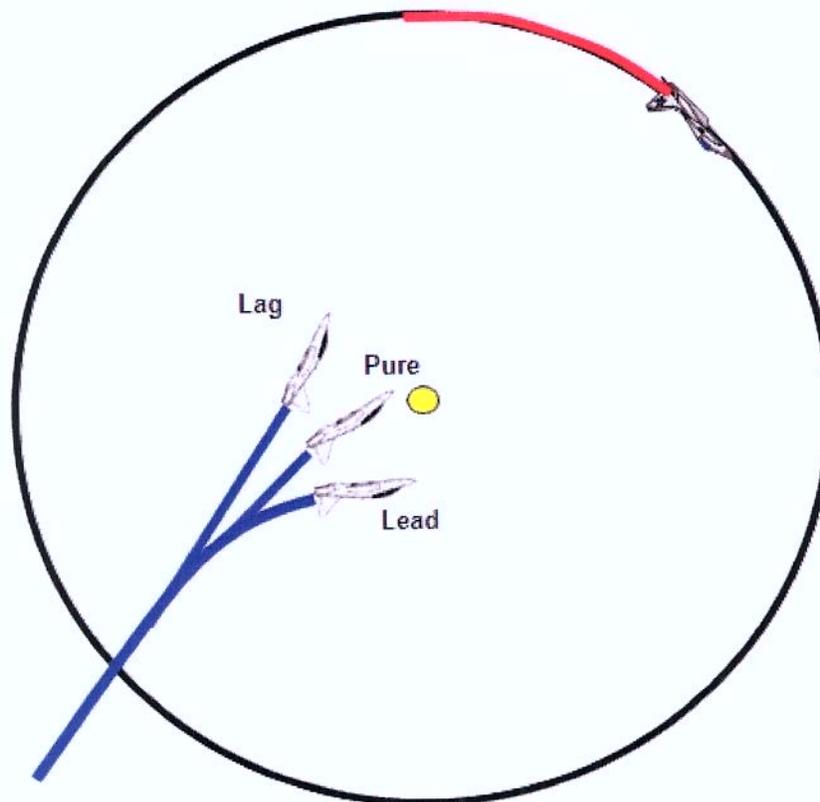


- *Attack Window* - A location inside the bubble that if we perform an offensive break turn we will arrive in the control zone with range, angles, and closure under control.

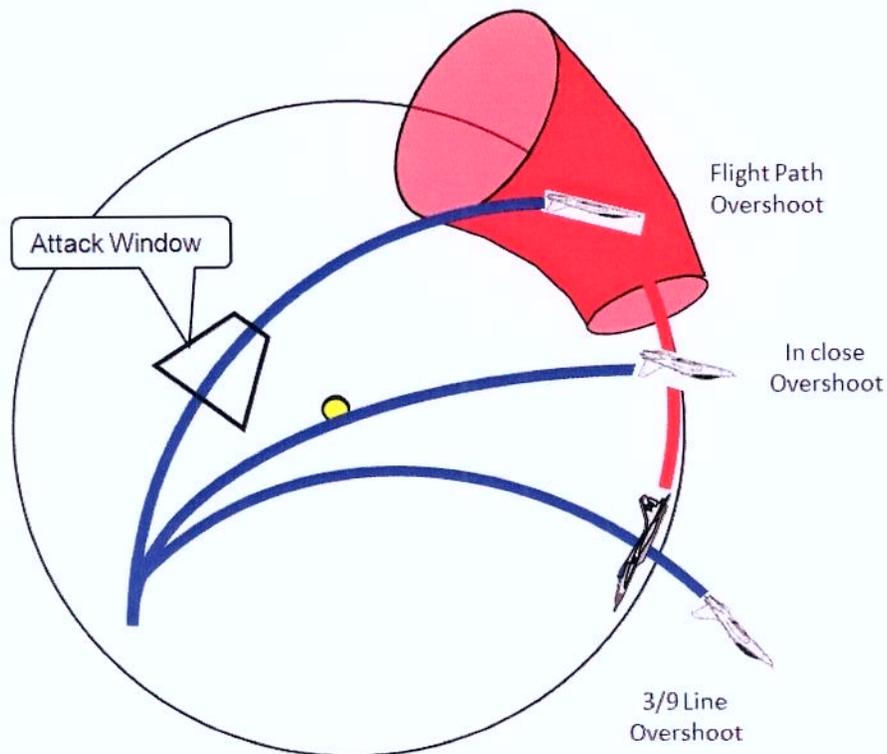
Pursuit Curves — Pursuit curves are based on our nose position when in the bandit's POM and our LV placement when not in the bandit's POM.

- . Lead Pursuit
 - o Nose or LV in front of the adversary
 - o Used to rapidly collapse the range without regard to angles
 - o Maintaining lead pursuit for too long can potentially lead to an in-close overshoot
- . Pure Pursuit
 - o Nose or LV on the adversary
 - o Used to employ weapons
 - o Leads to a moderate collapse in range and increase in closure without regard to angles.
 - o Maintaining pure pursuit for too long can potentially lead to an in-close overshoot
- . Lag Pursuit
 - o Nose or LV aft of the adversary
 - o Used to manage the range, angle, and closure problem

Pursuit Curves

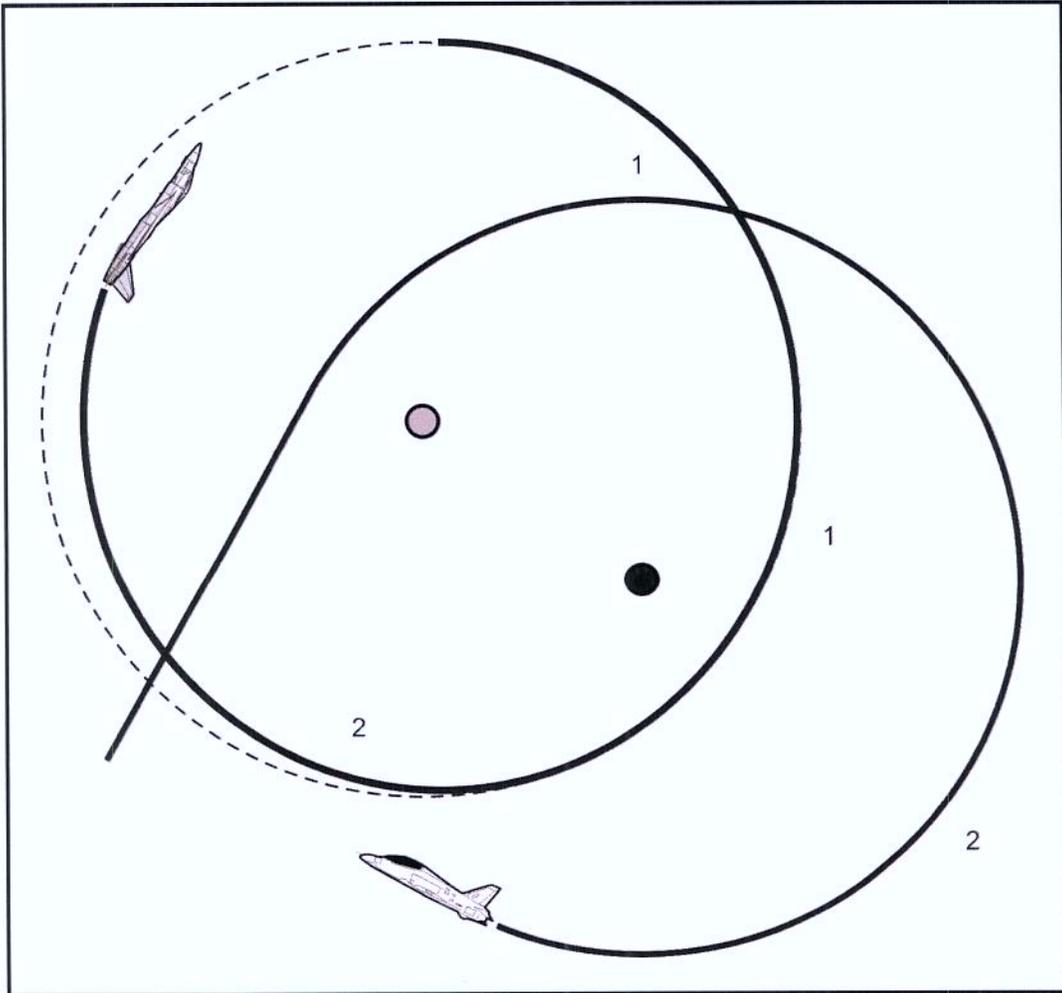


The 3 Overshoots



- **Overshoots**
There are three types of overshoots:
 - *Flight Path Overshoot*: Flying through the adversary's flight path. Ensure the flight path overshoot occurs within or aft of the confines of the CZ. This will deny a reversal opportunity.
 - *In-close Overshoot*: A flight path overshoot that occurs inside the near portion of the defender's CZ, less than 2,000 ft.
 - *3/9-Line Overshoot*: An overshoot of the defender's 3/9-line that results in a positional role reversal (i.e., passing from behind the adversary to in front of him).
- *Energy Excursions*: An energy excursion is when you trade airspeed for angles. It is used to take/deny a shot or to take/deny turning room.

- *Misaligned Turn Circles (MATC)*: MATCs are created due to the fact that each aircraft's bubble is displaced over a different geographic point in space. Given the same exact turn performance the geometry of MATCs will enable an attacker's nose to come to the defender through pure geometry without having to perform an energy excursion.



BFM CUES

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

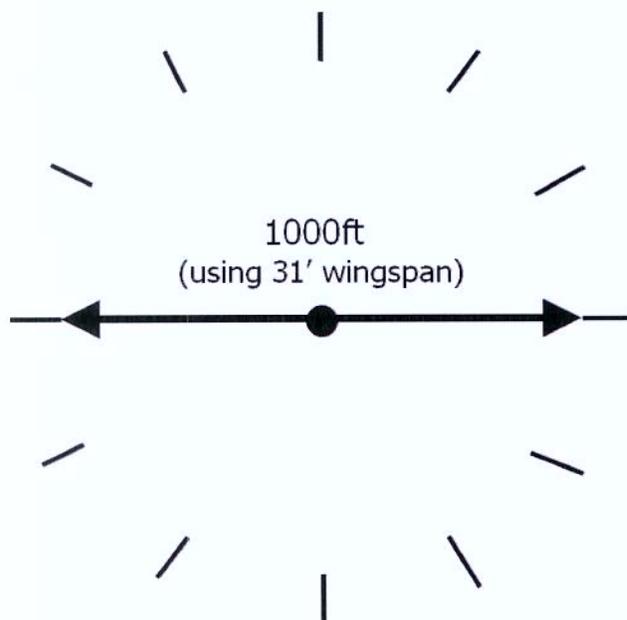
- *Range:* Being able to assess range is very important. Use your calibrated eyeball from the Formation and Tacform stage to assess ranges outside of .5nm (3,000ft). Inside .5nm, use aircraft size relative to the gun reticle (see aircraft cueing systems) .
- *Target Aspect (TA):* This is the angular difference between the bandit's nose and your aircraft. A bandit that is pointing at your aircraft has zero target aspect. Being able to recognize the change in TA is very important.
- *Angle off Nose (AON):* AON is the angular measure that an aircraft is off your nose.
- *Angle off Tail (AOT):* AOT is the angular measure that an aircraft is off your tail. This is the best way to assess the angular problem of the engagement. AOT is used mostly during defensive BFM discussions.

BFM CUE ASSESSMENT

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

Aircraft Cueing Systems — The T-45 lacks the on board sensors of fleet aircraft that help you assess range, TA, closure, etc. Use A/A Tacan and the Gun reticle to aid in range assessment.

The Gunsight



Lead Angle Computing (LAC)

- Used for tracking non-maneuvering targets at 1000' range. Must keep in reticle for >1 second. We don't use it.

Real Time Gun Sight (RTGS)

- Used for tracking a maneuvering target by aiming and keeping the reticle pipper ahead of the target (snapshot).

- Software positioned on the point that a shell would reach in the time it takes the shell to travel 1000ft. If range > 1000', you must shoot with enough **lead** for bullets to travel required distance.

Estimating Range



1000 ft

- **Closest shot range (Training Rules).**

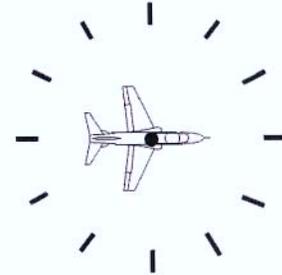
- **If wings overlap reticle, you're too close!**



1500 ft

- **Heart of Gun Envelope**

- **$\frac{3}{4}$ of reticle**



2000 ft

- **$\frac{1}{2}$ of reticle**

Eyeball Calibration (EBC) – Perhaps the most important aid you have in the cockpit is your own set of eyeballs and there are many cues in BFM that will require their use. For example, you will need to visually assess range, AON, AOT, TA, closure, as well as attack window entry, and MATC's, all the while making an overall assessment based on these cues of whether or not you are winning or losing the fight. A proper "eyeball cal" is something that develops over time. With your training here and at the FRS, you will soon begin to accurately recognize and assess all of the cues that present themselves in a BFM engagement.

ADMIN

1. The Admin portion of the flight (i.e. departure and RTB) will be conducted just as your flights were in the TACFORM stage.
2. Once established in the area, the section will use combat spread maneuvering to maintain the flight in the operating area.

TACADMIN

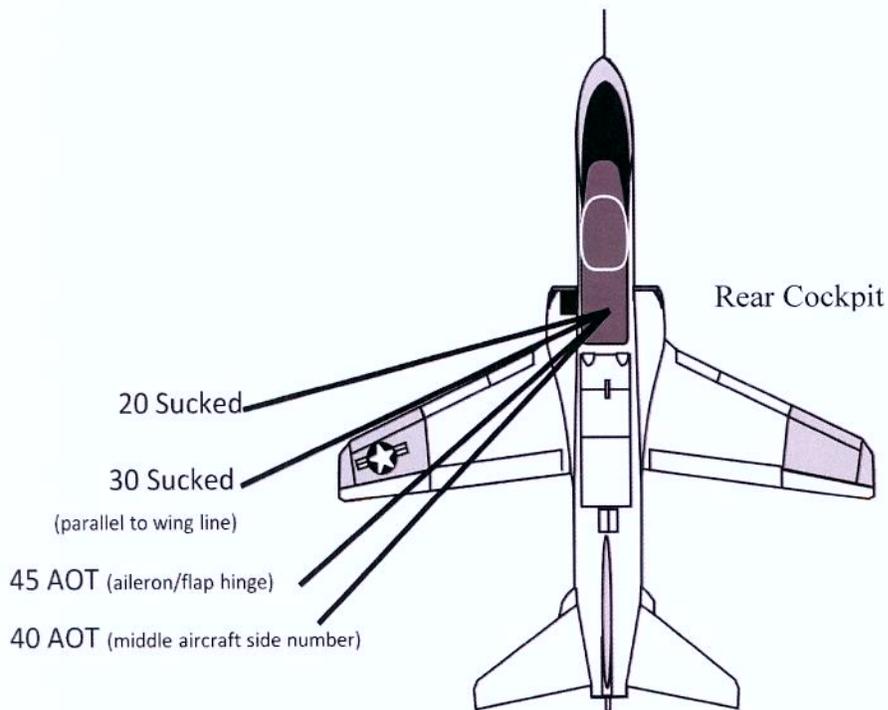
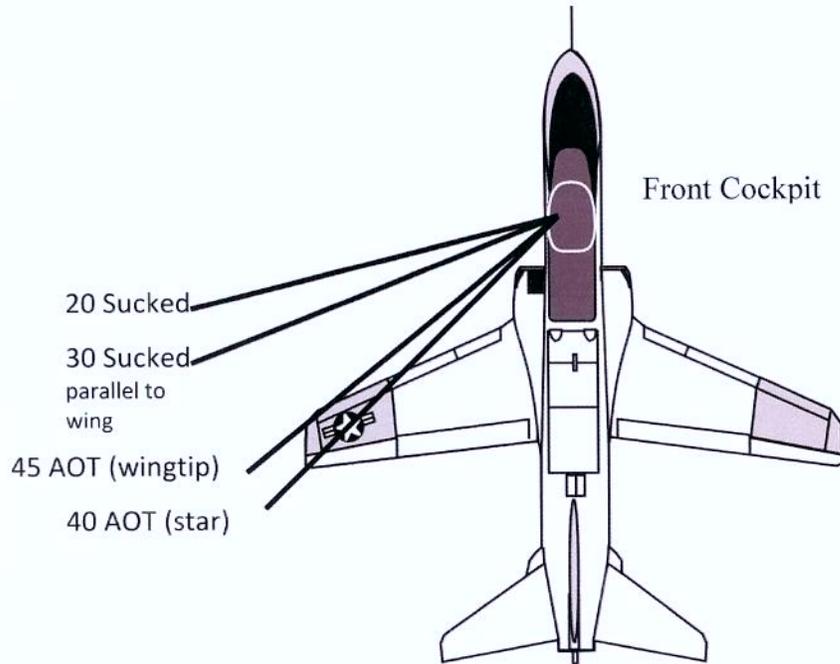
- a. TACADMIN will be conducted according to the TACSOP.
- b. Always reference 300kts for the climb. For sets that start at slower airspeeds lead will tell you when to decelerate. Use nose position and power to minimize your time to climb trading airspeed for altitude when necessary.
- c. PADS for each set will refer to the required parameters prior to calling "Speed and Angles" (some after a nose-low acceleration).

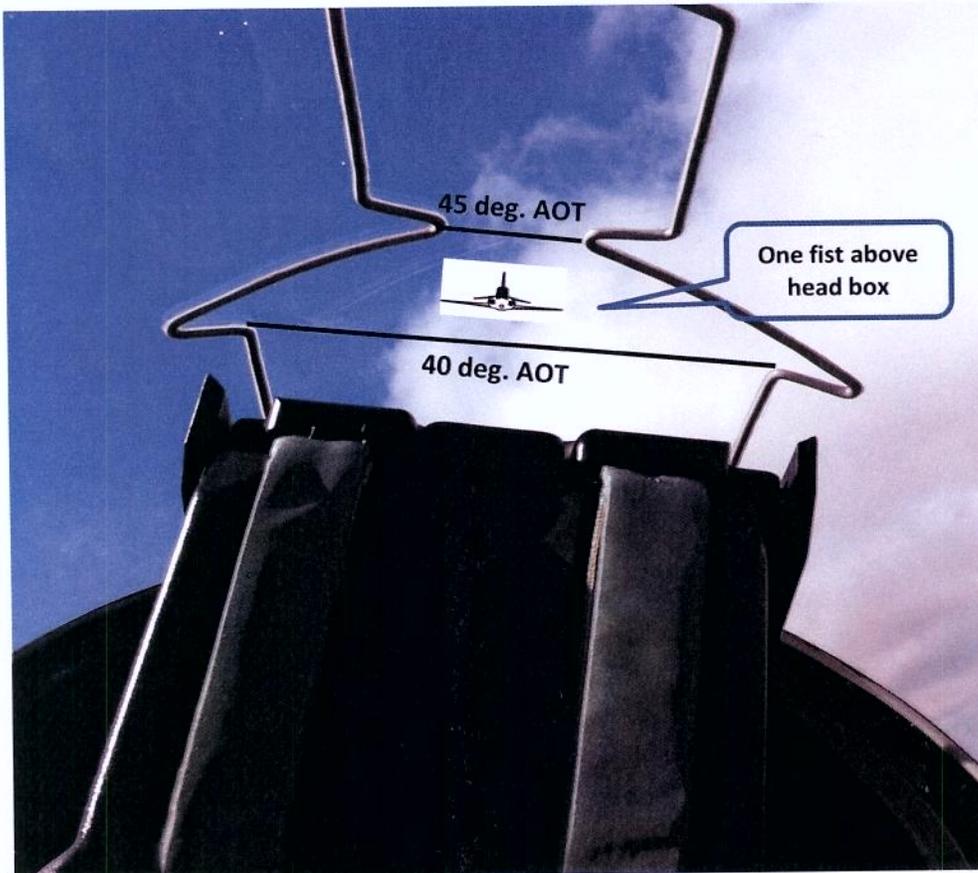
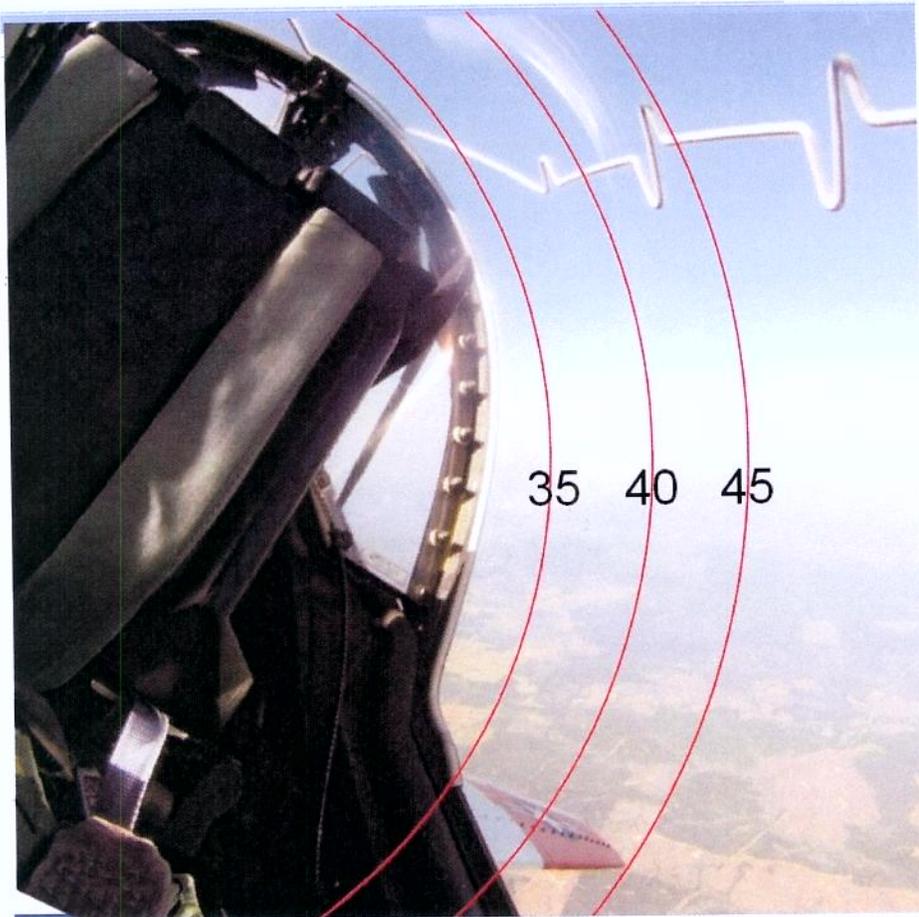
	Position	Altitude	Distance	Speed
SNAP SHOT DRILL	Abeam	Deck+4k	1.0 nm	300
FLATS	Abeam	Deck+5k	.5 nm	200
ROLLER	Abeam	Deck+6k	0.5 nm	200
6K' SET	Abeam	Deck+6k	1.5 nm	350 (after accel)
9K' SET	Abeam	Deck+6k	2.0 nm	400 (after accel)
BUTTERFLY	Abeam	Deck+6k	1.0 nm	350 (after accel)
ABEAM	Abeam	Deck+6k	1.5 nm	350 (after accel)

Tolerances:

Position: +/- 10 deg
Altitude : +/- 200 ft
Distance: +/- 0.1nm
Speed : +/- 10kts

The below diagrams is an aid for reference to determine angle off tail or degrees sucked from the 3/9 line.





VALID SHOT REQUIREMENTS

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

1. Missile Shot
 - a. Shooter within AIM-9 Envelope
 - b. Defender in HUD FOV and pulling lead (i.e. below altitude airspeed boxes)
 - c. Wingman must not be in HUD FOV (shot deconfliction)
 - d. PULL THE TRIGGER (with steps a,b & c met)
2. Gun Shots
 - a. Snap Envelope
 - i. Shooter within Snap Gun Envelope
 - ii. Pull trigger in order to establish bullets at target range
 - iii. Target must pass through piper
 - iv. 2 valid snaps equals a kill
 - b. Tracking
 - i. Shooter within Tracking Gun Envelope
 - ii. Pull trigger with piper on target
 - iii. 1 second of cumulative tracking time equals a kill

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

1. Missile Shot – With a valid shot, “Fox-2”
2. Guns
 - a. Snap – With a valid snap, “Trigger down snap... assessment”
 - b. Tracking – With a valid tracking shot, “Pippers on...tracking...pipers off”

DEFEATING SHOTS

In order to defeat shots we also must meet certain requirements. Because we lack the combat systems and the training systems to simulate when we have successfully defeated a shot, we will mainly use a timely comm. call. Performing these simple steps will let your instructor know that you recognized an impending shot.

1. Missile Shots
 - a. Call “Chaff Flare” no sooner than 2 seconds prior to sensor nose and no later than “Fox-2” call from bandit
 - b. Lift vector on bandit and defensive break turn
2. Gun Shots
 - a. Defeat POM (i.e. perform a timely “Guns D”, reference Snap Shot Drill guns defense)

SNAP SHOT DRILL (SSD)

- P - Abeam
- A – Deck plus 4,000ft
- D - 1.0 nm
- S - 300kts

The aerial gun was the first weapon employed in dog fighting and still remains the most difficult weapon to use in the BFM arena. The snapshot drill is a cooperative maneuver designed to teach employment of the gun at high angles off for the shooting aircraft and a timely guns defense for the target aircraft.

After the "Speed and Angles" call, lead will initiate the maneuver by calling "Hammer 11, in target/shooter." Wing will respond with "Hammer 12, in shooter/target."

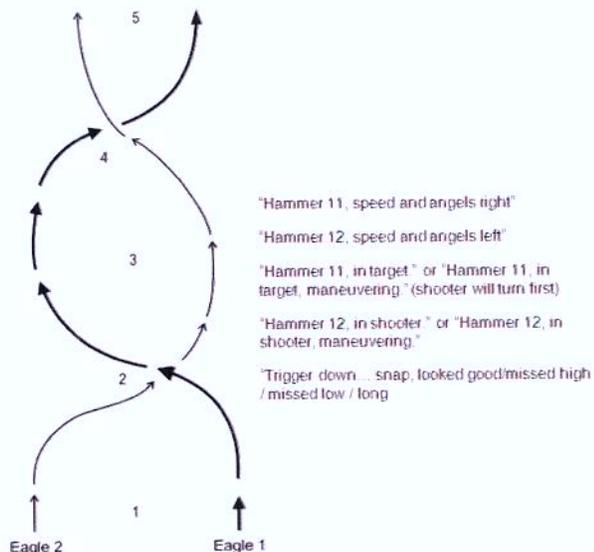
The two aircraft will turn in towards each other utilizing a 2-3G pull. The shooter turns in first then the target. The target aircraft will tighten / ease "G" to initially maintain the shooter at the 10 or 2 o'clock position. The shooter controls the range and angles while the target aircraft adjusts accordingly to maintain proper clock position only. When the shooter's nose starts to come on, the target will allow the shooter to track aft for the snap shot. When the shooter calls "Trigger down...snap, looked good / missed high / missed low," the target should evaluate the nose position of the shooter. The "Trigger down..." call should be made at the same time as the trigger squeeze. The "snap" call is made as the target passes through the HUD and is followed by the assessment of where the pipper actually was, as it passed the target. It is important for a timely "snap" call to be made so the target can make an appropriate evaluation of the shooter's nose position for future defensive maneuvers. Following the snap shot, both aircraft shall reverse the turn and adjust the pull to complete what resembles a shackle turn. You should strive to be back on the original PADS at the apex of the reversal. The shooter will then set the next pass.

On the maneuvering snapshots, the lead will call "Hammer 11, in target/shooter, maneuvering", followed by wing calling "Hammer 12, in target/shooter, maneuvering." During these passes, the target will attempt to maneuver out of plane in order to defeat the initial gun shot without subsequent maneuvers. The shooter will attempt to counter the defensive maneuver. After the gun defense and counter, both aircraft will maneuver cooperatively for the next pass. The flight shall attempt to work back to the original PADS, however, if the target cannot make it back to original altitude prior to turning back in, then the lead will call for an altitude reset and both aircraft will strive to achieve that altitude for the next pass motion.

Example

Lead: "Hammer 21 reset 13,000"

Wing: "Hammer 22 13,000"



SSD as THE SHOOTER

The snap shot is used when attacking at medium to high angles off in an attempt to achieve a quick kill. In order to achieve a valid snap there are three problems for the shooter to solve for.

1. PLANE OF MOTION
2. RANGE
3. LEAD

PLANE OF MOTION

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

RANGE

To solve range, tighten or ease your pull to have the Bandit filling $\frac{3}{4}$ to all of your pipper as "snap" is called (this indicates a 1,000 to 1,500' snap shot). If the shot looks like it will be long ease the pull to travel further down range then reset the pull. If you assess it to be close, tighten the pull to achieve your gun solution earlier. Some good gouge is that the Bandit's wingspan should fill about half of the pipper when he is at your canopy bow.

LEAD

A good rule of thumb for establishing Lead is to pull the trigger when the Bandit crosses the canopy bow and hold it down until he passes through your HUD. This will account for 1/3 second pilot reaction time, 1/3 second gun spool up time, 1/3 second bullet time of flight and allow the bullets to be at 1,000-1,500ft by the time the Bandit crosses your pipper. If the trigger is pulled too early, bullets will be wasted. If the trigger is pulled too late, bullets will fall aft of the Bandit. Therefore, in order to preserve ammunition a disciplined and well-timed trigger squeeze is imperative. That said, it's better to be a little early than late when pulling the trigger. Also, it is important to note that keeping the trigger down after the bandit passes through the HUD is also a waste of ammunition. A good rule of thumb is to release the trigger as you say "snap".

COUNTER TO A GUNS D

As the shooter you will need to react quickly to counter an effective guns D. Decide early then quickly roll to place the lift vector out in front and aggressively pull the pipper into the bandit's anticipated POM to establish the necessary lead. With over lead established pull the trigger and evaluate the shot.

SSD as THE TARGET

PLANE OF MOTION (performing the Guns Defense)

As the target during the maneuvering sets, we have two goals. First, we need to present the bandit with as little surface area as possible by placing our wingtip on the bandit, in effect, giving him a much smaller target. Second, we need to maneuver out of plane in a timely manner to deny his plane of motion solution.

TIMING

It is imperative we time our guns defense (Guns D) to defeat the shot. If we maneuver too late we will fly through the shooter's pipper and if we maneuver too early the shooter has time to counter our move and achieve a valid snap shot. As the target aircraft, we evaluated the shooters nose position during the "trigger down snap" call on the non-maneuvering sets. We will use this evaluation to time our Guns D. A good rule of thumb is to time the start of your Guns D just following the word "trigger".

Maneuvering

We have 3 basic maneuvers we can perform to defeat the impending gun shot.

1. Near wingtip on max performance pull –
 - a. Your only option when on the deck.
 - b. Quick to perform and easy to maintain sight. Allows for good aircraft displacement and good follow on BFM.
 - c. Maneuvering against gravity (i.e. "God's G").
 - d. Need some airspeed (energy) to displace aircraft
2. Near wingtip on bunt
 - a. Quick and may fake the shooter into going nose high. Easy to maintain sight. Little displacement out of aircraft and may accelerate further out in front i.e., poor follow on BFM.
 - b. Not an option when fighting on the deck.
3. Far wingtip on max performance pull –
 - a. Best aircraft displacement due to increased G available from gravity (i.e. "God's G").
 - b. May broadcast intentions.
 - c. Hard to maintain sight. Follow on BFM will not be as good as other options.
 - d. Not an option when fighting on the deck.

For the maneuvers that we are looking to max perform on, it is imperative that we pull to the lift limit. If we pull too hard (past lift limit) or too weak, we will not achieve maximum aircraft displacement. For the T-45, lift limit can be achieved by making a rumble of buffet pull.

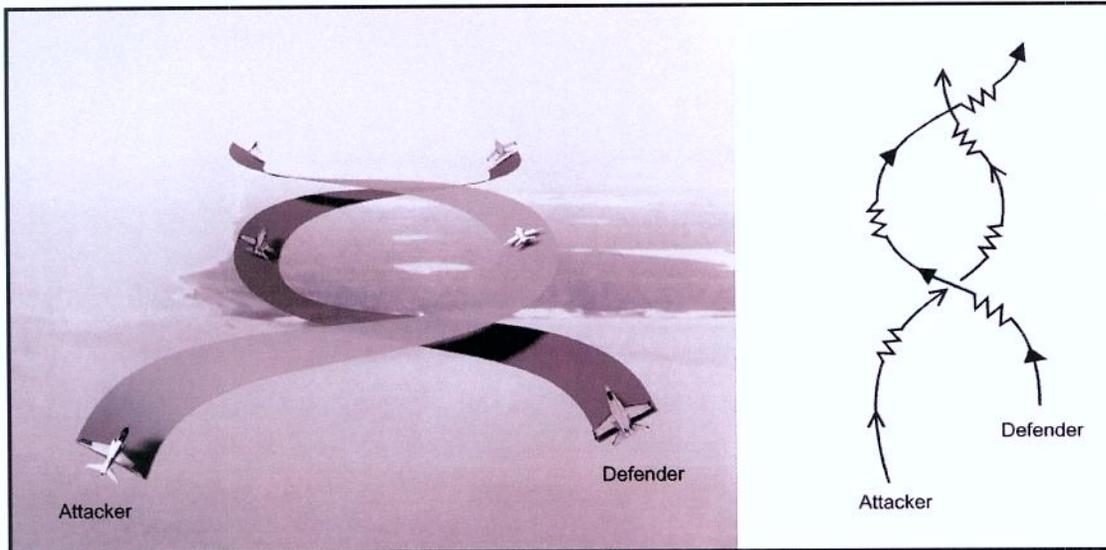
SAFETY

If it appears the shooter will violate the 500-ft bubble, either aircraft may call "Skip it". If a "Skip it" call is made, the shooter will de-conflict to the inside of the turn and low by overbanking and max performing his aircraft. The target will level the wings and go nose high. After a safe pass is affected, the maneuver may continue following the reversal unless a "Knock-it-off" is called.

If the shot will be inside of 1000-ft but further than 500-ft or if the shot is forward of the gun envelope, then the shooter may call "No shot, range" or "No shot, angles" respectively.

FLAT SCISSORS

- P - Abeam
- A - Deck plus 5,000ft
- D - 0.5nm
- S - 200kts



The horizontal or flat scissors is a slow-speed, high-AOA radius (one circle) fight where both fighters are attempting to minimize their turn radius and down range travel to achieve a positional advantage. A flat scissors typically results from an in-close overshoot. There are several reasons why fighters might overshoot and get into a flat scissors such as a delayed or poorly performed lag maneuver, following a Snap guns attempt, or follow-on flow from a rolling scissors (to name a few). The flats may also be entered from a high aspect merge where one fighter reverses to set one circle flow.

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

Kinetic energy (airspeed) is transferred to potential energy (altitude) by utilizing the vertical to aid in controlling your airspeed and downrange travel. Lift vector placement (typically placed aft of the bandit), airspeed/AOA control and reversal timing are the keys to success in scissor maneuvering. You must utilize all three in the proper combination to achieve success.

FLATS ENTRY

Lead will initiate the set by calling "3, 2, 1 Fight's On" and wing will respond with "Fight's On". On the "3" select MRT (both aircraft). On the "F" in lead's "Fights On" smoothly start a lift limit pull, then when you are **established in the pull** and flight path **deconfliction is established** (in the form of altitude separation) turn in towards the bandit (the bandit will delay turning in until the SNA aircraft turns). While in the pull trade your airspeed for altitude while the nose tracks up, then turn into the bandit thus minimizing turn radius and collapsing lateral separation. At a certain point you will no longer have the airspeed to continue the nose high pull. When this is the case you have two options to recover to a sustainable nose high position.

1. Over bank (roll past 90deg AOB) while maintaining the lift limit pull and get the nose tracking down, prior to 20 degrees nose up, roll upright to achieve 15-20 degrees nose up attitude at 130-150kts.
2. Push forward on the stick to get the nose down, and then reset back stick to achieve 15-20 degrees nose up at 130-150kts.

A good rule of thumb is arriving 40-50 nose high and 150-160kts begin your recovery maneuver.

FLATS MANEUVERING

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

REVERSAL TIMING

Time your reversals with the following criteria in mind.

- To work in phase (offensive), turn aft of the bandits 3/9 line and prior to flight path crossing.
- To work out of phase (defensive), reverse after bandit has crossed your extended six.
- If you notice a track crossing rate (line of sight rate), and you assess you are slower than the bandit you should turn a little early to deny lateral room and take advantage of your slower speed.

During your reversals utilize a small amount of rudder to turn towards the bandit and appropriate back stick to maintain optimum performance while monitoring your aircraft's attitude, airspeed, and AOA. Be cautious not to over control the jet. If you do, you can stall, the nose will drop causing you to accelerate and flush down range. If this happens relax back stick pressure get the wings underneath you and re-establish your pull working your nose up getting your airspeed under control, then reorient your lift vector as needed. Lift vector placement is more important the wider the fight becomes. As lateral separation decreases, precise airspeed control with an emphasis on generating the maximum amount of lift to minimize downrange travel becomes more of a priority. A good rule of thumb is: your airspeed over 100kts is max usable AOB (i.e., 130 kts ~ 30 degrees).

After maneuvering in the flats we will find ourselves eventually in an offensive or defensive position. We will summarize the positions in the following four situations with respect to energy and position.

1. Offensive

- a. Up and Aft. This is the most desirable. We are in an energy advantage in the form of altitude and a positional advantage behind the bandit's 3/9 line. Look to work just slightly out of phase (not letting the bandit hide under your nose) and assess weapons separation. With sufficient separation work your jet down to a weapons envelope using one of the following three methods.
 - i. Pulling beyond lift limit. This will increase drag and decrease lift, thus you will lose altitude without gaining airspeed. This is not desirable due to the T-45 being very difficult to control in this AOA regime and the possibilities of departing controlled flight or an engine compressor stall.
 - ii. Idle push over. Once you assess weapons separation, select idle/SBs and push the stick aggressively forward, then reset back stick prior to the nose coming on the bandit to prevent excessive altitude loss and airspeed increase. Select MRT and SBs in once you have the nose tracking up and work yourself back into your radius band. This technique is effective when desiring a quick shot. However it is difficult to time and you need a good amount of weapons separation due to gaining speed and flushing downrange.
 - iii. Reduce throttle and slowly work down utilizing precise AOA and airspeed control. This is most desirable, however you need to be patient and keep flying your best jet.
- b. Down and Aft. Attempt to work in phase by performing early turns (prior to flight path crossing). When the bandit reverses ease your pull momentarily to gain 20-30kts then use this extra energy to work your nose up into a weapons envelope. To be able to get the nose up to the bandit you will need to use less AOB with the wings underneath you to work the nose up and achieve a valid weapons solution.

2. Defensive

- a. Up and Forward. Work to get out of phase and if you sense the bandit is working into a weapons envelope look to redefine.
- b. Down and Forward. Continue to work out of phase and try to set up a high aspect pass to a bug. If the bandit has a good amount of nose to tail separation, look to redefine into a two-circle fight.

Redefining 2 circle out of the flats

If the bandit is able to flush you out in front to the point where he can take snap shots, it is time to get out of the flat scissors and redefine two circle (remember, two valid snapshots equals a kill). After a guns D, execute a ditch or positional deck transition if you do not have sufficient altitude to execute the ditch. This is NOT a bug out, so DO NOT level your wings. Once on the deck assess the fight and execute your best defensive game plan. For a discussion on ditches or positional deck transitions refer to the defensive BFM perch sets discussion.

Learning Objectives (emphasis) for the Flats.

- PADS fight set up
- 100% Training Rules Adherence
- AOA / airspeed control
- Lift vector placement
- Recognition of offensive / defensive position
- Reversal timing execution
- Shot opportunity recognition / mechanics
- Guns D recognition / mechanics
- Fight redefinition

ROLLING SCISSORS

- P Abeam
- A – Deck plus 6,000ft
- D - .5nm
- S - 200kts

The rolling scissors (Figure 1-16) results from an in-close overshoot where the pilot attempts to stop his down range travel by pitching up into the vertical without sufficient energy to execute a pure loop. The resulting fight is a series of vertical and horizontal overshoots where both pilots attempt to maximize their turn rate and minimize their turn radius in order to gain a positional advantage.

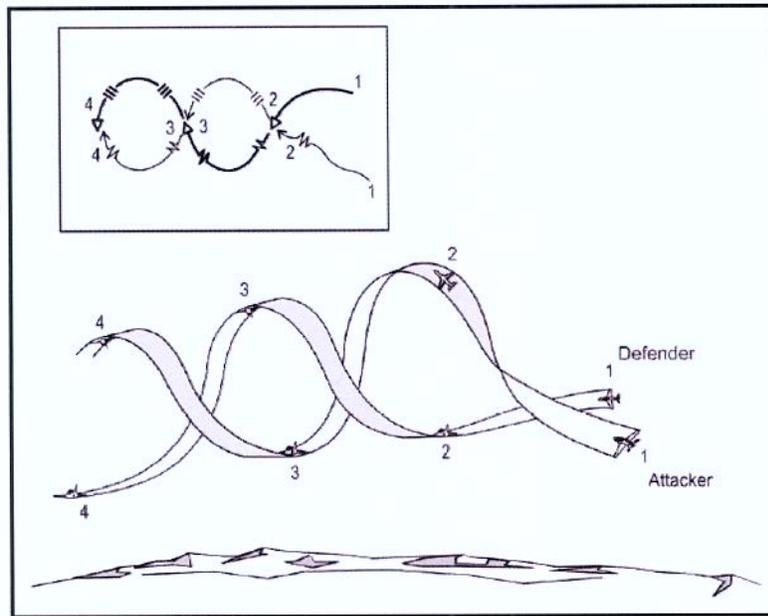


Figure 1-16 Rolling Scissors

ROLLER ENTRY

The lead will initiate the maneuver by calling "Hammers check R/L 45" (a check turn into the lead to establish wing on the 45deg bearing line). Once established on the 45deg bearing line, the lead will call "Bandit Going Up". The lead will maneuver to arrive over the top of the fighter, and then call "Fights On" with the Fighter echoing "Fights On".

ROLLER MANEUVERING

When lead calls "Bandit going up" select MRT. At the "Fights On" call, perform a nibble of buffet wings level pull to force a vertical overshoot. As you force the vertical overshoot roll to place lift vector over the top of the bandit, maneuvering your aircraft to force a 3/9 line overshoot. Be sure to keep your nose tracking above the horizon to preserve turning room (altitude above the bandit). At 3/9-line passage or prior to the bandit getting vertical airspeed, perform a pirouette maneuver by reducing the throttle to idle, unload then input full bottom rudder. Once the nose starts slicing down, input lateral stick to quickly roll the aircraft neutralizing the controls 10 degrees prior to the desired lift vector placement. Then reprogram in back stick to a nibble of buffet pull and fine-tune the lift vector placement. Place the lift vector on to slightly behind when following the bandit across the bottom, maintaining a nibble of buffet pull. Your airspeed should be enough to force a vertical overshoot but not so much as to flush down range (approximately 200-230kts) at the bottom. If you are slow, power up earlier and if you are fast delay to achieve the proper airspeed. As the bandit transitions above the horizon, asses lateral and vertical separation. With more vertical separation look to get your nose up, with more lateral separation look to collapse the fight by turning more level across the top. If you are becoming offensive with a positional

advantage, then at the pirouette, put your LV in front of the Bandit, pulling lead to align fuselages and possibly gain a shot opportunity. However if you do this, you must watch out for pulling too much lead and giving up your positional advantage. A good way to conceptualize lift vector placement is to place your lift vector on the bandit and vary it aft if you want to preserve/gain turning room, and vary it in front if you want to intimidate the bandit or take a shot. A key determinant in winning the roller is to strive to get your nose up when you are at the bottom before the Bandit can get his nose down when he is at the top, and vice versa. If you can continually do this without sacrificing your position, you are then gaining the advantage you need to win in a rolling scissors. At a certain point one aircraft will gain enough advantage to pull for a shot or the roller will be redefined.

Redefining the Roller

OFFENSIVE/NEUTRAL

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

Option 1: Place your lift vector so as not to get as nose low. This option will allow you to perform a roller iteration where maybe your opponent cannot. To do this you most likely will be placing your lift vector in front of the bandit. In doing this, you are pulling lead and are giving up turning room. So consider this option when you have sufficient nose to tail separation (i.e. offensive).

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

SLIGHTLY DEFENSIVE (<30deg)

If you are slightly defensive and feel that staying in the roller or redefining into the flats is not prudent look to bug. Look to bug out of the top of the roller with the bandit near the deck and his nose coming up. With the bandit on or near the deck he will have to perform a more level bug follow and not add airspeed as quickly. Pull to create as many angles as possible and use the vertical room above the bandit to bug out the 6 o'clock. In other words, instead of getting the nose above the horizon and doing a pirouette at the top of the roller, pull level across the horizon to slightly nose low in order to place your lift vector on the bandit as he comes through the bottom of the roller. By immediately putting the lift vector on the bandit, you are setting yourself up for a close aboard pass taking away turning room in order to give yourself the best chance for a successful bug. After the close aboard pass achieve 30-40deg nose down (altitude permitting) initially unloading; **keep sight** of the bandit until you are assured of a good bug.

DEFENSIVE (>30deg)

If you are defensive you are effectively in a two-circle fight. Execute your best two-circle defensive game plan. (Discussed later in perch BFM)

Radial G affects your "sight picture" of being offensive, neutral, or defensive at various points in the maneuver. You will experience several optical illusions. At the top, your slower airspeed and radial g give you a smaller turn radius, while your greater airspeed at the bottom causes a larger turn radius. As a result, relative position of the aircraft alone does not determine actual advantage.

If you are neutral with respect to the Bandit, at the bottom you are slightly ahead of the Bandit, while at the top you are slightly behind him.

Learning Objectives (emphasis) for the roller

- PADS fight set up
- 100% adherence to training rules
- Lift vector placement
- AOA / airspeed control
- Flight path projection
- Fight redefinition

Perch Sets

First we will take a look at offensive perch BFM then we will later discuss defensive perch BFM. Perch BFM is partial task training to practice offensive and defensive BFM with respect to aircraft's location to the bubble. As described in the concepts and definitions chapter we know the average turn radius of the T-45 is 3,000 feet with a bubble of 6,000ft in diameter. Thus, the 6k starts at the bubble, and the 9k set outside the bubble.

Note: You also need to understand that just because we are in a two-circle fight does not mean we are in a pure rate fight. The less neutral the fight the more it is a war of energy excursions, misaligned turn circles and angles. As the fight gets more towards neutral, it becomes a true rate war.

Offensive Perch

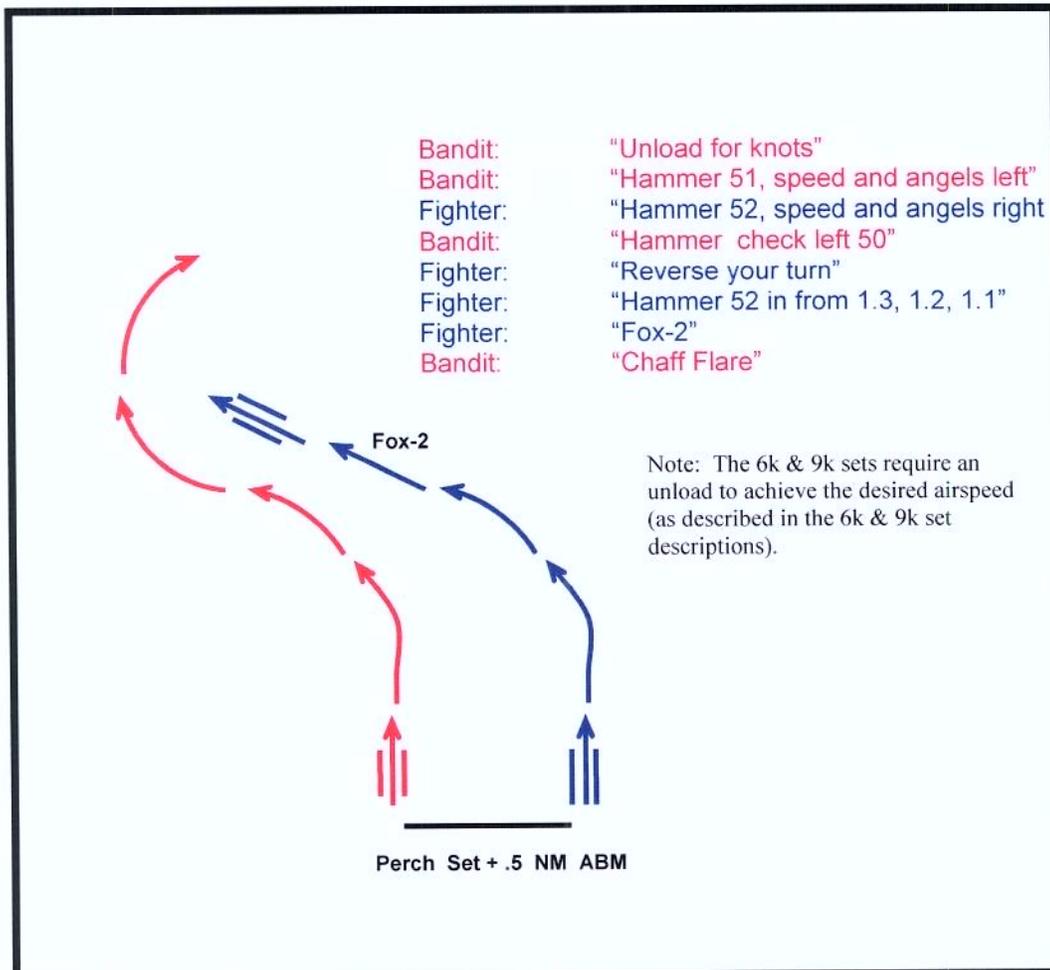
EXECUTION

Offensive Perch Entry

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

After a "Speed and Angels" call from both aircraft, lead will check the flight 50deg away from the fighter. The fighter will turn toward the bandit and direct a "reverse" when the bandit is at the fighters canopy bow. The fighter will reverse the turn and fly a pure pursuit curve maintaining airspeed and altitude. The Fighter will call "CS in from X.X" and count down the ranges in tenths of miles concurrently directing the bandit to "tighten/ease your turn" to maintain 40° AOT. At the desired range, the Fighter will call "Fox-2."

PERCH SET UP - OFFENSIVE



At the "Fox-2" call, select MRT and unload to the bandit's point of departure. A good technique is to use a geo-reference point to drive to bandit's departure point (a cloud, ground ref etc.) When aspect stops changing and the LOS rate explodes, you are inside the bubble at the Attack Window. You need to execute an Offensive Break Turn (OBT). Roll to place the lift vector on to slightly below and max perform to stabilize the bandit in your canopy. Analyze the Attack Window Entry (AWE) and subsequent defender maneuvering

- If you are early to the AW, it will be easy to pull the defender forward on your canopy, possibly to your HUD. Use a lag maneuver to prevent an in close overshoot. You can ease your pull or roll 45° up and out of plane momentarily then re-establish your pull or reorient your lift vector back on. An early correction normally results in a slight flight path overshoot similar to a slightly late entry.
- If late, to the AW, you will be unable to stabilize the bandit on your canopy while max performing. In this case, keep the pressure on the bandit with your lift vector on and maintain the pull to arrive in the rate band. Utilize a capture pull (G to maintain airspeed) once in the rate band. Now it is time to be patient and wait for misaligned turn circles. Keep in mind the later you AWE, the more neutral the fight and thus we are engaged in more of a rate war.
- With a "nailed" attack window entry and a properly executed OBT you will be able to stabilize the bandit on your canopy, with only a small amount of movement aft (i.e. slight flight path crossing)

The bandit will slide aft on your canopy slightly during the flight path overshoot due to misaligned turn circles. Be patient and do not bleed excessively. After the flight path overshoot the bandit will stabilize on your canopy then start to move forward. This is the time to perform an energy excursion with lift vector on and nibble of buffet pull, trading airspeed for nose position. If the bandit is smart, he/she will recognize your nose coming on and perform a defensive energy excursion. If the bandit is unable to counter your nose coming on due to a low energy state, he/she will perform a nose low maneuver to make use of potential energy in the form of altitude.

REDEFINITION FOLLOW

When the defender assesses your nose becoming a threat he/she will perform a nose low ditch maneuver. By maneuvering nose low the bandit is attempting to create angles and hold your nose in lag. Look to counter this by driving to the bandit's point of departure and aggressively maneuvering nose low adjusting your lift vector to align fuselages. When the deck becomes a factor, use the deck transition rule of thumb to prevent busting the deck. During this nose low fight, if range or closure becomes a factor, modulate the throttle or reorient the lift vector to aid in controlling closure. Make sure you have turning room above the deck to follow the bandit. If you or the bandit do not have the altitude to perform a pure nose low maneuver you need to maneuver in the oblique (positional or energy rate deck transition). Adjust your lift vector off of the vertical just enough to prevent busting the deck. Utilize the deck transition rule of thumb to aid you on the deck transition. You will learn more about the deck transition options in the discussion of defensive maneuvering. The main thing is you need to maneuver aggressively and timely to counter the bandit's nose low maneuver.

ON THE DECK

Arriving on the deck, AON will increase due to the fuselage misalignment. The more the fuselages are misaligned the more AON will be created. Be patient with your pull, using G to maintain airspeed on the deck until you identify a shot opportunity. The shot opportunity will come immediately following the deck transition with a small amount of fuselage misalignment or if the bandit did not perform a proper deck transition. With a properly performed deck transition or higher fuselage misalignment, the shot opportunity most likely will come in the form of misaligned turn circles and a timely energy excursion. The best way to recognize misaligned turn circles is to reference the bandit's position off your canopy. If the bandit is moving forward then misaligned turn circles are working for you. If the bandit is moving aft then you will have to wait until the geometry works for you. The time to start your energy excursion is as soon as the bandit STARTS to move forward on your canopy. Assess weapons separation; put your lift vector on and perform a lift limit pull. Employ the appropriate weapon and **immediately** lag off momentarily to maneuver back to the control zone then adjust your G to preserve airspeed and look for another shot opportunity. Do not bleed your airspeed without reason to do so!

The overall objective is to arrive in the control zone with range, angles, and closure under control. Take shots of opportunity and then apply follow on BFM (i.e. a lag back to the control zone) to maintain your offensive advantage.

Learning Objectives (emphasis) Offensive perch sets

- PADS / Fight set up
- 100% adherence to training rules
- AWE recognition / timing
- Offensive Break turn mechanics
- Energy management
- Fight redefinition recognition / follow
- LAR / Shot opportunity recognition
- Valid shots

6,000-FT OFFENSIVE PERCH SET (6K O)

- P - Abeam
- A - Deck plus 6,000ft
- D - 1.5 nm
- S - 350kts

To achieve the 350kts we will perform an unload for the extra 50kts. Climb to PADS altitude + 1,000ft at 300kts abeam lead. Lead will then call "unload for knots", select MRT and unload to 5 deg nose low. Adjust the throttle to maintain abeam and arrive at PADS altitude and 350kts. At this point the flight lead will initiate the Speed and Angels call.

The 6k"O" set positions you on the bandits bubble. So a small amount of angles will be generated by the bandit while you extend to the AW. Weapons selection should be the AIM-9. During this set if you nailed your AWE and performed an effective OBT you should have a small flight path overshoot in the control zone. Following the overshoot, expect misaligned turn circles to work in your favor and either pull for a shot or follow the bandit through the deck transition. If a shot opportunity is not immediately available, utilize G to maintain airspeed and look for misaligned turn circles for an employment opportunity.

9,000-FT OFFENSIVE PERCH SET (9K O)

- P - Abeam
- A - Deck plus 6,000ft
- D - 2.0 nm
- S - 400kts

To achieve the 400kts we will perform an unload for the extra 100kts. Climb to PADS altitude + 2,000ft at 300kts abeam lead. Lead will then call "unload for knots", select MRT and unload to 7 deg nose low. Keeping lead on the horizon, adjust the throttle to maintain abeam and arrive PADS altitude at 400kts. At this point the flight lead will initiate the Speed and Angeles call. The remainder of the set is similar to the 6k set.

The 9k"O" set positions you outside the bandits bubble. While you are outside the bubble the bandit will be able to generate angles in his break turn and you will see more target aspect change prior to LOS rate explosion. Also, due to the range and misaligned turn circles, you will have two bubble entries, with the second entry occurring at approximately 6,000ft (1.0nm). Weapons selection should be the AIM-9. At 400kts you are close to corner airspeed, so care must be taken not to overstress the aircraft. Perform a smooth pull to target a lift limit pull during the OBT. With a nailed AWE, expect a flight path overshoot of the control zone with medium angle off nose. Following the overshoot, you should be arriving at the second bubble entry at approximately 1.0nm. From this point the fight is similar to the 6k set, with the exception of greater AON. The resulting fight is more of a rate fight due to the larger AON. Due to this

you must ensure you are in your rate band and time your energy excursions with misaligned turn circles to take valid shots.

CONCLUSION

Offensive BFM is all about solving the 3 BFM problems of range, angles and closure. You must perform a timely well executed offensive break turn, utilize proper redefinition follow on mechanics, and intelligently perform an energy excursion to kill the bandit in a timely manner. This takes solid knowledge of the concepts, sound execution, and aggressiveness.

DEFENSIVE BFM

Defensive Objectives

1. Defeat initial weapons employment
2. Maneuver to deny follow on WEZ
3. Neutralize
4. Transition to HA BFM

The concepts that we learned in OBFM also apply to DBFM. The difference is that we need to assess the BFM cues while looking over our shoulder and look to create the same problems for the offender that we were attempting to solve in offensive BFM. That is to say, in DBFM we are looking to create range, angle, and closure problems for the bandit. The better we can do this, the more successful we will be at achieving our DBFM objectives.

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

YOU MUST MAINTAIN SIGHT!

There is a saying in the strike fighter community that says, "lose sight, lose the fight". This concept cannot be overemphasized. If you lose sight of the bandit, you will get shot.

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

1. KEEP SIGHT / REGAIN SIGHT - You cannot fight what you cannot see. You will lose sight at times, however, think about the geometry of the fight and bias where you think the bandit should be. Be ready to execute the "Lost Sight Game plan" found later in this section.
2. MAX PERFORM THE AIRCRAFT – Don't just float your turn and become a target.
3. AVOID THE DECK - This was a challenge during your offensive BFM training, but it's now more difficult due to the increased time you will be looking over your shoulder. A rapid inside-outside scan is necessary. Being able to fly close to the deck gives the Bandit less turning room to convert to angles.

Above all: No matter how dire the situation may seem, NEVER GIVE UP!

Defensive Axioms

1. Survive
 - a. Deny sensor nose
 - b. Defeat shots; Missiles and Guns
2. Attacker moving forward on canopy = Keep pulling
3. TA decreasing = Increase pull to hold attackers nose off
4. Redefine if unable to perform steps 2&3

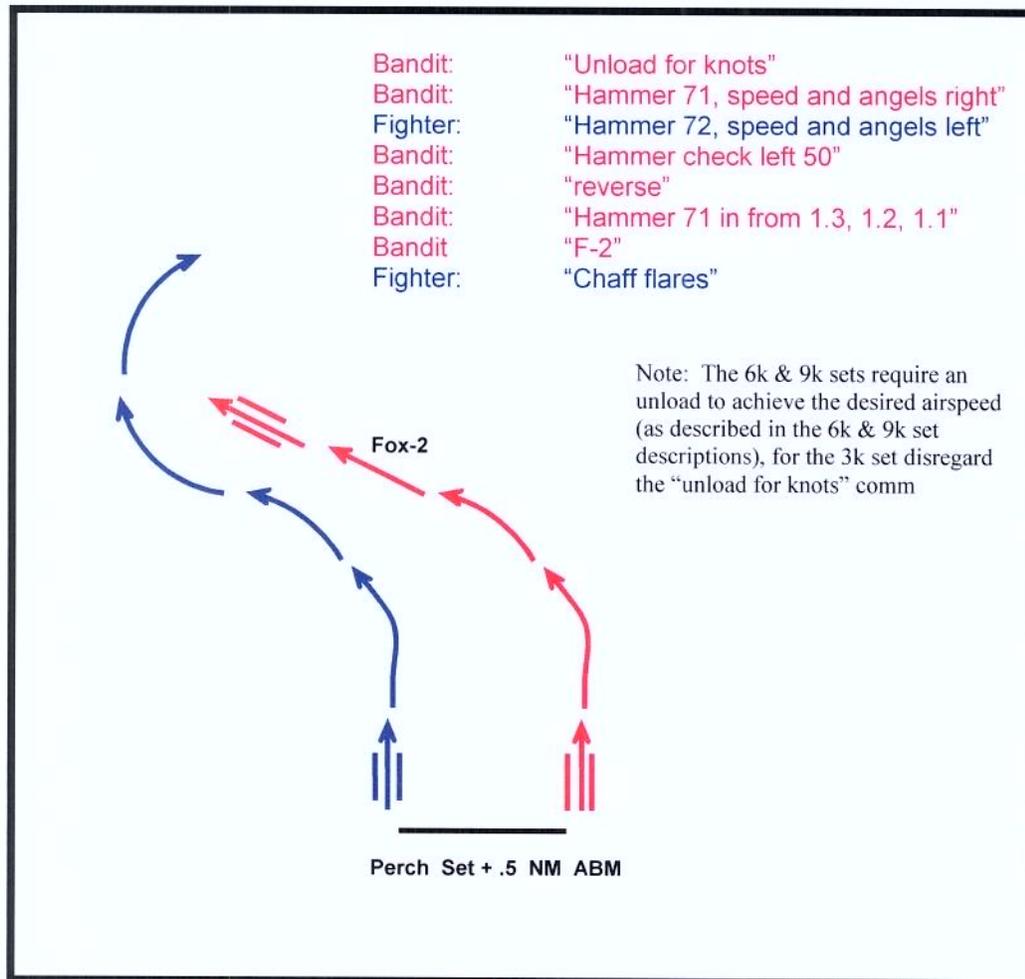
Now we will take a look at defensive perch BFM. The sets are the same as the offensive perch sets with the roles being reversed.

EXECUTION

Defensive Perch Entry

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

After a "Speed and Angels" call from both aircraft, lead will check the flight 50 deg into the fighter. The bandit will direct the fighter to "reverse". The fighter will reverse the turn and maintain airspeed and altitude pulling the bandit to 40 AOT. The bandit will call "CS in from X.X" and count down the ranges in tenths of miles concurrently directing the fighter to "tighten/ease your turn" to maintain 40° AOT. At the prescribed range the bandit will call "F-2."



PERCH SET UP - DEFENSIVE

At the "F-2" call, select MRT, roll to place your lift vector on to slightly below the bandit and perform a lift or G limit pull. Assess the bandit's attack window entry.

- Early AWE (or pure/lead pursuit), the bandit will appear to be nose on and you will be able to hold the bandit stationary or pull him forward on your canopy. If the bandit does not maneuver to fix the early AWE, this is good; you are creating angles and closure problems, keep max performing down to gun range. When you assess the bandit has closed into gun range perform an appropriate Guns-D. Then reorient your lift vector back into the bandit looking to force an in

close overshoot. If the bandit gets too greedy, you will force an in close overshoot and should now apply your reversal game plan. If the bandit prevents the overshoot by an OOPL nose high maneuver you have two options

- If you have vertical airspeed match the bandit nose high, to collapse the range.
- If you don't have airspeed to counter nose high, continue in the current turn, 5-10deg nose low and execute follow on DBFM looking for opportunities to ease and regain energy.
- Late AWE (or Lag), you will be able to create greater fuselage misalignment and thus increase your time to live. Maintain your max performance pull down to the tactical rate band creating the most amounts of angles possible. Assess AOT and TA.
 - If high AOT (more toward your abeam position) with high TA, fight your best HA rate war.
 - If low AOT and high TA the bandit will still be able to benefit from MATC. The bandit will have a flight path overshoot. How much TA exists at flight path crossing will determine severity of MATC. During the overshoot the bandit may disappear behind your 6 o'clock. If the bandit still has a high amount of TA, then pull G to maintain your airspeed in the rate band. If the bandit has a low amount of TA, then execute a max performance pull. When the bandit reappears at your aft visual limit, MATC is working for him/her. If TA is decreasing, perform a second DBT; if able to hold the bandit in lag, continue the DBT. If unable to keep the bandit in lag redefine.
- Nailed AWE (slight lag), you will only be able to pull the bandit forward while he/she is outside the bubble. The bandit will have a small flight path overshoot in or aft of the control zone. When the bandit reappears and TA is decreasing redefine.

REDEFINITION DITCH

When unable to pull the bandit forward on your canopy (i.e. create angles) and the bandit's TA is decreasing you need to redefine. Ensure you have enough altitude to perform a pure nose low maneuver (generally 6,000ft).

- Perform a DBT to collapse the range and create the most amount of angles as possible. It is optimum to have the airspeed below 270kts.
- Roll to place the lift vector underneath the bandit while inputting rudder to create the most amount of angles possible. If the bandit is unable to follow the maneuver you have created angles that he/she will not be able to get back.
- As your nose comes up to the horizon, turn into the bandit to create a closure problem. If you have lost sight, turn in the same direction you just performed the first ditch.
- If the bandit performed a good follow, you will need to perform another ditch if you have the altitude. Utilize the procedures stated above turning in the same direction. Once you assess you don't have the altitude to perform a pure nose low maneuver you will need to perform a deck transition.

DECK TRANSITIONS

If you do not have the altitude above the deck to perform a pure nose low maneuver (i.e. ditch) you will have to perform in the oblique to prevent busting through the deck. First we need to assess the amount of fuselage misalignment (When arriving on the deck fuselage misalignment translates into greater AOT) that exists.

- With high fuselage misalignment perform an Energy Rate Deck transition. This maneuver trades altitude for airspeed to ensure we arrive on the deck within our rate band. Adjust lift vector and pull to arrive on the deck within the rate band concurrently not sacrificing angles so that we become more defensive. Usually 30-40deg nose low is a good rule of thumb to achieve a good energy rate deck transition.
- With low fuselage misalignment perform a Positional Deck transition. Roll to place the lift vector as nose low as possible without busting the deck. Utilize a lift limit pull with the objective of creating angles without initial regard to airspeed. Usually 50-60deg nose low is a good rule of thumb to achieve a good positional deck transition if you have less than 6,000ft of available altitude.

ARRIVING ON THE DECK

As you arrive on the deck, you will need to assess the fight. If High Aspect (HA), apply your HA game plan (discussed later). If still defensive, and the bandit's TA continues to decrease then perform a DBT attempting to hold him in lag. Hold the DBT until the bandit closes within guns range, and then perform a Guns D. Following the Guns-D, reorient your lift vector back into the bandit (above the bandit would work best for follow on BFM) and look to force an in-close overshoot. If the bandit does not counter properly, an overshoot will occur. With reversal criteria met (outlined below), perform a reversal and fight your best one circle game plan. If the bandit does not meet reversal criteria maintain the current direction of turn utilizing any altitude above the deck. Perform another guns D and defend to survive as long as possible.

REVERSING

Criteria (all three criteria must be met)

1. < 2,000ft (Inside the Control Zone)
2. Pass extended six with high LOS.
3. Visualize reversing inside bandits turn radius.
- 4.

Once the criteria have been met, perform an unloaded roll placing the lift vector on to slightly higher than the bandits projected flight path. Then perform a lift limit pull trading airspeed for angles and altitude to transition to scissor maneuvering.

IF EVER IN DOUBT, DO NOT REVERSE

SEPERATION/BUG

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

Bug criteria

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

Bug mechanics

1. MRT
2. 40-50° NOSE LOW (altitude dependant)
3. UNLOAD – After pulling to the Bandit's extended 6 o'clock in the nose down attitude unload to zero G. Don't look at the HUD to check your G's, just unload until you feel light in the seat. (Note the unload can occur at any nose position and AOB)
4. KEEP SIGHT – Roll to insure the wings are not in line of sight of the bandit. As the bandit moves to your aft visual limit perform a check turn to keep the bandit off your six.
5. CHECK TURN – Check turn 20°-30° away from the bandits' nose, then unload again. Check turn no more than two times in order to maximize your separation from the Bandit.
6. ASSESS BUG – If you look over your shoulder and the Bandit is inside 1.0nm, with less than 90deg of turn remaining, you will not escape. If greater than 1.0nm or with more than 90deg of turn remaining, you should be outside of his weapons envelope while running away to fight another day!

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

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

RULE OF TWOS

By quickly calculating the opening velocity between aircraft and adding that to your range from the Bandit, you can determine the success or failure of the bug attempt. If you reach 2.0 or greater, you've successfully bugged and would kinematically defeat a missile launch. In this event, you can expect to hear a KIO call from the Bandit or your IP. If 1.9 or less, execute a defensive break turn into the Bandit while calling "chaff, flares" and continue fighting. If A/A DME (yardstick) is inoperative, begin honing your eyeball calibration skills. If the math eludes you and you're unable to determine if the bug was successful, you will need to assume the bug was unsuccessful. See the below chart for further explanation.

A few examples of good bugs:

YOUR A/S	DME (RANGE)	BANDIT'S A/S	RESULT
390	1.1	300	2.0
410	0.8	290	2.0
400	0.5	250	2.0

Unsuccessful bugs:

YOUR A/S	DME (RANGE)	BANDIT'S A/S	RESULT
390	1.1	310	1.9
410	0.7	290	1.9
390	0.5	250	1.9

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

LOST SIGHT GAMEPLAN

You may have an idea of where the Bandit was; max perform the jet in that direction. As you do this, it will make a weapons solution for the Bandit more difficult.

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

With significant altitude above the deck, execute a Positional Deck Transition. Basically, pick a direction and max perform nose low to the deck. Keep the direction that you are turning when you lose sight, this is usually a good bet as reversing your turn typically helps the bandit gain a weapons solution. Scan for the Bandit from your aft visibility limit then forward to the wing line in the direction of the turn.

If lost sight while on the bug, you must check turn at least one clock code, or 30°, in order to flush the Bandit out from your 6 o'clock. If still no-joy, break back into the fight (best guess direction that breaks you into the Bandit).

6,000-FT DEFENSIVE PERCH SET (6K D)

- P - Abeam
- A – Deck plus 6,000ft
- D - 1.5 nm
- S - 350kts

The 6K "D" set positions the bandit on your bubble. During your DBT you will be able to generate angles as the bandit extends to the AW. You are attempting to create an angular and closure problem. The bandit is near a missile WEZ, so attempt to collapse the fight down inside missile min range. If the bandit nails the AWE there will be a small control zone overshoot. When unable to pull the bandit forward and you observe decreasing TA, redefine.

9,000-FT DEFENSIVE PERCH SET (9K D)

- P - Abeam
- A – Deck plus 6,000ft
- D - 2.0 nm
- S - 400kts

The 9k"D" set positions the bandit outside the bubble. While the bandit is outside the bubble you will be able to generate angles. Continue the maximum performance pull **as long as you are pulling the bandit forward on your canopy**. With a nailed AWE the bandit should have a flight path overshoot at or beyond the far side of the control zone, with significant TA. Following the flight path overshoot the bandit will have a second bubble entry. From that point the discussion is similar to the 6kD.

Note: To max perform the jet at 400kts you will generate up to 7.0G's. Care should be taken to "set" your head prior to inducing such high G's. After the airspeed bleeds off and the G load decreases you will be able to move your head with reduced possibility of neck/back injury.

Learning Objectives (emphasis) Defensive perch sets

- PADS / Fight set up
- 100% adherence to training rules
- Defensive Break Turn mechanics (lift vector placement)
- AWE timing recognition
- Sensor nose recognition
- Fight redefinition selection / mechanics
 - Ditch
 - Positional
 - Energy Rate
- Deck transition
- Energy management
- Reversal criteria recognition

CONCLUSION

Defensive BFM is extremely difficult. However, a solid understanding of the aircraft and BFM should give you the tools you need to survive. This section has described many techniques to try 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, or perhaps disengage and live to fight another day.

HIGH ASPECT BFM

If we referred to perch BFM as the science, High Aspect BFM is the art of 1v1. It takes time, patience, and continuous assessment of angles and energy to become successful. The basics of LV placement, energy management and controlling merges will aid you in molding your piece of art. However, no matter how well we execute those basics the fight will quickly transition to offensive or defensive BFM in which you can then apply the principals discussed earlier to kill the bandit or live to fight another day.

HA Objectives (in order)

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

HA Basics (tools to become successful)

1. LV placement
2. Airspeed excursions (energy management)
3. Controlling merges

In order to achieve our objectives we need to properly utilize the basics, the question is how. Below we will discuss these foundational concepts to become successful.

LIFT VECTOR PLACEMENT

Generally you can utilize lift vector on and pull tactics. From that starting point adjust the lift vector to achieve the desired affects to range, angles and closure.

1. Lead = Collapse range, decrease angles, increase closure
2. Pure = Utilized for WEAPONS EMPLOYMENT, with byproducts of collapsing range, increasing closure.
3. Lag = Preserve range, control closure

ENERGY MANAGEMENT

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

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

AIRSPEED EXCURSIONS

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

1. Deny a shot
2. Take a shot
3. Create turning room
4. Deny turning room

CONTROLLING MERGES

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

1. Altitude. Look to utilize altitude to your advantage. If the fight is near the deck and you are low the bandit has the inability to commit nose low. So the altitude is turning room for you. If up high and slow it is best to arrive at the merge stacked high which will yield an energy advantage to you.
2. Energy. Not only know your energy state (airspeed) but also utilizing the BFM cues, assess the bandits. Does the bandit have vertical airspeed and you don't? Do you have the ability to fight 1 circle (i.e. 400kts in plane 1 circle fight would yield bad results for you)
3. Geometry. Angles equal a BFM advantage so look to take advantage of any angles you might have at the merge.
4. Turning room. Turning room belongs to whoever takes it. If you assess turning room, turn to take it out which will yield an angular advantage to you at the merge.
5. Lead turn. As LOS rates take off max perform across the tail to create a flight path crossing in the control zone. This also will take out turning room (the 500' safety bubble that existed for training) and make it easier to see the bandit post merge.

INITIATING FLOWS

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

1. IN PLANE (<45)
 - a. In plane one circle. For this flow insure you have enough energy to counter a pure nose high maneuver, but not so much airspeed that when you set one circle flow you will be unable to perform a lift limit pull and thus flush out in front of the bandit. Utilize a combination of lift vector placement and an energy excursion to attempt to tighten your turn radius inside the bandit. A good rule of thumb is to hit the merge with tactical vertical airspeed.
 - b. In plane two circle. It is best to be at corner airspeed. If you have an airspeed advantage at the merge you will be able to create angles and turning room in the form of an energy excursion. If the bandit reverses one circle and you assess that you will lose the resulting in plane one circle fight, counter with an OOPL nose low or high maneuver. Refer to the discussion below for your best two circle OOPL fight.
2. OUT OF PLANE (>45)
 - a. OOPL one circle. Out of plane one circle will result in one aircraft nose high and the other nose low. (The below discussion describes the fighters actions with the bandit OOPL i.e opposite)
 - i. Nose Low, this flow is optimum to force a low to high merge. Continue with your current direction of turn. Utilizing a nose low (approximately 40°) nibble of buffet turn to maintain energy on the jet and maximize turn rate. You need to maintain enough energy that you can pitch up to the next merge. Prior to 90 TA place the lift vector slightly below the bandit and pitch up into the fight. By placing the lift vector below the bandit you are attempting to make the merge more vertical.
 - ii. Nose High. Maintain a lift limit pull in order to tighten your turn circle inside the nose low bandit. If you assess the bandit does not have the energy to come up to meet you, unload above the bandit to create exclusive use turning room. If you assess the bandit can come up to meet you, keep your pull on and get the nose below the bandit in order to flatten out the merge, but make sure you adjust nose position to meet the next merge. Assess your airspeed at the merge and whether the bandit is attempting an early turn.
 - b. OOPL two circle
 - i. Nose low. It is best to be at corner airspeed. In most cases performing nose low will be your best two circle flow. (airspeed altitude dependant) Max perform across the bandits tail then overbank nose low. This does two

things for you, allows you to trade altitude for turn performance and achieves out of plane maneuvering. The amount of nose low is dependent on airspeed and altitude. Utilize a nibble of buffet pull, if you are above your rate band maintain more level to bleed your airspeed and preserve altitude. When approaching your rate band commit nose low to maintain your airspeed in the rate band. As the bandit pitches down to meet you, adjust lift vector to make the next merge happen.

- ii. Nose High. To initiate this flow you will need excessive airspeed above rate, upwards of 370+. Max perform across the bandits tail oblique nose high, you will be trading airspeed for altitude. When your airspeed bleeds down to the rate band overbank to maintain your airspeed and pitch down to meet the next merge.

UNIQUE MERGES

1. Merges with a significant vertical component (>45deg)
 - a. Low to High merges. This is a desirable merge. You should attempt to make this merge as steep as possible by placing your lift vector underneath when pitching up into the fight. Ensure you have tactical vertical airspeed and execute an early turn PRIOR to the merge. Time your turn to be nose on the horizon when the bandit passes through the horizon. If the bandit attempts to counter the early turn by pitching into the vertical prior to your early turn, look to extend momentarily in the vertical to deny the bandit exclusive use turning room.
 - b. High to Low merges. Although less desirable there are steps you can take to preserve your advantage. Attempt to shallow out the merge (early) by placing the lift vector or nose below the bandit then start pitching up to make the merge happen. The earlier you can execute this the more you can shallow out the merge. If the merge still has a substantial vertical component and the bandit executes an early turn, counter by performing a lift limit pull as soon as you recognize the early turn. This will collapse weapons separation. If you see the bandit extending in the vertical unload for vertical airspeed and attempt a pure nose high maneuver. You might not be able to go pure nose high, but the more vertical your maneuver the better the subsequent merge will be.
2. Slow speed merges.

You want to delay executing a pure nose low maneuver due to the shifting of the post and increase in turning radius (pg 13). If you go nose low right away you are affectively performing an in close overshoot pure nose low. Instead pull across the horizon with the lift vector on to slightly below the horizon, if the bandit commits nose down wait until LOS accelerates then roll to place lift vector in front and perform an aggressive nose low lift limit pull.

GAME-PLAN

You should enter every fight with a game plan. Look to exploit the weaknesses of your adversary and capitalize on your strengths. Going in with the game plan "I am going to shoot the bandit first", while admirable, it is lacking in foundation and basic execution. Think of it more as "I am looking to force 2 circle flow and fight a reactive conservative pressure fight" This gives you an idea of your desired initial energy package, how you would like to set up the merge, the flow, and your reactions based off the bandits maneuvers. Finally, strive to think one merge ahead; this will let you know what to do with the jet NOW.

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

Note: For the below discussion we will consider the maneuvers pure nose high/low/level.

1. FTR NOSE HI

a. VS. BANDIT NOSE HI: This is essentially a once circle fight in the vertical. The pilot that properly assess the situation (i.e other aircrafts energy state and nose position) and adjusts his/her pull accordingly should have a slight advantage at the follow on merge. Look to max perform using a nibble of performance pull. If you do not have an employment opportunity look to extend in the vertical; collapse the fight just enough to deny weapons employment then momentarily unload with your nose above the bandit. The result should be a slow speed merge with exclusive use turning room.

b. VS. BANDIT LEVEL: This example is an un-counterer OOPL maneuver. Initially lift vector on nibble pull. After coming over the top shift the lift vector aft to create weapons separation, with weapons separation reposition the lift vector out front and aggressively pull for a shot. Left un-counterer this should result in two circle offensive flow.

c. VS. BANDIT NOSE LOW: Difficult flow for both aircraft due to the high probability of losing sight. You will initially gain angles after coming over the top but as the bandit comes up and you go down the result in an extremely high to low follow on merge. For this reason look to come off in the oblique early to flatten out the follow on merge.

2. FTR NOSE LOW

a. VS. BANDIT NOSE LOW: This most likely will result in a neutral merge across the bottom. Look to gain exclusive use turning room by repositioning the lift vector slightly off pure nose low (displaced post above bandits) and controlling altitude loss by selecting IDLE and speed brakes. Reselect MRT and speed brakes in order to insure you have tactical vertical airspeed. Against a pure nose low bandit you should have a stacked merge above the bandit.

b. VS. BANDIT LEVEL: This should result in an offensive advantage. Perform a lift limit pull across the bottom. Consideration should be given to repositioning the lift vector into the oblique to minimize altitude loss (turning room). Then reposition the lift vector out in front to align fuselages and pull for a shot.

c. VS. BANDIT NOSE HIGH: Again extremely difficult for both aircraft to maintain sight. Angles will be gained by the bandit when he/she is at the top. The follow on merge should be an extremely low to high merge. Look to early turn the bandit in the vertical for an offensive advantage.

3. FTR TURNS LEVEL (this is not optimum and should only be done with no other options available)

a. VS. BANDIT LEVEL: This essentially will be a rate fight with an advantage going to the aircraft that manages his/her airspeed the best. If above your rate band perform an energy excursion to bleed down to your rate numbers. In this pure rate fight it would be best to initially target the tactical rate band (300-330kts). However, if the bandit is gaining angles it would be prudent to take an energy excursion down to 240kts. Doing, so, denies the bandit angles and will not cost you turn rate in the long run.

b. VS. BANDIT NOSE HIGH: As you turn level across the horizon a positional advantage will be yielded to the bandit. For this reason look to force a low to high merge by pitching up into the bandit before he/she comes down.

c. VS. BANDIT NOSE LOW: Again, the bandit will gain a positional advantage in this fight by utilizing an OOPL maneuver.

NEUTRAL SETS

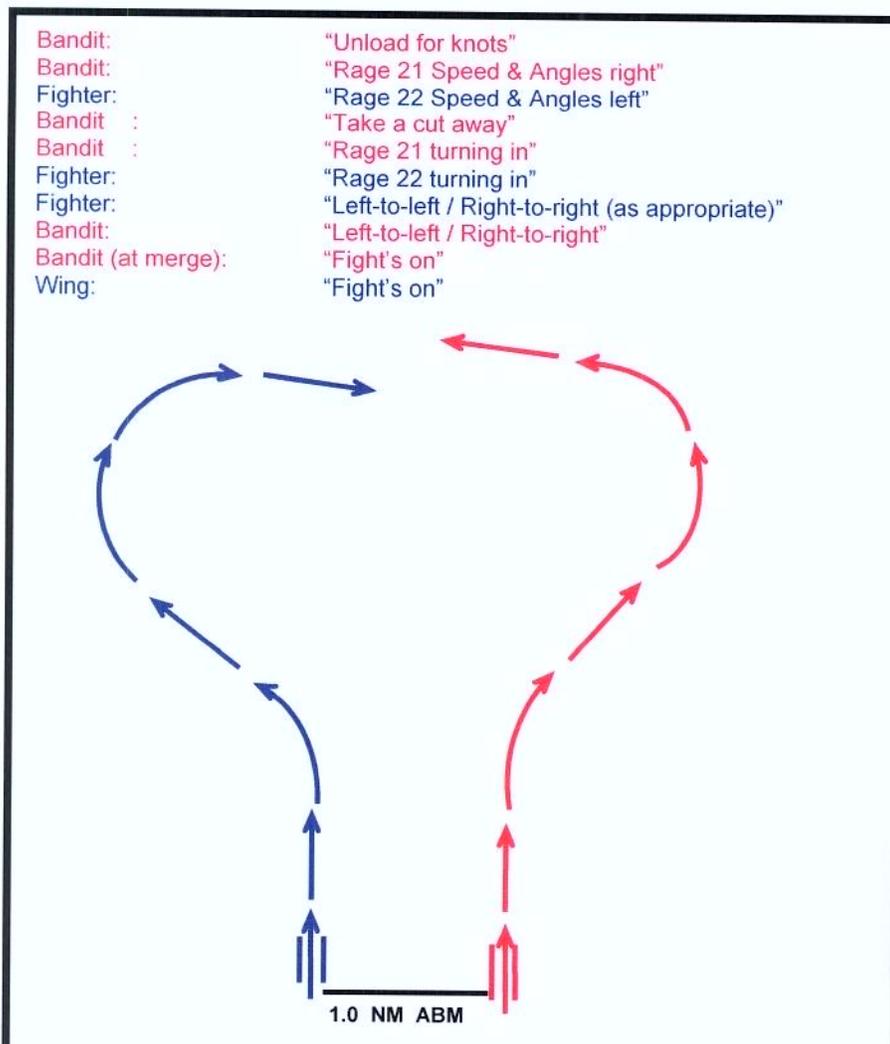
BUTTERFLY

P - Abeam
A - Deck plus 6,000ft
D - 1.0 nm
S - 350kts

The objective of the butterfly set is for each fighter to arrive at a positionally neutral, co-altitude, 500-1000' abeam wings level merge with an **unknown airspeed**. Each pilot is free to modulate the throttles to achieve the airspeed desired at the merge. You will have to utilize the BFM cues to assess the other aircraft's energy state and fight accordingly.

Set up

1. Both aircraft will climb to PADS altitude plus 1,000ft in combat spread at 300kts. When lead calls "unload for knots", select MRT and unload matching lead on the horizon. Lead will set 5deg nose low. Keep lead on the horizon and adjust the throttle to maintain abeam, arriving at PADS altitude and 350kts. At this point the flight lead will initiate the Speed and Angeles call.
2. Lead will then call "take a cut away". Both aircraft will take a 30° cut away. During the cut away, each fighter is free to adjust airspeed for the desired merge game-plan.
3. At 3.0 NM or the visual limits, whichever occurs first, the flight lead will call "turning in". The fighters will turn into each other for a cooperative merge, with wing calling the pass
4. Adjust flight path to set the neutral pass. **Both aircraft shall maintain wings level until 3/9 passage ("fight's on")**.
5. At 3/9 line passage, the flight lead will call "fight's on" and both fighters will begin fighting their high aspect game plan.



Butterfly Lost sight game plan: If you go blind at the turn in, call it immediately. The lead will talk you to the merge, so listen to his/her directions and do exactly as directed. Once tally is regained call it. If both aircraft are blind, lead will climb 1,000ft and wing will descend 1,000ft with a KIO call from lead.

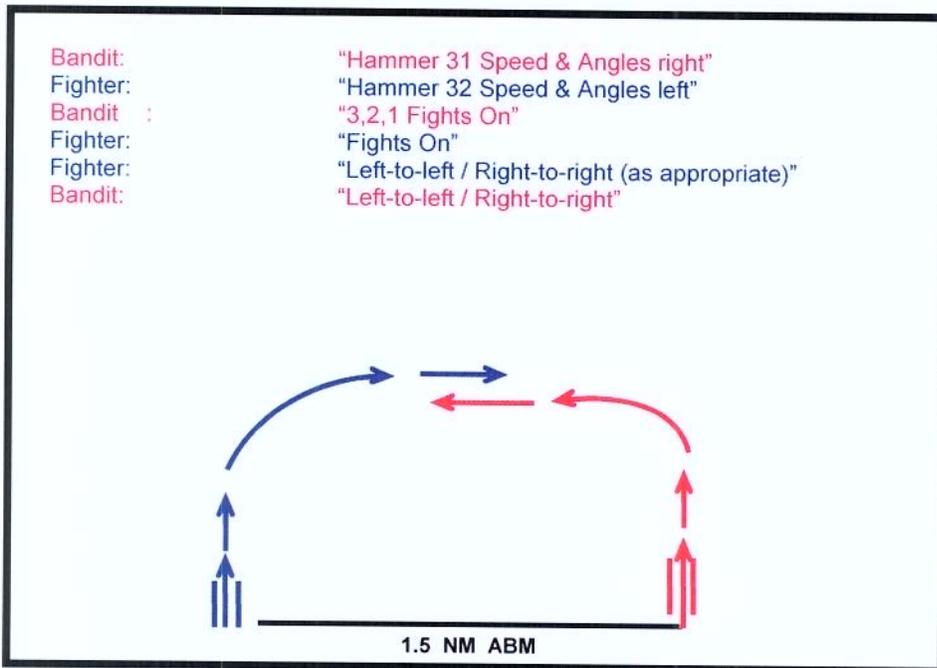
ABEAM

- P - Abeam
- A - Deck plus 6,000ft
- D - 1.5 nm
- S - 350 kts

For the Abeam set the fight is on right away, it is a neutral **known airspeed start**. Each fighter is free to execute their respective BFM game plan. Look to control that first merge so you can execute your HA game plane.

Set up

1. Following the speed and angels call lead will initiate the fight by call "3,2,1 Fights On". On the "3" both aircraft will select MRT, with both aircraft free to maneuver on the "F" in Fights On.
2. Wing will echo the call, "Fights On" and call the pass.



BVR

The Beyond Visual Range (BVR) set introduces you to the BVR environment including the use of altitude blocks, the associated communications and gaining a tally. Furthermore it presents an "unknown" start to a visual engagement, where you must evaluate the situation and react appropriately to be successful. Due to the lack of sensors (i.e. radar, data link etc) in the T-45, the training you receive on these sets will be vastly different than the FRS, but the basics will still apply.

COMMUNICATION

The associate communication sequence during BVR's has three parts to it.

1. Tacadmin
 - a. "set in the east/west" calls lets everybody know you are ready to fight
 - b. "turning in tapes on, fights on", is the initiation of the fight
2. Tactical
 - a. The "picture" call and response is the "tactical" portion that would occur inter-flight during an actual engagement. The Fighter is querying an Air Intercept Controller (AIC) for what they see on their radar. AIC responds with location and direction of flight and the declaration (i.e hostile or bogey)
 - b. The "commit" tells AIC that you are going to prosecute that group (i.e. go fight them)
 - c. The "5 miles eyes out" call reminds aircrew to shift their scan from onboard sensors to outside the aircraft to pick up a tally.
3. Safety
 - a. The "block" call is a safety of flight function that reminds all players that they MUST be in their briefed blocks without the required SA (which in the training command is Tally Visual).

Communication Example

BANDIT: "Fighter is cleared out to the West"
FIGHTER: "Fighter cleared to the West"
BANDIT: "Bandit set in the East"
FIGHTER: "Fighter set in the West"
BANDIT: "Bandit's turning in, tapes on, fight's on,"
FIGHTER: "Fighter turning in, tapes on fight's on"

FIGHTER: "(pre-briefed AIC call sign (Screwtop), picture."
BANDIT: "Screwtop, single group, Bull 150/40, track West, high, hostile"
FIGHTER: "Hammer 22, commit."

At 10NM:
FIGHTER: "Fighter in the block."
BANDIT: "Bandit in the block."

At 5NM:
FIGHTER: "5 miles, eyes out."
BANDIT: "Eyeballs out."

SET UP

Lead will direct you to a Combat Air Patrol (CAP) station that will be defined by radial/DME. Flow out to your CAP point and wait for the bandit to call set. When the bandit is at the CAP point he/she will call set, if you are not at your CAP point respond with a "standby" until you are at your CAP point. Ultimately we are looking for greater than 12nm separation and near the radial lead stated.

Once the "fight's on" call has been made and echoed, flow towards the Bandit's CAP. The Bandit is going to fly down the course line at the top of the block if low and the bottom of the block if high.

OFFSETTING FROM THE COURSE LINE

The Bandit will be flying right down the course line; you however, will offset to one side. This yields some advantages

1. **Reduced Scan:** Isolating the bandit to one side results in having to scan half as much sky thus increasing the chances of picking up a tally.
2. **Harder to gain a tally for the bandit:** The bandit does not know which way you have offset thus he/she has a larger scan volume.
3. **Utilization of environment.** You can decrease the probability of the bandit gaining a tally and increase your chances by utilizing the environment. Offset into the sun or utilizing clouds (white jet vs white clouds) is just a couple of examples we can use from the environment

BLOCKS

Be established in your block by 10nm from the Bandit. If you are not in your block at 10nm, call a KIO and perform a 180 turn back to your CAP and inform the Bandit you were not in your block.

GAME PLAN

Just as discussed in high aspect BFM you need to have a game plan and look to control merges. If the bandit is in the low block, having 400+kts at the merge and being high might not be the best answer. On the other hand being at 250kts with the bandit in the high block may not be the best answer either. With the knowledge that the bandit is in the low block you most likely will be stacked high at the merge and or have a slight high to low merge. On the other hand if the bandit is in the high block you will be stacked low and or have a low to high merge. Look to achieve an energy package that will yield an advantage to you at the merge. Refer to the HA BFM section to figure out your best game plan.

GAINING A TALLY

It is extremely difficult to gain a tally of a T-45. But, due to our offset we know the bandit will be on one side of our nose, and we know based on the AIC whether the bandit will be high or low. This drastically narrows our scan. Now, utilize off center sector scanning to systematically search the sky. Momentarily look at a cloud or the ground to refocus your eyes to infinity then continue the scan.

Tally / No Joy Game plans

1. *Bandit no joy.* As long as you have SA (i.e. tally) you can come out of your block. Apply the above considerations if you assess the bandit is "no joy", to gain an offensive advantage. You must remember that you will own deconfliction until the bandit gains a "tally"
1. *Fighter no joy.* If you do not pick up the Bandit you have a couple of options.
 - a. You can "blow through" (continue straight ahead), hoping the bandit does not pick you up. If you perform this technique and have enough airspeed, it may not allow the bandit to turn and arrive in a WEZ.
 - b. The second option is to turn when you assess you have passed the bandits 3/9 line. Although this may aid in gaining a tally by turning back into the threat, it also may aid the bandit in either picking up a tally (i.e. showing planform in the turn) or achieving a WEZ. **It is imperative that the fighter remains in his block until "Tally."**
2. *No joy both aircraft.* If either aircraft does not gain a tally it is flight leads discretion to either call for a turn (in the blocks) or to flow out to opposite CAPS for another set.

INITIAL MOVE

Once you pick up a tally assess whether the bandit sees you. If the bandit is not turning toward you he/she most likely does not see you. Consideration should be given to maintain separation to make it harder for the bandit pick up a tally and to utilize that turning room when it is best for you. If the bandit is turning toward you apply merge mechanics and turn towards the bandit. This will deny the bandit angles at the merge. Once at the merge fight your best 1V1.

CONCLUSION

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