

A HANDBOOK

SECTION 1

BVR

SECTION 2

BFM

THE FIVE STAGES OF BVR

- Captain Chris “Dax” Widick

If properly performed, a BVR engagement will remain a BVR engagement through its entirety, which – ultimately - is our goal. It is often said in the fighter jock world that, “If you have to go guns or heaters on your bandit... you’ve done something wrong.” This logic certainly holds true when a strictly BVR fight is desired. Though there are times when a knife fight is preferable to a long range engagement, WVR tactics are outside the scope of this Guide, and - as such - will not be addressed here.

The Five Basic Stages (in chronological order) are:

1. **Awareness and Detection**
2. **Sorting**
3. **Intercept**
4. **Defensive Response**
5. **Kill Confirmation**

AWARENESS AND DETECTION

It stands to reason that in order to knowingly engage a suspected bandit, one must first be aware of, and detect said target. As it pertains to this discussion, the difference between Awareness and Detection, must be explained.

Awareness, as the name implies, is the pilot's ability to know, suspect or be aware of an aircraft that *exists* somewhere in the relatively near vicinity, though it may not have, as yet, been detected. This is accomplished through the development of the fighter pilot's most important skill, Situational Awareness ("SA", an especially vital concept discussed later).

Detection, for the purposes of this discussion, will be defined as a confirmed radar contact and/or "strober" indication, unknown or thought to be potentially hostile. For example, a RWR indication of a Slot back type radar, outside of lethal range at 11 o'clock is "awareness" of a MiG-29/Su-27 where as an AWACS call of nearest bandit off the nose at 20 miles and a corresponding "strober" on the scope can be considered "detection".

Awareness may come from a variety of sources. Within the Falcon 4.0 world, AWACS is most often your first indication that a potential threat exists. AWACS is, for all practical intents and purposes, omniscient in the Falcon world and - if utilised properly – can be a tremendously powerful resource.

Awareness may also come from other flights, whether they be AI or Human. Often overlooked, AI Flight communications are an excellent source of information when building your Situational Awareness. They indirectly provide you with information that *adds* to the mental picture of your environment that you ought to be creating in-flight. Though not always relevant, the more information you can acquire by any means the better. Human pilots of other flights will tend to be part of your package and as such, the information available from them will tend to be especially relevant to your flight. And, as common sense would dictate, information from aircraft within your flight is crucially relevant.

There are two primary methods of detection, Radar and Visual. By strict definition, Visual detection has no relevance to the BVR fight (at least not at this stage), and therefore only Radar detection will be discussed.

It is assumed those reading this have a cursory understanding of the mechanics of modern radar and - as such - this discussion will limit itself to topics regarding proper deployment of radar scan techniques.

RADAR & SCAN-PLANS: What is often stated, in one manner or another, is that the greatest weakness of radar is the operator. What this really means is that the inability of a radar to detect an object is most often as a result of the radar looking at the wrong portion of the sky. Radar control and operation ought to be considered fundamental basics; learned and mastered to a level of proficiency that allows the APG-68 to be operated as though it was an extension of yourself.

Part of any thorough preflight briefing should include a "scan plan". It should include altitude blocks and ranges for each member of the flight and specifically scripted with regards to the type of flight, mission, and flight plan. The idea is to have as much coverage over sky that is relevant to your flight and is possible given the resources on hand (i.e. number of radars available to you and your flight).

A two ship “scan plan” may consist of something as simple as Lead scanning mid to high altitudes, and wing scanning low to mid altitude, 40 mile range, enroute to target during a strike mission, leaving the longer range scanning responsibilities to it’s escort, if applicable. Furthermore, it may be briefed that should escort flight be engaged within that 40 mile scan area, that the two ship assume long range scan duties until such time as escort can resume.

A two ship “scan plan” in the BARCAP role, may be just as simple, with addition of alternating headings in a holding pattern type orbit, maximizing area coverage at any given time.

Four ship “scan plans” can become more complex as well as more inclusive with regards to the amount of area that may potentially be scanned. Lead element may duplicate a scan pattern similar to the one mentioned above for the two ship strike, only now they may shift their scan laterally off course to the left, while second element follows opposite to the right, thus effectively covering the entire front hemisphere relative to their heading.

Regardless of the pre-briefed plan, the primary goal is to ensure that an understanding exists between all flight members with regards to their area of responsibility. Having four capable radars scanning the same exact area of sky is a horrendous waste of resources, not to mention a perfect recipe for ambush.

Ideally, in the detection stage the decision is made as to whether to push the fight, or to bug out. A thorough preflight briefing should have covered the ROE so as to give the flight members a better level of expectancy when an engage/disengage order is given by lead.

SORTING

Once the decision has been made to continue the engagement the task at hand becomes effectively sorting the bandits. The primary goal is to ensure that each flight member is aware of and has a positive ID on his bandit and/or area of responsibility within the fight.

A sort can quickly become a complicated tangle of communications that can quickly lead to a tumbleweed situation for the entire flight, and - as such - proper brevity and sort techniques must be utilised. Any one of, or combination/variation, of the following methods can be employed to help ensure an accurate sort.

Lateral Sort - The most obvious method is to sort laterally as depicted on the radar scope. Often lead and trailing aircraft are readily apparent and can quickly be sorted and a verification of this should sound something like:

Falcon11 - *"Bandits, two-ship, Bullseye 270, 40 miles, angels 22... One has lead"*

Falcon12 - *"Confirmed, two has trailer."*

Vertical Sort - When enough lateral separation does not exist or an altitude difference within the hostile flight is the most distinguishing feature sorting vertically may be implemented.

Falcon11 - *"Bandits, two-ship, Bullseye 270, 40 miles split vertically.
One has bandit angels 22"*

Falcon12 - *"Two has second bandit, angels 17."*

All that needs to be accomplished is that the friendlies involved verify their target's altitude which ideally should provide enough of a discrepancy to ensure effective sorting has been accomplished.

Often, within the myriad scenarios Falcon presents, you'll find that other methods may be more effective. The means to the end in this case are incidental, and the primary focus needs to be that proper sorting is quickly and accurately accomplished. Otherwise, far too often, multi-ship flights can easily Fox on one individual bandit, not only wasting valuable missiles but allowing the lost bandit a perfect opportunity to go on the offensive whilst he's unengaged.

INTERCEPT

We've detected, identified and sorted our bandits at this point. Upon entering this stage of the engagement the Flight Lead has essentially two options: Prosecute or go Defensive. Depending on the resources available (i.e. A2A weapons, Escort Flight present within the package, friendly fighters/SAMs nearby) Flight lead may opt to go defensive, which in and of itself offers a few options. At his discretion, he may slow your flight to allow your escort an opportunity to engage, or he may opt to have the flight change heading or even reverse course for a short period of time, again allowing the Escort Flight more room to engage. Given extreme circumstances an abort and RTB order may be given.

Should the Flight Lead determine the bogeys to be hostile, a threat to your flight, and Lead makes the decision to engage, the prosecution stage of the engagement begins. At this point the Flight Lead's workload increases dramatically, and it is all important that his flight react quickly and as a cohesive unit relying on his command decisions. Poor communication and teamwork is the Achilles heel of any Air to Air engagement.

Depending on the threat and the flight's current status, the flight may either push for a WVR range fight or call for a BVR fight. For example, a heavily loaded four ship Strike package of F-16s are no match for a pair of Flankers in the close in arena, without having to drop their mission critical stores. However - given the right circumstances and cohesive teamwork - that same two ship of Flankers can be effectively dealt with, without sacrificing the mission outcome, through a successful BVR engagement.

Conversely, though not often advised, the same Flight Lead may opt to push a WVR fight with a pair of MiG-23s, so long as heaters are available, in an attempt to conserve the number of available AMRAAMs, if more lethal threats are expected. A skilled and practiced flight of four F-16 pilots can just as effectively, as with the SU-27 engagement mentioned above, deal with a pair of Floggers in the WVR arena. Such a decision relies heavily upon knowing the capabilities of your flight.

In any event, within this context the Flight Lead will call for an intercept procedure consistent with a successful BVR engagement, and the flight itself will act accordingly.

Such tactics will be discussed further in this Guide.

DEFENSIVE RESPONSE

Though, in a sense the Defensive Response of your flight in a BVR should be apparent in the BVR intercept tactics given by the Flight's Lead, it is crucial enough in the BVR environment to acknowledge it as a separate entity within the engagement. Given the mechanics of modern day BVR weapons, their threat is often not realized until far too late. Case in point - there is no positive indication of an AMRAAM or AA-12 launch until either visual acquisition is acquired or its own onboard radar goes active. Both scenarios are not a good place to be if you have a strong sense of self preservation. All too often a pilot's family receives a letter of condolence as a result of his failure to react to the potential threat that may be inbound. As a result, careful consideration must be given with regards your threat's type and capabilities. For example → a proper BVR engagement against a pair of SU-27s potentially armed with AA-12s should involve a just barely within Max Range shot of your AMRAAMs, and a subsequent forsaking of the radar guidance until "pitbull". This provides for a defensive posture or maneuver that ensures a higher chance of survival. Conversely, if the capabilities of the Flogger are understood, a BVR launch against a MiG-23 allows the launching F-16 more freedom to close and increase the Pk of his launch.

KILL CONFIRMATION

As self-explanatory as it seems, the final basic stage in the BVR engagement is crucial, yet often deceptively difficult. Once a hit is expected, it should not be considered as such until positively confirmed. Assumed kills have a nasty habit of biting pilots in the ass, unexpectedly.

Targets often fade from radar, RWR nails can be eliminated with the flick of a switch, and even those dark plumes of smoke that so easily provoke the elation of a kill can easily represent nothing more than an injured, and probably irritated, bandit. However, the presence of all three of these criteria is often indicative of a good kill.

A positive visual on a secondary explosion marking the disappearance of your bandit entirely is even better, but not always available within the BVR realm. Much like proper sorting, the means to the end are relatively incidental so long as proper precautions are taken to verify that the kills have been made. Until such time as the kills can be properly confirmed, the Flight Lead should maintain a defensive stance for his flight, and be prepared for a re-engagement or separation, as necessary.

BASIC PROSECUTION OF THE BVR FIGHT

Successful prosecution of the BVR engagement relies heavily on a simultaneous execution of both offensive and defensive tactics, when dealing with high threat bandits such as Su-27 and MiG-29S's. Both the Flanker and Fulcrum "Sierra" model are AA-12 capable, making them the most lethal Red aircraft in the sky. As such, Prosecution tactics will be discussed with regards to them. The Soviet Adder indeed has a longer range than that of the AMRAAM, however it's less maneuverable and its radar's cone of vision is slightly smaller than that of the AIM-120. These two deficiencies can almost entirely negate the longer range of the Soviet missile, if exploited properly. In facing the AA-12 in combat, there are several primary methods each of which have their own benefits and deficiencies:

THE BEAM

The concept of the beam is based on exploiting a flaw inherent to most modern Radar. In order to reduce ground clutter on the radar scope, modern radars filter out what they see as stationary objects through the use of the Doppler Effect. What that this means to you as a pilot, is that if you were able to make your aircraft appear stationary to the hostile radar, it will indeed filter you out just as it does buildings on the ground. Initially you might think this not possible, however "Beaming" your bandit does exactly this. The term "Beam" refers to your 3 and 9 o'clock lines. So following logic, to beam or the act of beaming refers to placing the object in question along that axis of your aircraft. When that object is a Pulse Doppler type radar the end result is that you have effectively zeroed your speed *relative* to the radar. The only closure the radar senses is that of its own aircraft's speed. At this point you are filtered out as being nothing more important to the radar than a tree. At best this will prevent the bandit from locking you solidly enough to engage, but more realistically it will make their life more difficult by providing intermittent chances of locking. In order to apply this technique in a BVR fight the Bandit should be identified and locked by no closer than a 20 nm range. This will give you adequate time to set up for a head on engagement, which is desirable in this situation. While head on, keep a close eye on your range to target, his aspect, and closure rate. You may launch at anywhere inside 20nm and possibly acquire a kill, but generally speaking 12-15nm is preferred depending on closure and aspect (aspect simply put is the number of degrees you are off your target's nose).

Launches at the longer ranges (15nm+) are often successful in spooking the bandit just enough for him to go defensive, which sometimes is an adequate resolution to the engagement, while ranges closer than that dramatically increase your PK (Probability of Kill). In any case, practice in Dogfight type engagements setup in Falcon for BVR will allow you to find the range that you feel allows you both the highest chance of a kill as well as highest chance of survival. With much practice that range will greatly decrease.



Figure 1a: Depicts just prior to the launch and initial turn into the Beam.
 Notice: Range - 14nm, Heading - 181 degrees, Speed -: 642 knots.

Near Head On orientation to bandits. Jammer on. Immediately after launching on the Bandit the Beam is executed. This is performed by a high G turn either left or right, roughly 90 degrees. Should the Slot back still have his radar active, the RWR will provide an excellent reference to place the boogey on your 3 or 9 line. Should his radar be intermittent or off entirely, some estimation is required as you're sure to bust gimbals (lateral range of your radar) in this maneuver, which means you had better been paying close attention to his heading/aspect before going into your turn. At this point the defensive maneuvers are begun.

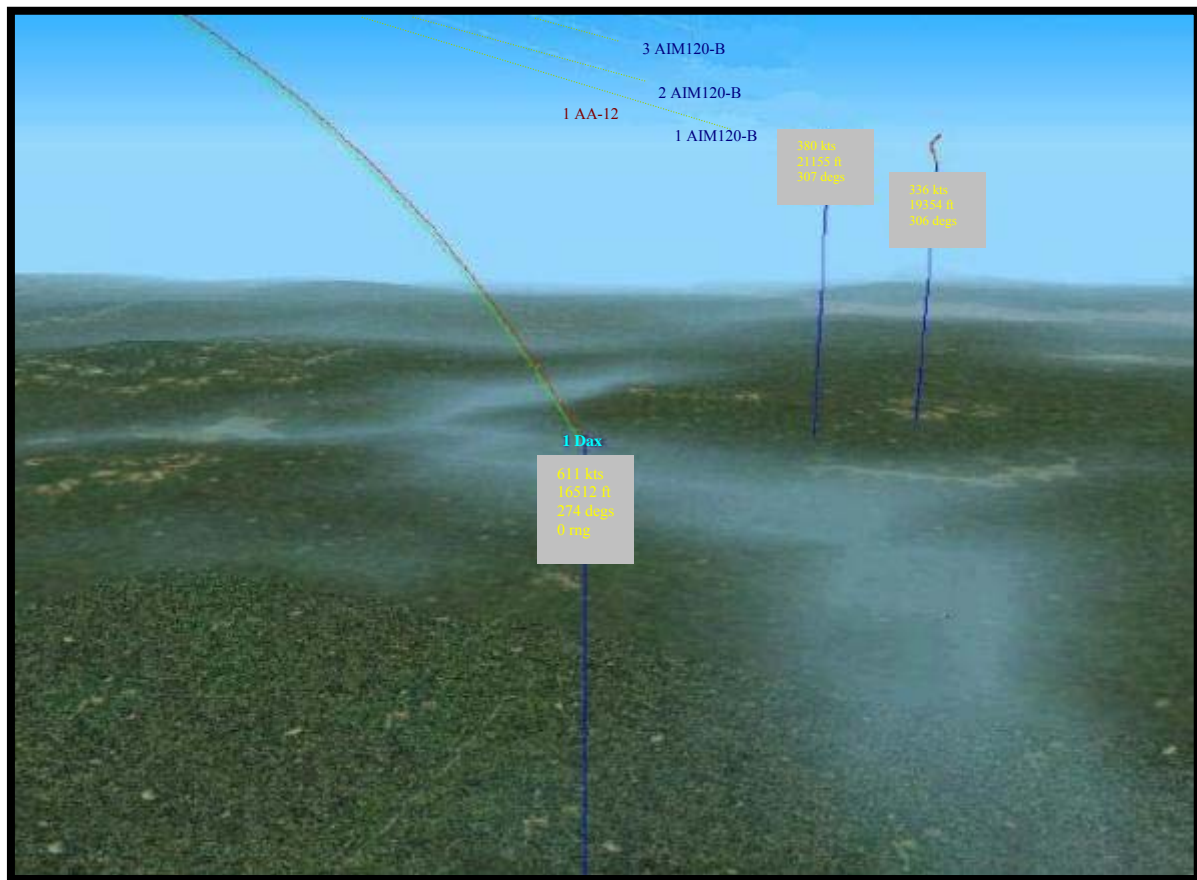


Figure 1b: Nose down attitude, speed increasing extending from bandits.
 Heading, 274 degrees, nearly a perfect beam (93 degrees of original heading of 181). Jammer off.

If your launch range approached 15nm, it's a safe bet that the Slot back has launched on you. Remember, always defeat the threat, and when a missile is launched it becomes the threat and the launching aircraft should be secondary in your mind.... but still on your mind. Once the Bandit is Beamed several actions must be performed as quickly as possible in order to ensure survival. Any Jammer in use **MUST** be turned off. Negating closure rate to a radar guided missile, while making you invisible to the missile, does nothing to hide the emissions your ECM pod is broadcasting, and the AA-12 is very capable of locking on to those emissions in HOJ (Home on Jam) mode. At the same time a nose down (anywhere from 10-20 degrees is sufficient), full mil to AB attitude should be established while scanning visually for the missile and several bundles of chaff should be pumped out. This serves a couple purposes.

First, it increases your energy state as you increase your speed, sometimes upwards and past 800kts+. By this time, the missile's motor is sure to have burned out and it is strictly an energy fight at this point. The drastic increase in your speed helps diminish the missile's closure rate, forcing it to continually lose ground in the energy fight. Remember, with less than a 10 second burn time any missile's energy is limited, while that of your jet is relatively infinite.

In addition, you'll eventually level out at close to ground level. If you haven't beat the missile at this point, the un-filterable ground clutter will help mask your presence, possibly spoofing the missile. Furthermore, radar guided missiles fly a lead pursuit (a course that points their flight path ahead of yours for intercept). As a result, radar guided missiles have been known to smack into the deck while trying to maintain a lead pursuit on a lower level aircraft. Finally, being at a low level often allows the option to place a large object (i.e. mountain) between you and the chasing missile.

During your descent a slight turn into the missile helps maintain a proper aspect for beaming. The missile flying a lead pursuit already as an inherent angle on you, small enough to negate the effect of beaming so in order help remove this advantage, a slight bank of 10-15 degrees often creates just enough of a constant change in flight path to maintain effective beaming.

Once on the deck, the priority becomes visually acquiring that missile. The missile may not be present on your RWR, but that is not to say that you have beaten it just yet. All too often overconfidence in the situation has prompted a pilot to turn back into a missile still looking for a target... and found himself the target. Visual acquisition can be relatively difficult at this point as the missile's motor is spent, removing from view the very easy to spot smoke trail. However, once acquired visually, immediate recognition of whether you are still its target



Figure 1c: The Beam is established and maintained at this point, maintaining a heading roughly 270 degrees off from original at full/AB. Missiles are effectively beaten and need only be outrun at this point prior to reengagement is required. This is done by observing its relative motion.

A visual target, and this applies to aircraft as well as missiles, that has no relative motion (i.e. it is not moving in your canopy) is on a collision course for you (also known as a lead pursuit). With this information at hand we can deduce that if the missile is visually moving to your aft, it has lost its lock on you and is now without a target, or at the very least, you are not its current target. If this is the case, maintaining your defensive stance and current heading or a turn into the missile's point of origin, should spoof the missile entirely. Should the relative motion be towards your nose, a high G turn *into and past* the missile should be enough to place it behind you with no hope of reacquiring you. In the case of no relative movement, it should be considered tracking you, regardless of RWR information. At this point you are in a position of considerable advantage as the missile has been nearly depleted entirely of any sort of effective energy and a well timed high G turn into or above the missile will effectively beat the missile.



Figure 1d: View from inside the 'pit of visual acquisition of inbound AA-12.

At this stage in the fight the high G maneuver performs two functions: It burns off even more energy from the missile putting it in an energy state, hopefully, where it may become effectively unable to close in near enough to cause damage. Secondly, at shorter ranges the cone of vision of the radar's seeker is very narrow, and the high G maneuver increases your chances of moving out of the field of view of the radar.

The Beam tactic, as effective as it might be, carries with it some serious disadvantages. Primarily, in performing the maneuver, you effectively lose radar lock and greatly diminish your chances of visually acquiring the Slot back, preventing you from going defensive or even re-engaging it should your initial launch miss its mark. Should this be the case, you will find that unless the Slot back disengaged, he will still be in your forward hemisphere and looking to reacquire you. At this point you will be in a seriously disadvantaged situation: low to the ground with minimum look up capability and most likely tumbleweed as to the Slot back's posit, while he has spent the time of your maneuver looking for you. The Beam tactic is good for a defensive disengagement, but poor on offense after your initial launch.

THE DRAG

"The Drag" concept is the most simple of the options and should be learned to proficiency first. It offers a high chance of survival, however it also diminishes your ability to maintain accurate Situational Awareness, and by its very nature forces you into a very defensive stance. The technique involves a mid to max range shot on the bandits (12-20nm miles) and a Split-S maneuver to reverse and extend from the incoming threat (the AA-12). This is most effective in a nearly head on engagement.

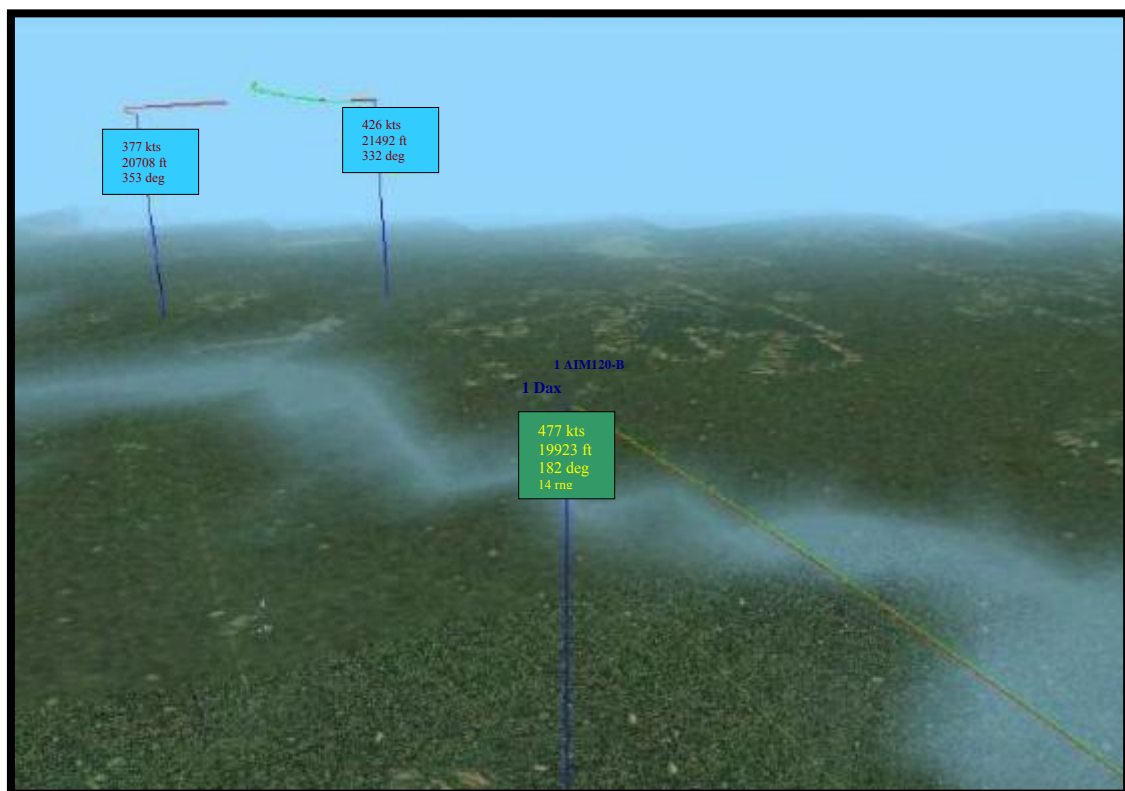


Figure 2a: Initial setup for the Drag. Head on engagement, range 14nm, positive radar contact on lead bandit. Heading 182, speed well above corner speed. Jammer on.

The bandit needs to be identified and locked on to by no later than 15nm in order to ensure success. When this is accomplished, preferably prior to 20nm, wait patiently for the range to pass 15nm, unless a low PK shot is desired with the hopes of pushing the bandits to go defensive. In either event, once your AMRAAM is off the rail a negative Split-S maneuver is performed, reversing your course 180 degrees, accompanied by several bursts of chaff.

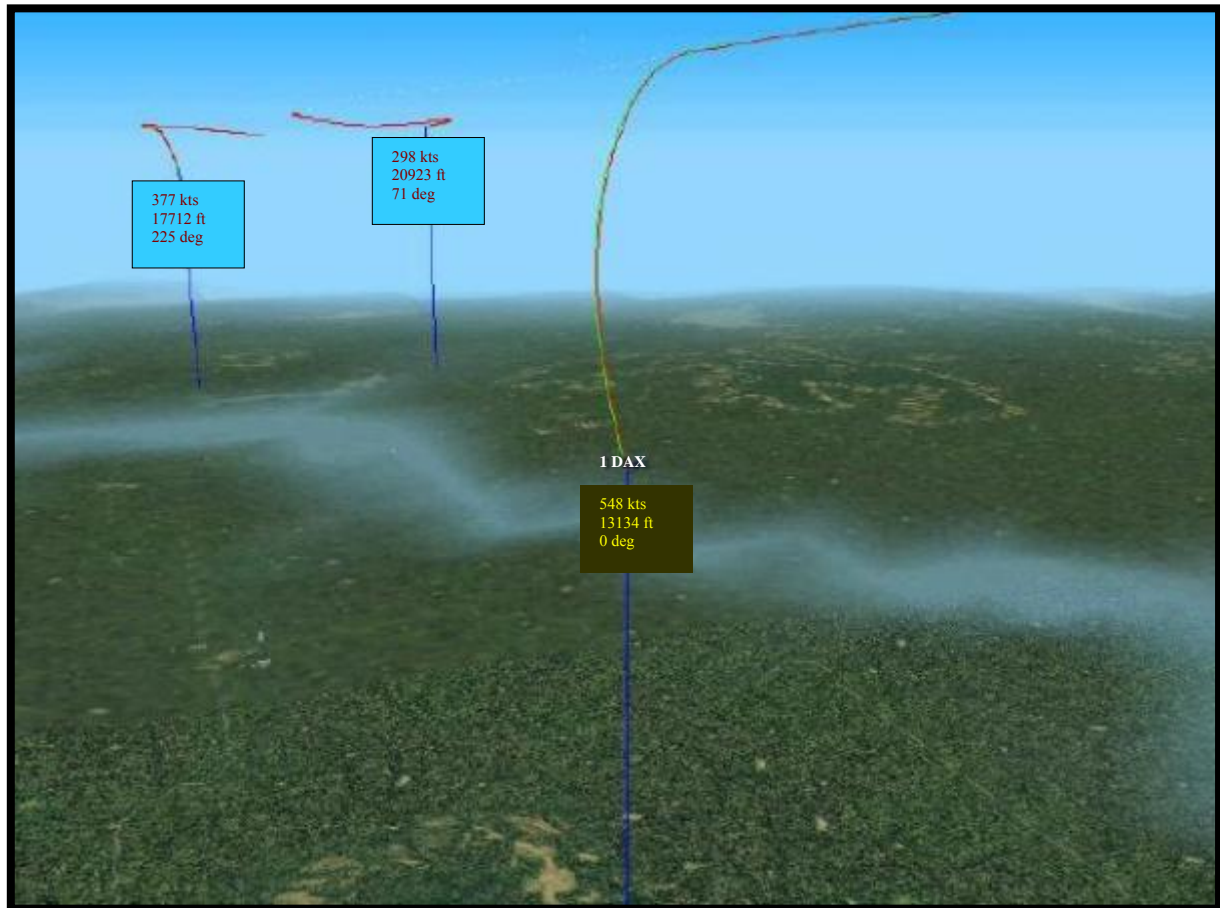


Figure 2b: The offensive launch has been performed and the Split-S is commenced, reversing heading, increasing kinetic energy state. Jammer is off.

Several things are accomplished through the Split-S. First and foremost, you are increasing your kinetic energy (speed) while establishing a heading that is more or less directly away from the bandit and its missiles, reducing the closure rate as well as the missile's PK on you. The increase in kinetic energy improves your situation should you need to defeat the missile close in. During the reversal, specifically during the vertically nose down portion of it, you are essentially a target with no relative speed and for a brief moment making it difficult for the hostile radar to maintain lock, effectively beaming the bandit (as discussed above). This in and of itself will not prove effective enough to spoof the missile entirely, however it may provide you with a very few valuable seconds to add to your defensive time. As with the "Beam" above, make sure that your ECM are off, preventing a HOJ situation during the maneuver.

The downward vertical velocity of your aircraft ensures that your chaff bursts will be as effective as possible. Instead of being merely between you and the missile (leaving you as a still very lucrative target in front of the chaff) the chaff are now independent targets while your aircraft is quickly trying to exit the cone of sight of the hostile missile. Once a reverse heading is established, maintain a 10-15 degree nose down attitude, preferably in full AB, for the drag. At this point the inbound missile will be just a few miles aft of you in full pursuit, with more than likely a solid lock on your aircraft. Regardless of the lock, you have a very high chance of defeating the missile in the energy fight. All that is left to do ideally is to maintain best possible forward speed until the hostile missile has lost all its energy and drops from the sky. Should enough distance still separate you and the missile at this point, it will be likely that the hostile aircraft is still locked on to you and guiding the missile, as the missile hasn't closed within range to go active with its own radar guidance (pitbull).



Figure 2c: View from the AA-12s as the Drag is finished, leaving the aircraft only needing to maintain speed and heading as the missiles lose energy and ultimately, the fight.

The benefit in this is that one of two things may happen, either the launching bandit must go on the defensive leaving its missile blind and searching, or your AMRAAM will destroy the hostile, again leaving the missile blind and searching. In either event the hostile missile still has the opportunity to reacquire you, but you've gained another few valuable seconds in the fight.

During the drag, it's advisable to scan your aft hemisphere for the missile. When the maneuver is performed flawlessly, simply out running the missile will beat the missile. However, rarely in a high threat environment do things go exactly as planned. Padlocking the missile will allow you to decide whether you have the missile beat, or if a high G maneuver as described in the above section is needed.



Figure 2d: *The inbound AA-12 is visually acquired, however being directly on the aircraft's 6 o'clock makes padlocking impossible.*

The missile is outlined in red, barely noticeable even at this range. As with the Beam tactic, the Drag is enormously effective and very easily executed. If timed correctly and performed at just the right range, a CAT III loaded F-16 can easily dispense of two Slot backs, with a high chance of survival. The Drag is also the most reliable tactic with regards to evading multiple missile launches as it keeps all missiles launched at you in your rear hemisphere with little to no change in heading on your part to evade. Effectively, this lines up the multiple missiles directly behind you and you need only use the same tactic to spoof them all. The downside, again as with the Beam, is the immediate loss of radar contact, situational awareness and most hope of visually acquiring your bandit. Should the bandit evade your launch, The Drag places him in your rear hemisphere, should he choose to maintain the offensive. Defensively you are in a safe position, high energy with good separation and the option to completely disengage from the fight or drag into friendly controlled airspace. Should your bandit go on the defensive and perform a similar evasion tactic, the separation will be much greater at which point you have the option to bug out or reengage.

Should you reengage, the separation and comparative energy states should be such that you have effectively neutralized the fight. However, kill confirmation is difficult at best in both the Drag and Beam often making it a tough decision to re-engage or bug out. Support from any trailing flights in your package or AWACS can help alleviate this problem. Re-engagement or re-establishing original heading from a Drag evasion can be dangerous and should be performed only when adequate SA has been reacquired. While the Beam and Drag are primarily defensive in nature the remaining two tactics offer a more aggressive engagement that allow for maintaining SA and an offensive stance.

THE OFFSET

The Offset is first and foremost a missile evasion technique. When performed correctly it allows for a high chance of survival while at the same time maintaining the highest PK possible. SA is maintained, and reengagement if necessary is possible in an offensive position with regards to both BVR and transitioning into a WVR fight. Again begin with a lock at ranges preferably greater than 20nm, ideally with the bandit roughly off your nose. At roughly 14-15nm, contingent on aspect, speed and closure, launch your Slammer. Throughout this maneuver you will maintain radar lock until well past the time your A-120 goes autonomous, further increasing your PK.

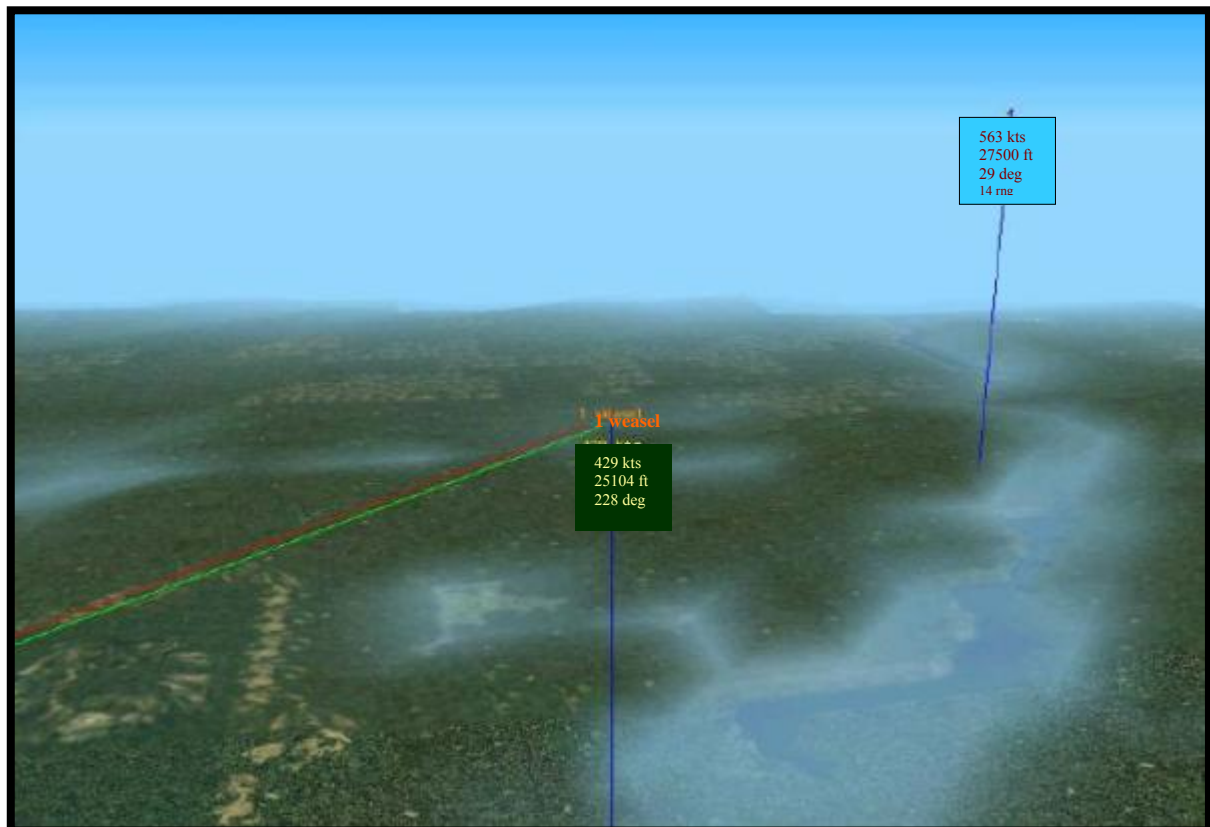


Figure 3a: The aircraft is in perfect position to implement an Offset maneuver. Head on, 14nm range, and at high corner speed (440Kts), Jammer on.

Note heading of roughly 230. Immediately after launch, a turn opposite of the bandit (offset) roughly 40 degrees is performed and the new heading maintained putting the bandit's bearing at roughly your 2 or 10 o'clock position. The radar target should be approaching gimbal limits at this time. During the turn simultaneously add or decrease throttle to establish max corner speed (330-440 kts) or slightly higher.

The assumption is of course that the adversary has already launched his missile, so a visual scan is commenced for the missile inbound. It is imperative that the missile be visually acquired for a successful outcome. The missile should be inbound from roughly the same bearing as your bandit. Once acquired, maintain padlock on the missile as well as your current heading.



Figure 3b: The initial Offset is seen here, after launch, establishing a left offset roughly 50 degrees left of original course (180). Once wings level, the pilot will immediately go to visual scanning for the AA-12 (in this example a AIM-120 is being used as the hostile missile), also shown here. Music and Radar off, as the remainder of the maneuver is strictly visual, until reengagement.

Approximately 5-6 seconds before the missile is expected to impact, a high G turn opposite of your initial offset is executed, 60-70 degrees (or 20-30 degrees opposite your initial heading). The end result should be that inbound missile tries desperately to correct for and maintain a lead pursuit but the angle and distance proves to be too much for its current energy state. The missile will, if the offset is properly timed and executed, either fly harmlessly past you completely unable to reacquire you, or detonate somewhere in your rear quadrant as it sense your aircraft is within its proximity blast radius.

Should the missile explode, it is still very likely that your aircraft will be left unscathed as your angle and velocity allow you to escape the blast radius.

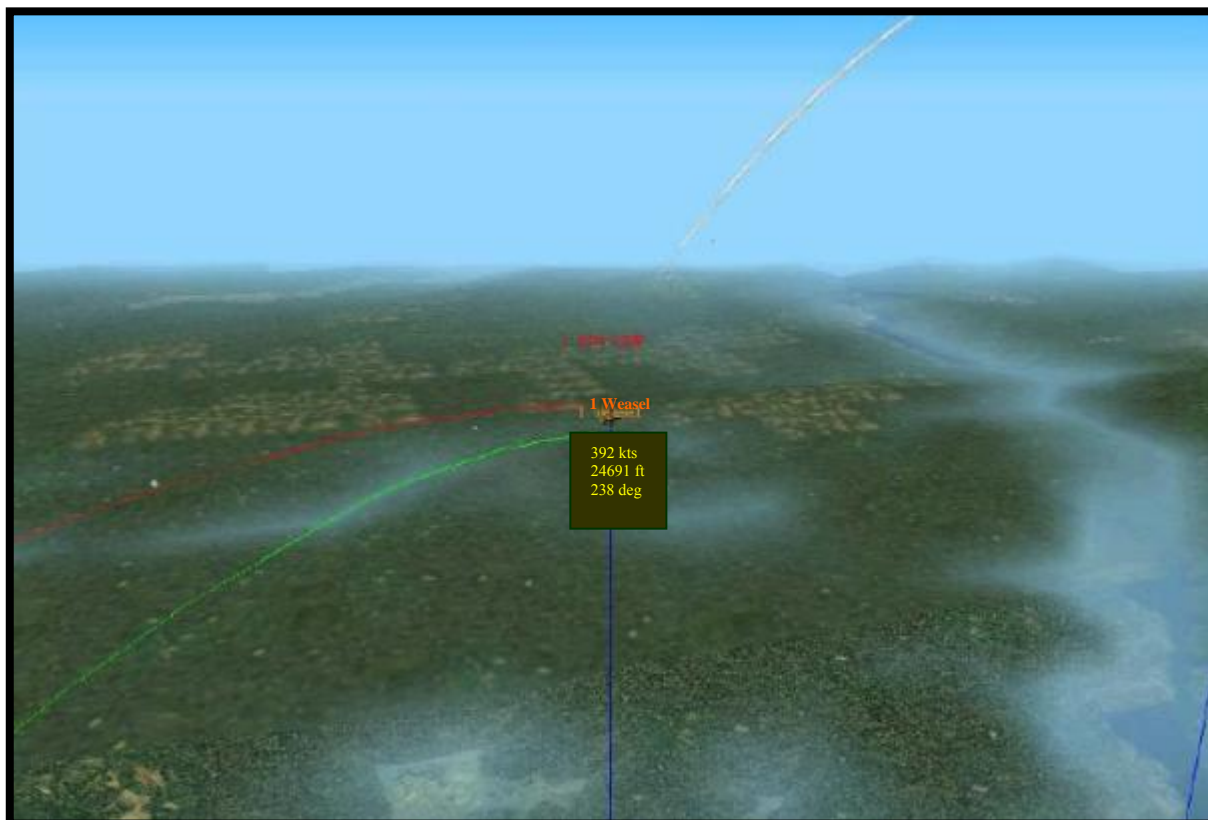


Figure 3c: The high G turn opposite of original offset angle to a heading of 240 beats the missile entirely.

Should the initial Aim-120 launch miss its target, the hostile aircraft will be somewhere in the forward quadrant in a perfect position for either another Aim-120 launch, or an intercept into a WVR fight. To be sure a quick scan visually before referring back to the radar scope is advisable. In either event, the follow up is relatively simple as the bandit is sure to be either still performing or just recovering from his defensive maneuvers.

When dealing with multiple missiles inbound, some issues arise with this tactic. If the missiles are launched relatively close together, the Offset should defeat them both. But as the distance between the lead and any missiles in trail increases so does the trailing missiles ability to correct for and maintain its lead pursuit. Extreme distances between missiles may allow for a follow up Offset to be performed, in the opposite direction, to spoof the second missile.

The Offset relies entirely on a visual acquisition of the hostile missile and as a result some practice is required to be able to not only consistently acquire such a small object but to become proficient at judging just the right moment to offset opposite and beat the missile. This sort of practice should be attained only in the Dogfight environment prior to utilizing this tactic in a campaign type mission.

Very high in offense, the Offset is equally effective defensively when mastered. However, it does almost guarantee a WVR fight should your initial launch miss its target, a fact that must be taken into consideration. Under ideal circumstances your initial launch will have forced the bandit into a reversal placing you in his rear hemisphere in perfect position to continue prosecution of the fight in the manner most suitable. At most, this tactic should be used against 1v1 or 1v2 situations. In 2v2 or 2v4+ situations the friendly flight should make sure to split the opposing 4 ship into elements prior to launch.

UNDER AND OVER (Orthogonal Break)

Conceptually, this tactic is similar to the Offset. It differs only in the technique deployed to evade the missile. After launch, given the same set up as in the Offset, a 120 degree roll is performed followed by a high G pull into a 40-50 degree nose down attitude making small corrections to make sure that the bandit's bearing is at your 2 or 10 o'clock position. Speed should be adjusted to maintain well above max corner speed (440kts) as the maneuver quickly bleeds energy.

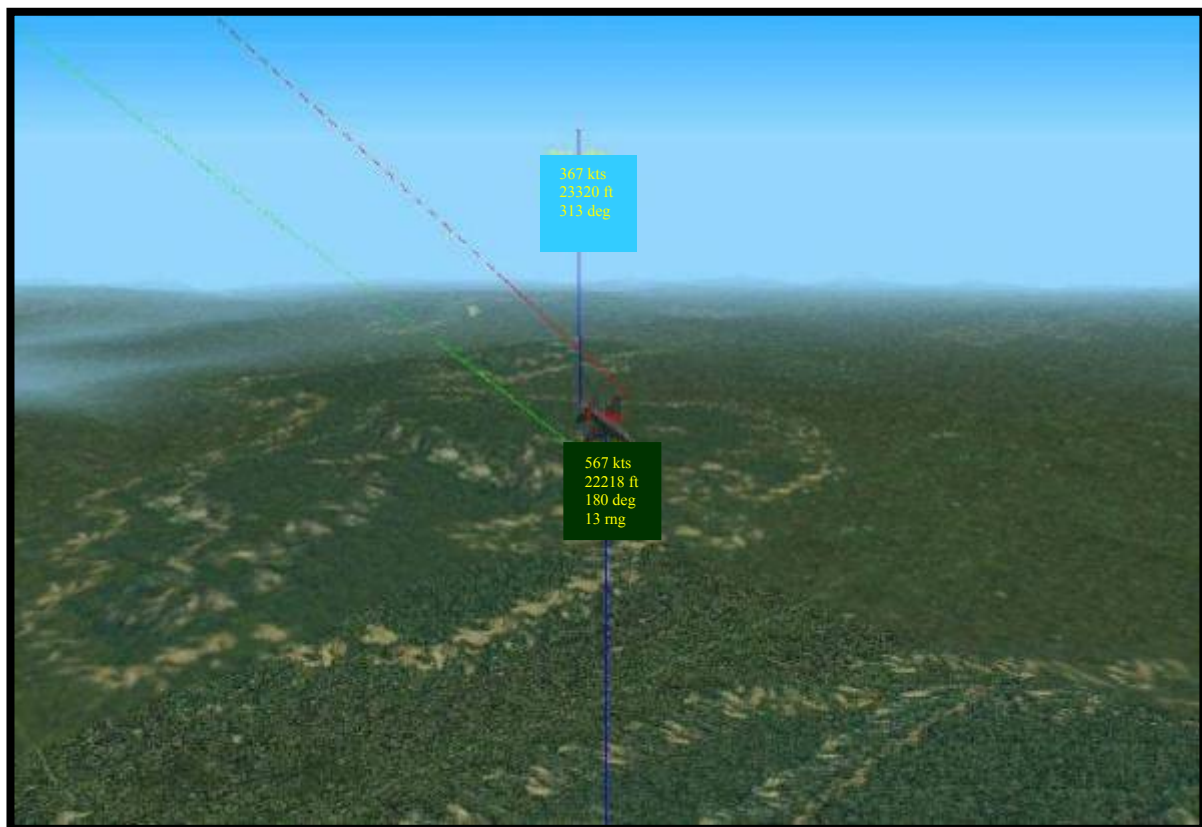


Figure 4a: The roughly 120 degree roll dive is shown here, inducing a turn placing the AA-12 high and at 10 o'clock. The Chaff is clearly visible as well. 20

As with the above tactic, visual acquisition is all important. The missile ought to be off your forward quadrant and high as a result of your dive.



Figure 4b: The missile is visually acquired by this point and the defensive “over-the-top” maneuver is commenced.

Shortly before impact, a climbing turn above and into the missile is executed, defeating the missile. The premise is the same as with the Offset, yet a vertical element is introduced, which further helps to spoof the missile in the energy fight.. **Figure 4c:** The combination of both the high G turn and steep climb effectively beats the missile in the energy fight.



This maneuver offers the same benefits at the same cost as the Offset, while additionally keeping the bandit forward of you and above you, making visually reacquiring him much easier should further engagement be required.

Essentially these basics are most useful in 1v1 and 1v2 encounters. Learning to forsake the radar guidance until “pitbull” and trust that the AMRAAM will find its mark, assuming no friendlies are in the proximity, allows for quick ripple shots on multiple hostiles prior to committing to defensive maneuvers for an acceptably diminished PK at the same time dramatically increasing your chance of survival.

In situations of 1v3+, variations of these tactics can be used with the teamwork of your flight. For example, the Drag can be altered into a “pinwheel” or “Drag and Tag” type attack. Lead and wing go into a 3-5 mile trail formation, and lead executes his Drag maneuver. As the Lead is disengaging, the AI flight is most likely still focused on him as their primary threat, leaving the wing free and uncovered, close in to more lethal range before his extension.

There are myriad variations for every scenario. The importance of every maneuver is to understand its parts and how they constitute a whole. Beaming as a BVR tactic is only one use of the technique. Understanding its effects and limitations allows you to incorporate its use into all sorts of practical applications. Learn to recognize a high PK shot opportunity, as a result of constant scanning of target aspect, speed and closure information without a “Shoot” cue as in all the above mentioned tactics a “Shoot” cue will never be displayed on the HUD.

Five ACMIs are included as support to the above concepts. Four outline the individual maneuvers while the fifth is a demonstration of these tactics in a practical, if wholly unrealistic, application (1v6 Su-27). Despite the final ACMI being an ultimately unsuccessful engagement 4 of the bandits were damaged/destroyed while spoofing 20+ AA-12 launches, thus validating the implementation of these tactics.

With a little practice all of these maneuvers can be executed at ranges that almost guarantee a successful kill. Mastering these fundamental maneuvers provides a staging point for more complex tactics.

***-Captain Chris “Dax” Widick
X/O, 162nd Fast and Furious 16th ACCW Flying Tigers***

Section 2 - BFM

DICTA BOELCHE

- Try to secure the upper hand before attacking. If possible, keep the sun behind you.
- Always continue with an attack you have begun.
- Only fire at close range, and then only when the opponent is properly in your sights.
- You should always try to keep your eye on your opponent, and never let yourself be deceived by ruses.
- In any type of attack, it is essential to assail your opponent from behind.
- If your opponent dives on you, do not try to get around his attack, but fly to meet it.
- When over the enemy's lines, never forget your own line of retreat.
- Squadrons: In principle, it is better to attack in groups of four or six.
Avoid two aircraft attacking the same opponent.

Largely a re-publication of information we've studied before, this section acts as a refresher course. Credit goes to various sources, including the *Falcon3.0 Manual*; *Falcon4.0 Manual*; Ed "Skater" Lynch; and, **Pete Bonanni's Art Of The Kill**. Some things – you can never get enough of... ☺

In order to achieve victory in air-to-air combat, a pilot must be both aggressive and self-confident.

To be an expert in fighter combat, a pilot must know how and when to engage the enemy. The first rule of WVR BFM is to avoid it... ☺ Colonel Phil 'Hands' Handley says: *"Any thoughtful examination of today's aerial combat arena will show that longevity does not accrue to those who make it their habit to enter into sustained turning engagements... Such action draws enemy fighters like a magnet, and makes you highly vulnerable to the unobserved 'meat shot'..."*

Then – why even BOTHER with BFM...? Because eventually – through design or accident, the pilot IS going to find himself in a WVR fight. And – when this DOES happen – the middle of a knife-fight in a phonebooth is a bad time to START learning BFM. So – let's start now, instead.

TACTICS

As stated, the following is based largely on the teachings of Pete "Boomer" Bonanni – the Virtual Instructor of every Falcon4.0 Virtual Pilot who has ever prowled the Virtual skies.

Tactics background: The nature of air combat has remained largely constant since Fokkers fought Spads over the stinking trenches of WWI. Thus, we still look to the Dicta Boelcke - by famed WWI Fighter Ace; Teacher of Manfred Von Richthofen; Grandfather of Aerial Fighter Tactics: Oswald Boelcke - as a work relevant to today's aerial combat. Boelcke's most famous student - The Red Baron - summed up the foundations of air combat when he said: "Rove your allotted area, find the enemy and shoot him down.... anything else is rubbish." During WWII, history's TOP ace (Erich 'Bubi' Hartmann) accrued 352 kills with the simple formula – *see; decide; attack; break off* .

90 years since Richtofen, these philosophies still hold true. K.I.S.S. - Keep It Simple, Stupid.

Whilst the nature of air combat has remained the same, the mechanics have undergone radical change. Most of this change, has come about very recently as high-thrust fighters such as the F-16 entered service in large numbers and expanded the combat maneuvering envelope. The BFM that many generations of fighter pilots grew up with became obsolete with the introduction of the F-16.

Quite suddenly, in one-versus-one maneuvering, vertical out-of-plane maneuvers such as high yo-yos were replaced with in-plane turn circle BFM.

BASIC FIGHTER MANEUVERS *One Vs One Air Combat*

BFM is the art of exchanging energy for aircraft position.

The goals of **offensive maneuvering** are to remain behind an adversary and to get in a position to shoot your weapons. In **defensive maneuvering**, you turn your jet and move the bandit out of position for a shot on your aircraft. In **head-on maneuvering**, you get behind the bandit from a neutral position.

When you execute maneuvers to accomplish any of these objectives, you invariably bleed off or expend energy. "Pulling Gs" and turning cause all aircraft to slow down, lose altitude, or both.

Let's examine the geometry of the flight and the specific maneuvers needed to be successful air-to-air Falcon pilot.

BFM is flown in the future. Many discussions of BFM describe maneuvers as if they were cards or chess pieces played sequentially in a game of move and countermove. Modern aerial warfare, however, is more accurately compared to a wrestling match. It is a fluid contest of quick reactions with both opponents executing their moves in a blur. Aerial combat requires immediate reaction.

Fighter pilots, as a rule, are not too bright on the ground; in the air, however, they are brilliant for very short periods of time. Within seconds, a pilot must constantly go through the following basic steps:

1. Observe the bandit.
2. Predict a future position in space for the bandit based on that observation.
3. Maneuver the jet in response to this prediction.
4. React to changes in the situation as one executes one's maneuvers.

BFM is flown in the future and not in the present. You must constantly predict the bandit's future position - where he will be a few seconds from the time you observe him - and fly your jet based on this prediction.

BFM GEOMETRY

In order to perform BFM, and discuss his tactics on the forums, the pilot must understand his spatial relationship to the target from four perspectives:

- *positional geometry*
- *attack geometry*
- *the weapons envelope*
- *the control zone*

Positional geometry: Range, aspect angle, and angle-off - also known as heading crossing angle or HCA - are terms used to describe one aircraft's position relative to another. These conditions, shown below, define the angular relation between two aircraft. This angular relationship in turn tells you how much position advantage or disadvantage you have.

* **Range** is the distance between your jet and the bandit. (fig.1)

* **Aspect angle** is the number of degrees measured from the tail of the target to your aircraft. Aspect angle is important because it tells you how far away you are in degrees from the target's six o'clock, which is - of course - one's desired position. (fig.2)

* **Angle-off** is the difference, measured in degrees, between your heading and the bandit's. This angle tells you relative fuselage alignment. *For example:* if the angle-off were 0 deg, you would be on a parallel heading with the bandit and your fuselages would be aligned; if the angle-off were 90 deg, your fuselage would be perpendicular to the bandit's. (fig.3)

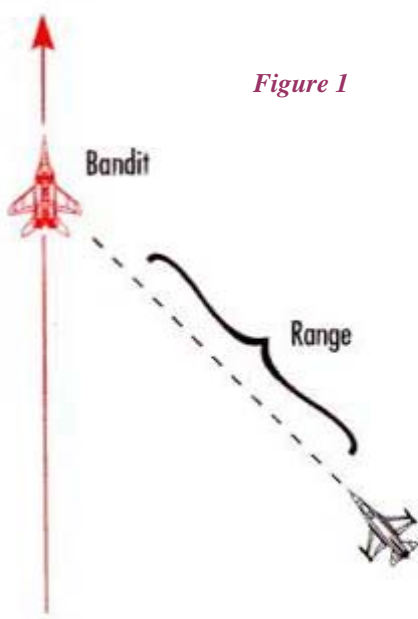


Figure 1

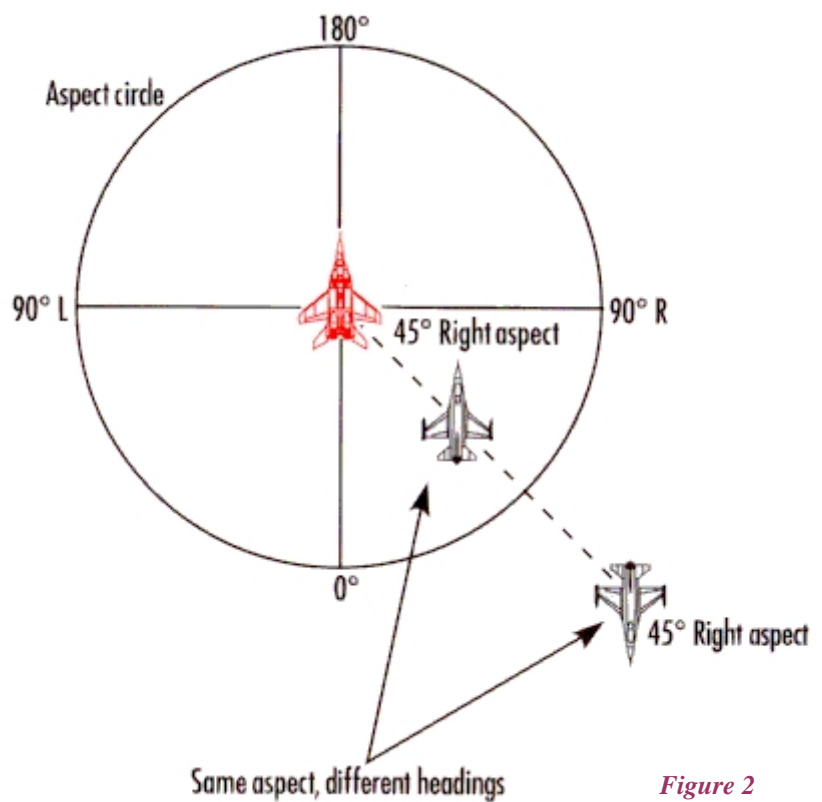


Figure 2

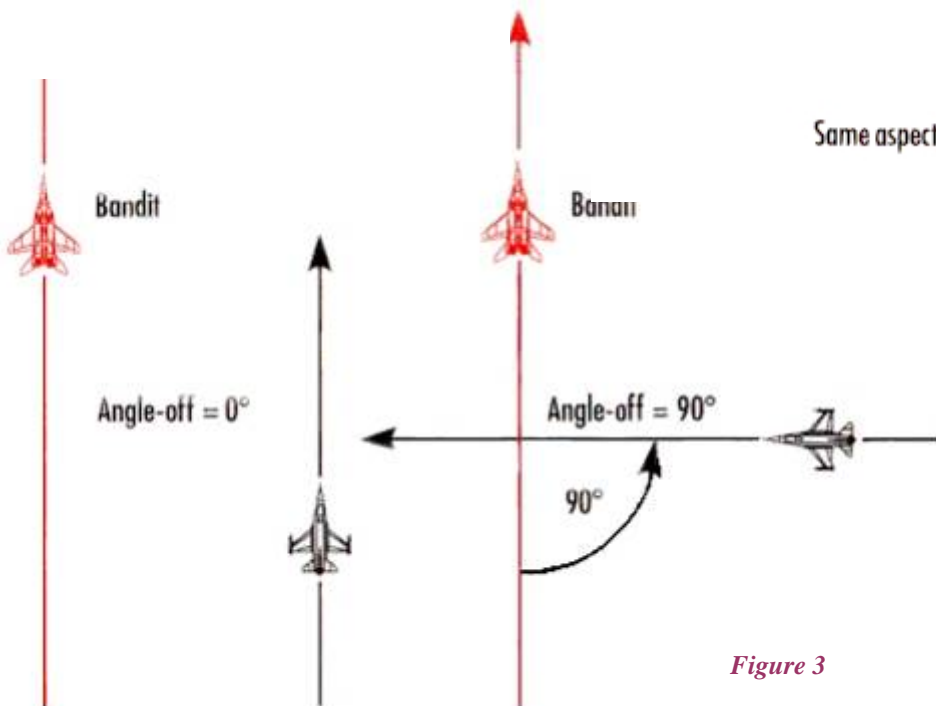
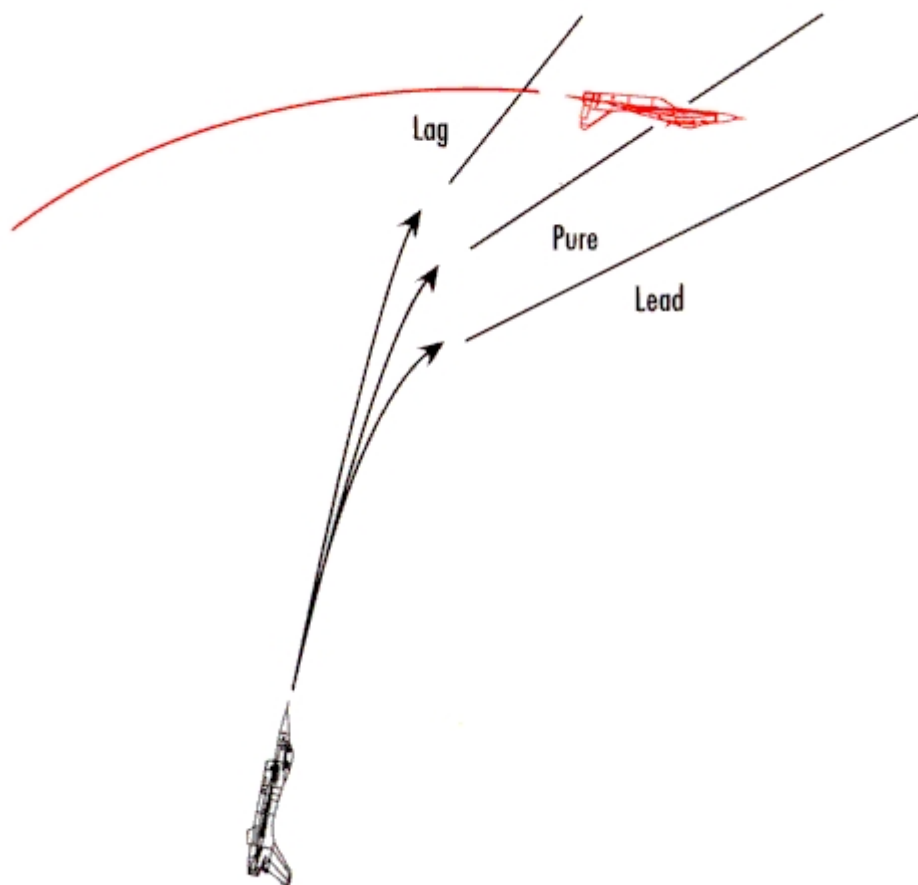


Figure 3

Attack geometry: Attack geometry describes the path that an offensive fighter takes as he converges on the bandit. To start an attack on a bandit, there are three distinct paths or pursuit courses that you can follow:

- *lag pursuit*
- *pure pursuit*
- *lead pursuit.*

- * If you are pointing behind the bandit, you are in **lag pursuit**.
- * If you are pointing directly at the bandit, you are flying a **pure pursuit** course.
- * If your nose is out in front of the bandit, you are in **lead pursuit**.¹



¹ If you are developing Falcon for profit, you may also be considered “in Lead Pursuit”.

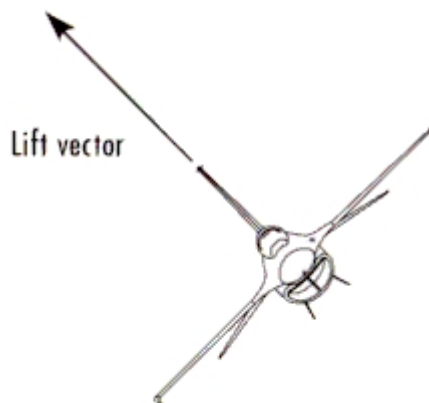
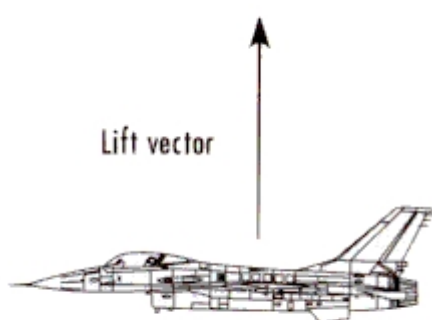
LAG PURSUIT → *Used for approaching the bandit.* Used when the attacking jet drives “out of plane”. Lag pursuit requires the attacking jet to have a tighter turn circle than the prey. If the prey has a tighter turning circle, then the attacking jet will NOT be able to rate his nose onto the target, and will thus be “stuck” in lag-pursuit ad-infinitum.

PURE PURSUIT → *Used to shoot missiles at the enemy.* Flying a pure pursuit course all the way into the bandit will lead to an overshoot. For this reason, you should only point at the bandit when you are going to shoot.

LEAD PURSUIT → *Used to close on the bandit; Used for gun shots.* Flying a lead pursuit course is the fastest way to get to the bandit because you cut him off in the sky. The problem with establishing a lead pursuit course too early is that you can very easily overshoot the bandit. If you are fighting a similar aircraft, such as the MiG-29, you will not normally be able to stay in lead without being forced into an overshoot. *It is important, however, to establish lead pursuit at the proper time in the fight because it is the only way that you can get into the gun envelope.*

WHICH PURSUIT COURSE TO CHOOSE...?

- Attacker in same plane of motion as defender → Velocity dictates choice.
- Attacker in different plane of motion to defender → Lift vector dictates choice.

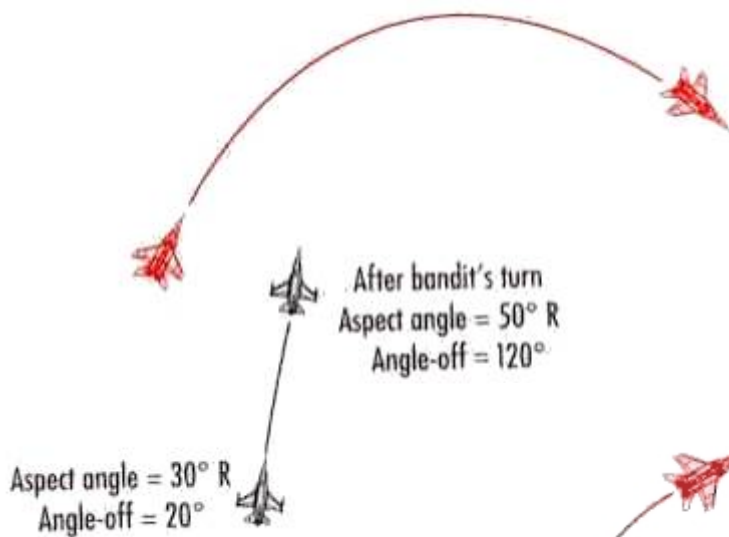


Lift vector describes the invisible line which projects outward from the a/c, perpendicular to the wings. When you roll and pull G's the a/c will track toward the lift vector.

OFFENSIVE BFM

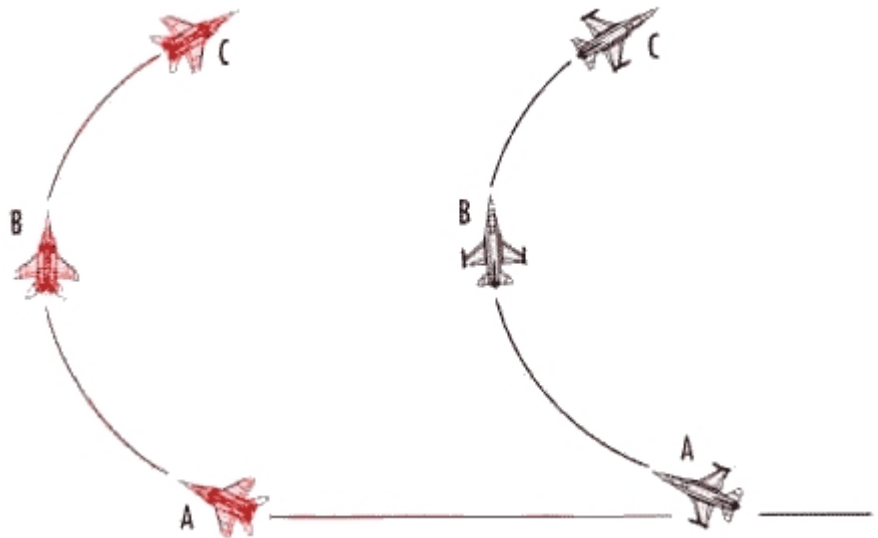
The obvious goal of offensive BFM is to kill the bandit as quickly as possible. WWI produced a steady evolution of “tricks” and “moves” used in aerial combat. The sustained maneuverability of a modern fighter has made a “move-counter-move” discussion of offensive BFM obsolete. Modern aerial combat is more “fluid”; simply a matter of driving one’s jet into an offensive position, wherein the distinction between each “move” is blurred.

The primary use of offensive BFM is to counter a bandit's turn. When you are behind a bandit who is flying straight and level, it is a simple matter to control your airspeed with the throttle and fly around behind him. A turning bandit – however - will immediately create BFM problems.



By simply turning, the bandit has changed our aspect angle from 30° to 50° and our angle-off from 20° to 120°.

*However, simply following the bandit into the turn will not work, as we simply end up **BEHIND** him...!*



Turns

BFM is largely concerned with turns.

Let's examine the concepts of:

Power for position, Turn radius, Turn rate, Corner velocity and Vertical turns.

"Power for position" is an integral part of BFM. Fighters have two types of energy: kinetic and potential. Kinetic energy is simply the velocity or speed at which the jet is traveling. Potential energy is "stored" energy (such as fuel or gravity) that can be converted to kinetic energy. Think of it as a transaction. One may 'purchase' kinetic energy, by 'spending' potential energy. Always remember that – as with cash – you ALWAYS have a limit of how much you may spend.

Potential energy is directly related to aircraft altitude. If a jet is at high altitude, its potential energy is high (more to spend; more kinetic energy to purchase). If the same jet is flying at low altitude, its potential energy is low. One can trade altitude (potential energy) for speed (kinetic energy). But, transactions work BOTH ways. So – one can always convert kinetic energy back to potential energy. Therefore, one can convert aircraft speed back into altitude (potential energy for later 'purchases').

You can also exchange energy for nose position. Anytime you maneuver or turn a fighter; it "costs" energy. When you turn a jet at high G, you "spend" or lose energy.

Apply to weapons. One way to increase a missile's effective range is to launch at a significantly higher altitude than the bandit. This will give your missile a reserve of potential energy that it can convert into kinetic energy

Turn Radius is simply the size of the “circle” in which you are turning in the sky. If looking from above, the distance (in feet) from the centre of the circle to your aircraft is the turn radius.

Turn Rate is simply how fast your nose is moving around that circle.

Corner Velocity is the optimum speed at which your a/c will describe the most efficient circle. One may mistakenly think that going slow will give the optimum turn radius. Not so. Gravity plays an IMPORTANT role in turn radius. At lower speeds, those “Gs” are not available. Conversely, “pedal to the metal” is also ineffective for the same reason. We need a compromise between speed and gravity; rate and radius. This is the corner velocity. **For your f-16, the corner velocity is 450kts.**

The airspeed of a jet can be controlled by the pilot in the following four ways:

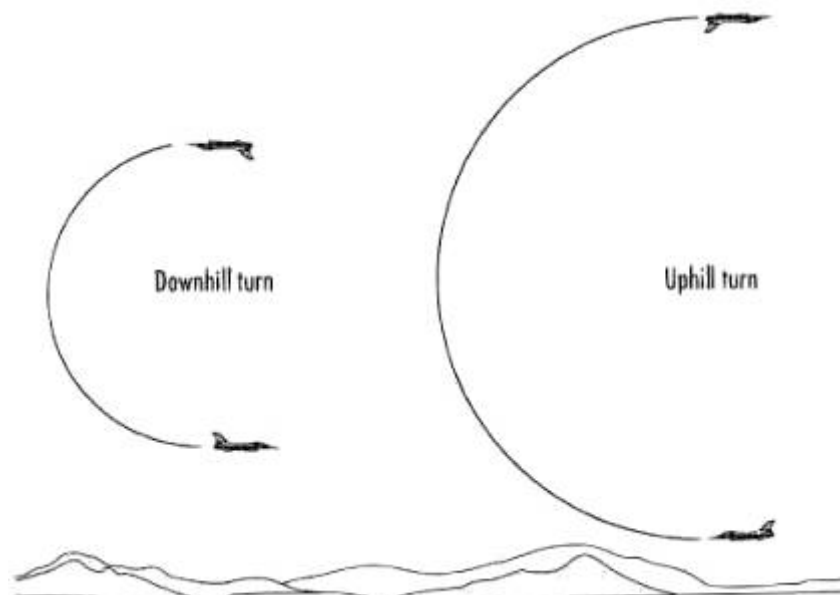
- Throttle position
- Drag devices (*such as airbrakes*)
- Nose position in relation to the horizon (*above costs energy; below buys energy*)
- Aircraft G (*see Vertical Turns*)

No modern fighter flying at medium altitude can stay at corner velocity while pulling max G's for long. As you pull G's, you will get slower. It is important, however, to start maneuvering close to corner velocity because ***the first turn you make is usually the most important in the fight.***

Think in terms of both turn rate and turn radius. Fighter pilots have a simple two-word saying: **"Rate kills"**. The ability to move (or rate) your nose is the primary means of employing weapons. A bandit may have a tight turn circle, but if you can rate your nose on him and shoot, the fight is over.

Vertical Turns: Your a/c attitude affects G availability. If you pull the nose of a fighter straight across the horizon, gravity will have no effect on your turn performance. When you pull the nose up or down, however, gravity becomes a player. The extra G you can get by placing your nose below the horizon when you turn can give you at least 2' per second turn advantage. Most of the time, 1G equates to 3°-4° per second.

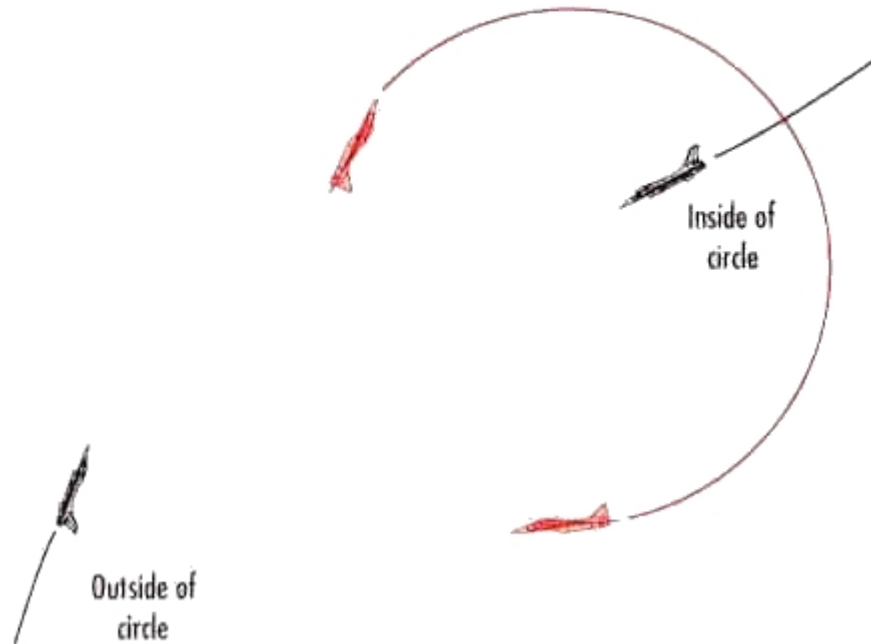
The effect of G can be seen in the image below. Notice that the fighter with his lift vector below the horizon is turning tighter. What is not so obvious in this figure is that the fighter turning toward the ground is also moving or rating the nose faster.



Turn Circles – Turn circles are simply the “circles” that aircraft trace as they turn in the sky. *For offensive BFM, the attacking jet must stay within the bandit’s turning circle.* If you are outside the bandit’s turning circle, the bandit will have time to completely come around, and face you head on. Thus – if you do not drive your jet **INSIDE** the bandit’s turning circle, the fight will become a “Head-On” rather than “Offensive” engagement.

In order to turn and solve BFM problems created by the bandit, you must first drive your jet inside the bandit's turn circle.

Any maneuvering you do outside the bandit's turn circle will delay you from getting inside the bandit's turn circle.



You must be inside the bandit's turn circle in order to turn and solve the BFM problem.

Anytime you can take a shot and end the fight, do it. The problem is that when you start from 1.0 to 1.5 nm behind the bandit and he turns, you will only be in AIM-9M parameters for a very short time. Heaters don't like the high line-of-sight rates generated by targets in tight, turning fights. You have time for one shot. If you miss, you had better be ready to put some offensive BFM on him, or you will end up wearing an AA- 11 Archer. The end result of your best offensive BFM will be a gunshot. Here is how you do it.

The bandit turns. Ask yourself: "Am I inside or outside the bandit's turn circle?"

How do you know? If the bandit's present turn rate will force his nose on you or even close to you, you are outside the bandit's turn circle. For modern fighters at high G, *you are normally outside the bandit's turn circle at ranges outside 2 nm; at 1 nm, you are normally inside the bandit's turn circle*, and between these ranges, you are in a transition zone. These ranges, of course, do not really matter to a fighter pilot. When you start behind a bandit, you simply fight what you see. As the bandit turns, you predict where he is going and maneuver based on this prediction. For example, if the bandit is only pulling 4 G's, then at 2 nm you are still inside his turn circle.

If you are outside the bandit's turn circle at the beginning of the fight, you are not in an offensive fight-you are in a head-on BFM fight. If that is the case, just think about an AIM-9M shot. The bandit cannot shoot you until he gets his nose around to within about 40° of your jet. You should be able to get one good missile shot at him before he forces you inside Rmin.

Remember, *to fly offensive BFM, we must drive our jet inside the bandit’s turn circle.*

Okay – let's put the theory into practice. Let's drive into the Entry Window...

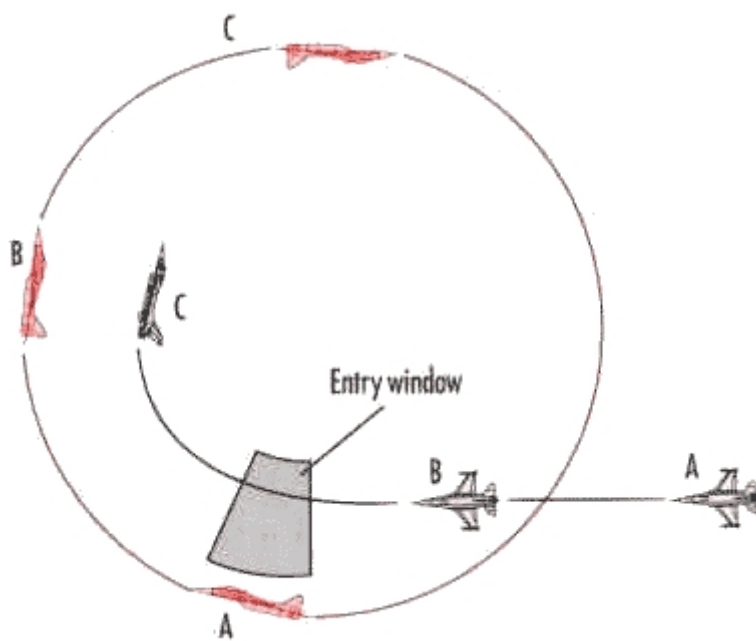
GUNS, GUNS, GUNS

Flying good offensive BFM against a bandit will put him right in your gun sights. You'll get him there by under-standing the dynamics of getting into position, closing and firing.

How and when to turn to stay behind the bandit...? You are inside 1.5 nm on a hard turning bandit, and you need turning room to get around on his six. The first step is to observe the bandit's turn. If you are outside the bandit's turn circle, get ready for a head-on BFM fight. If you are near or inside the bandit's turn circle, you have a positional advantage that you can keep. Shoot, if a shot presents itself, but don't get mesmerized watching your own missile and forget to BFM.

Driving into the Entry Window: Next, drive to where the bandit started his turn. If the bandit drops flares or chaff, he will mark the point in the sky where he started his turn. Drive to this position. This spot is *the entry window*. The entry window is located inside the bandit's turn circle. ***You can start your high G turn into the bandit once you arrive inside this window.***

In the below image, the F-16 drove in a lag pursuit course to a position inside the bandit's turn circle. By driving to this position, the F-16 gained horizontal turning room that the bandit can't use or take away. ***You know you are at the entry window and must start your turn when the bandit is approximately 30° off your nose.***



When you get into this relationship with the bandit, start your turn.

Remember corner velocity. If you arrive at the window too fast or too slow, you will get stuck in lag pursuit because you will not have sufficient turn rate to get your nose out in front of the bandit.

The next step is to pull 7 to 8 G's into the bandit. As you come around the corner, keep your nose in lag. If you see the nose of your jet approaching pure pursuit, ease up on the G. Hold this lag pursuit course until you get within 3,000 feet of the bandit. At this range, go to lead pursuit and get ready for a gun shot.

When you arrive ***inside 3,000 feet on the bandit with your nose in pure or lead pursuit, your throttle controls your overtake.***

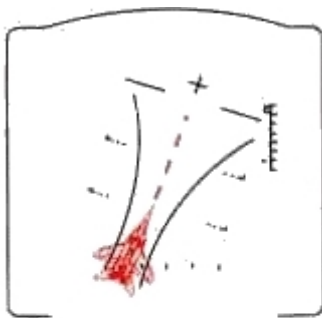
Remember this → In close to the bandit, with your angle-off less than 45° and your nose in pure or lead pursuit, the position of your throttle controls your closure. **When you get saddled up for a gun shot, you must match airspeed with the target.** In most cases, this will require constant movement of the throttle. In addition to banging the throttle off both stops, **you may have to maneuver out of plane to control your airspeed.** If a throttle reduction and the speed brakes don't slow you down enough, roll the jet to orient your lift vector out of the bandit's plane-of-motion and pull. Hold this lag pursuit pull for about two seconds; then ease off the G and watch the bandit. When he starts to move forward on your canopy, it is time to pull back into him. Pull your lift vector out in front of the bandit as you pull down.

Taking a Gun Shot: You are inside 3,000 feet on the bandit with your nose in lead.

You must be in range. This range varies, depending on aspect, but it is usually about 2,500 feet at low aspect angles and about 4,000 feet at high aspect.

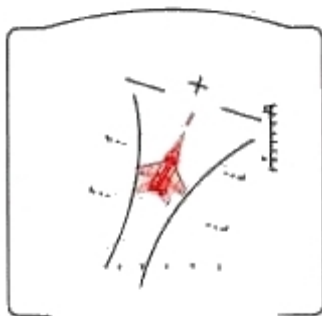
You must have your nose in lead pursuit. The bullets fired by the gun are unguided projectiles that take time to get to the target. For most gunshots, the bullet time-of-flight (TOF) is .5 to 1.5 seconds. If you point directly at the target and fire, the bullets will pass behind the target. Since the bullet is not moving at the speed of light, you must pull lead. However – at close range - this lead may not be very pronounced.

You must be in the bandit's plane of motion. When an aircraft turns, it carves a circle in the sky that creates a plane. In order for you to hit the target with the gun, you must be turning in the same plane as your target. For example, if the target is flying a loop and creating a vertically oriented plane of motion, you have to be flying a loop in the same plane as the target.



High G & Shoot

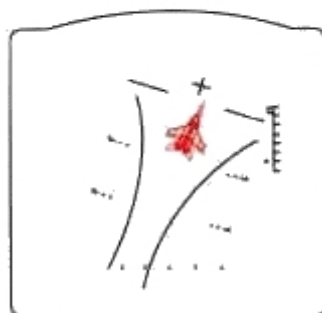
The Gun Sight: EEGS (Enhanced Envelope Gun Sight). The EEGS funnel allows the pilot to match the wingspan of the target with the width of the funnel to determine the proper firing range. The other important gun aiming cue in the HUD is the gun cross. The gun cross represents the departure line of the bullets. You can consider the gun cross as the gun barrel. Bullets pass straight out the gun cross.



Ease off G while shooting

Place the gun cross out in front of the target. Picture the target with a long pitot boom sticking out the nose. The gun cross should be placed on this extended pitot boom. If the target changes his plane-of-motion, then fly to place the gun cross on the new position of this imaginary pole sticking out of the nose of the target.

Next, over lead the target by making the wingspan of the target extend past the funnel. This will place your bullet stream in front of the target's nose.



Cease firing

Fire the gun while easing up on the G. This will move the target from the bottom of the funnel to the top. Cease fire when the target's wings are inside the funnel.

DEFENSIVE BFM

It was stated that offensive BFM is not a set of specific moves but rather a series of fluid maneuvers. The same is true when you start with a bandit behind you. There are no magic moves that will move a bandit from your 6 o'clock to your 12 o'clock. In fact, ***if you fly perfect defensive BFM and the bandit flies perfect offensive BFM, you will get shot down.*** This statement speaks volumes about defensive BFM; it basically tells you all you need to know about being defensive... ☺

Defensive BFM is very simple: ***create BFM problems for the bandit***, and when he BFM's, try to counter his BFM to buy time and survive a little longer. By forcing the bandit to BFM, you may force him to make a BFM error.

Detecting the Bandit: Situational Awareness is PARAMOUNT. SA may mean the difference between being “Defensive” and being “Offensive”². Your three primary SA enhancers are:

RADAR
TWS
VISUAL³

Fundamental A-A Combat Rule: ***Fight the most immediate threat.*** Remember this especially whilst defensive. So – a MiG is on your six, and he fires a missile. When that missile leaves the rail and starts guiding on you, the MiG is no longer the biggest threat to your jet. The missile becomes the primary threat, so you must fight the missile.

Defensive BFM Vs Missiles: Fighter pilot axiom: ***“Fight missiles with aspect.”*** When a missile is fired at your jet in the aft quadrant, the best way to defeat it is with a maximum rate turn to put the missile on the beam (along your 3/9 line). In this position, the missile will have the worst possible line-of-sight rate problem to solve. Missiles fly lead pursuit courses to the target in order to achieve maximum range. If you hold the missile somewhere on your 3/9 line, you will make the missile pull the maximum amount of lead. You will also be moving across the missile field-of-view at the fastest rate. So → ***CORNER VELOCITY to put the missile on your 3/9 line.*** And remember to drop chaff & flares as you turn.

Defensive BFM Vs The Bandit⁴: MiG on your six...? If he fires a missile, you must follow the Fundamental Rule and fight the missile. But – before he does that, you need to create BFM problems for the Bandit. ***Make the quickest, tightest defensive turn you can make, STRAIGHT INTO the bandit.*** As you start the turn, you should place your lift vector directly on the bandit. This will give the bandit the most angle-off and aspect problems to solve. You will also deny him turning room by keeping your lift vector directly on his jet. Remember: CORNER VELOCITY...!

So you have rolled your jet to place your lift vector right on the bandit and executed your best high-G turn at corner velocity. What now? Now you must determine if your defensive turn is working. If the bandit is being forced forward from 6 o'clock toward your 3 or 9 o'clock position, then the turn is working. ***A bandit that starts outside your turn circle will be forced in front of your 3/9 line if you perform the defensive turn correctly.*** Your turn is working if you push a bandit forward towards your nose. Keep in mind that he can still shoot you! If the bandit has his nose in lead as you drive him forward with your defensive turn, be ready to defend against a gunshot.

² Fortunate people like T-Rex, for example, can always claim to be offensive.

³ Track-IR comes HIGHLY recommended by this Editor. (Thanks ddocg)

⁴ Burt Reynolds and Sally Fields notwithstanding.

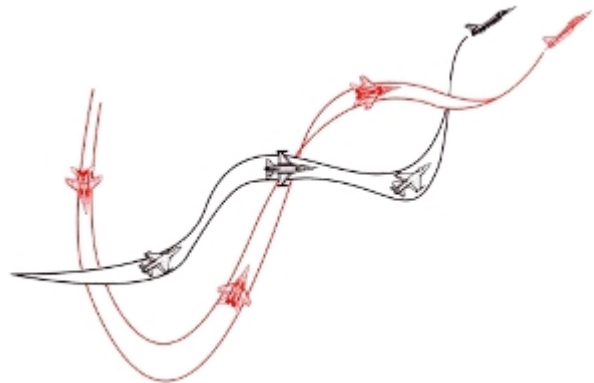
Remember, in order for him to take a gunshot, he needs to meet three conditions: he must be *in range*, he must be *in plane*, and he must have his nose *in lead pursuit*. If the bandit's nose is in lead pursuit, take care...! Even though he will overshoot, the bandit will probably attempt a gun shot at the pass. To defend against this type of gunshot, all you have to do *is break suddenly out of plane*. Because of the high line-of-sight rates involved, the bandit will not be able to correct in time and will overshoot. *A bandit that starts outside your turn circle and drives in with his nose in lead for a gunshot will overshoot.*

Defensive BFM Vs Bandit Inside Your Turn Circle: What if the bandit starts at 1 nm? Your reaction should be the same. Put your best defensive turn on the bandit and see what he does. When a bandit starts close to your turn circle, he is a serious threat, and your best defensive turn may not force him forward. The bandit's best option will be to fly lag pursuit to get to your turn circle entry window. When a bandit starts inside your turn circle and drives to lag, you are in for a long day. The best course of action is to *continue your high-G turn and try to stick his nose in lag*. Unload the jet (*release the G*) and extend for energy...? The problem with an extension is that it is very hard to judge how long to keep the jet unloaded and driving straight. *If you unload and accelerate, the bandit will move quickly to deep 6 o'clock*, and you will probably attract an AA- 11 shot. Better to continue turning and see if the bandit has a sufficient turn rate to get his nose around on you. If he does, get ready for gun defense.

With LUCK – however - the bandit may not fly perfect BFM.

What if he climbs above you? *If the bandit pulls into the vertical for turning room, keep the hard turn coming with your lift vector directly on the him.* As you pull up into the bandit, watch him. If he keeps his nose high, you will end up in a neutral position on the bandit because you are slower and have a smaller turn radius.

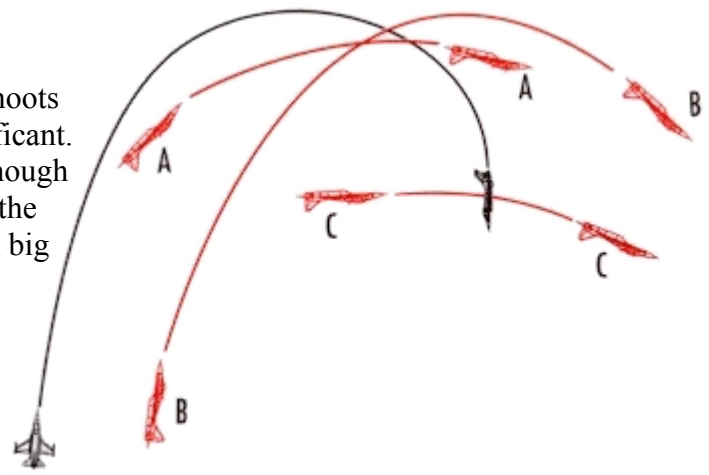
In this type of fight, you will end up in a scissors. Scissors occur when two fighters are in a line-abreast, neutral position. They both pull for each other's 6 o'clock position and, as they pass, they roll back into each other and pull. The scissors is usually won by the fighter that can slow his forward velocity, in relation to the bandit, the quickest.



What if he flies a lead pursuit course? If a bandit starts at 1 nm back and flies a lead pursuit course, he will probably overshoot. In order to force the bandit to overshoot, however, you must be executing your best turn. *The bandit will not overshoot if you are 50 or more knots slower or faster than corner velocity, or if you are not pulling enough G.*

Overshoots: What if the Bandit overshoots? It depends on the nature of the overshoot. There are two type of overshoots: *the flight path overshoot* and the *3/9 line overshoot*. A 3/9 line overshoot is always tactically significant, while a flight path overshoot may not be.

In the image to the left, **Aircraft A** slightly overshoots the F-16's flight path. This is not tactically significant. **Aircraft B** overshoots the F-16's flight path far enough that he **may** end up line-abreast or out in front if the F-16 reverses his turn. **Aircraft C** is obviously in big trouble because he has blundered past the F-16's 3/9 line.



3/9 line overshoots are always significant.

When you predict that a bandit may overshoot, note the range, angle-off, and the line-of-sight rate of the bandit. His position, in relation to you, will dictate how you will reverse. As a rule of thumb, **the greater the range when he overshoots and the slower the line-of-sight rate, the less chance you have of forcing him out in front of your 3/9 line with a reversal.**

When a bandit overshoots, there are basically two ways to reverse your turn to take advantage of it. **If you see the bandit is going to overshoot with a high line-of-sight rate, you should perform an unloaded reversal.** To do an unloaded reversal, simply release the G, roll the aircraft to position your lift vector directly on the bandit, and then pull maximum G directly at him. You should only use this reversal method when you are sure that the bandit will overshoot. **This type of reversal does not "force" the bandit out in front of you;** it just gets your nose on the bandit quickly when he does overshoot.

The other type of reversal should be used with caution. It is called a loaded reversal. **To execute a loaded reversal, keep the Gs on the jet as you roll and pull toward the bandit. This type of reversal is used to "force" a bandit that is about to overshoot into an overshoot.** The problem with a loaded reversal is that, if you execute it and the bandit doesn't overshoot, you will have a bad guy in your chili at close range, and you won't have the air-speed to maneuver. **A loaded reversal is used to stop your aircraft in the sky, and if doesn't work, you're in trouble.**

Overshoot rules of thumb → *When in doubt about a bandit's overshoot, don't reverse your turn. It is best to reverse when a bandit is overshooting your flight path inside 2,000 feet with a high line-of-sight rate. Outside 3,000 feet, it is best not to reverse your turn. The bandit has too much room to correct his overshoot and maintain a 3/9 advantage on you.*

Guns Defense: The bandit flew perfect offensive BFM? Here comes the gunshot? When a bandit is closing with his nose in lead, think "snap-shot". **To defend against a snapshot, break out of plane.** It is better to make it too soon rather than too late. If you go early, the bandit can correct, but when he does, you can jink out of plane again. If you jink late, you may die. How about tracking gun shots? In a tracking gunshot, the bandit is in a stable position behind you and will take multiple shots. You must make multiple out-of-plane jinks. **The key to tracking guns defense is to make sudden jinks at least 70° out of plane with the attacker.** Keep a tally on the bandit, and before he gets established in this new plane of motion, jink again. This type of defense is a random guns jink.

PETE BONANNI CONCLUDES: *Offensive* → you must remain aware of your position relative to the bandit's. Control your airspeed or lose the fight. Corner Velocity + Entry Window. *Defensive* → Put your lift vector on the bandit, pull hard and watch what he does. NEVER give up. Push the aircraft to it's limits at all times, and maintain the will to survive.