

Feature

# LOMAC and BVR: Beyond Visual Range Combat

by Jim "Hornit" Campisi



## Introduction

The use of missiles to kill an airborne foe at distances outside the range of the human eye. This term has existed in the realm of air combat for quite some time. The ability to actually carry it out, at least on a regular and reliable basis, has not. The definition is simple. The actual execution is rather more complex. The history of air-to-air combat is not a long one. Only in the last twenty years or so has the technology existed to shoot down another aircraft at ranges considered outside the "visual" arena. Normally, engaging a target outside of about 15 miles would be considered a BVR fight. It can happen at much greater distances, but tactics and weapons will dictate the actual ranges at which the kill takes place. The technology exists today for reliable, accurate, and effective BVR combat. Missile and radar electronics are robust and lethal. The real problem comes with tactics, command and control, and positive identification. The most difficult of these is obviously one of identification. How can we be sure the aircraft we are shooting at is a bad guy? This is a tough problem but it's not insurmountable.

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BVR combat has been the goal of aircraft and weapons designers since the dawn of the radar guided missile. Some time after the Korean War it became possible to shoot down aircraft outside of the visual arena. The Cold War drove technology at a furious pace and the development of the SAM (surface-to-air missile) helped to accelerate the air-to-air aspects of radar and missile technology simultaneously.

During the late sixties and early seventies it became evident that BVR engagement of aircraft was a very desirable and possible goal. With the advent of the cruise missile it became paramount to have the capability to shoot down multiple targets at long ranges outside the visual arena. Development of high power and accurate long-range radar has given us the ability to realize this concept. The development of the F-14 Tomcat and the Phoenix missile as a pure BVR platform is a prime example. The F-14 was designed to protect the carrier battle group from attacking bombers and cruise missiles with engagement ranges of 100 miles! We don't need to get into nitty-gritty detail on the history and development of radar and missile technology. It's actually rather boring. I am betting the reader has at least a rudimentary knowledge of how radar works and the current state of the art when it comes to long range air-to-air weapons.

The object of this article is to introduce the concept and talk about how one can be successful in this arena. Also some tips and comments on how to succeed in LOMAC will be provided.

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As I mentioned earlier, one of the really huge problems with BVR combat is how to identify friend from foe. Shooting down friendly aircraft is something to be avoided at all costs. There are many layers of complexity involved in making sure you kill the bad guy — and not your wingman. Tactics and procedures help to minimize the threat, and electronics back up the tactics. The use of IFF (Identification Friend or Foe) is used to ID targets. Also, geographical coordinates and flight patterns can be used to distinguish good from bad. IFF is nothing more than a transponder that is interrogated and replies with a specific code. If the code is correct, it's a friendly. If not, lock and load. Most of the time there will be very descriptive Rules of Engagement (ROE). The ROE will drive the type of engagements. True BVR fights on a large scale are not likely in this day and age. With the demise of the Soviet Union, it's not likely we will see huge air-to-air battles in the near future. There has historically been very little true actual hostile BVR air-to-air at all. Most of this has taken place as small engagements with few aircraft. That won't change in the near future.



Let's take a look at the mechanics of a BVR engagement. As we know you have to have an operating radar and the weapons to effect an engagement outside of visual range. A lot will depend on the ROE as I stated, but let us assume we have a hot shooting war, and well defined battle lines and airspace. For simplicity's sake we will only go 1V1 against a third or fourth generation fighter. It has to be assumed that the opponent has full weapons capability and we must treat him as lethal. A lot of things can be surmised by who we fight and where we do it. You will likely know what type weapons and how good (*or not good*) your opponent is in the real world. Intel is not always correct, so assume the worst!

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The first part of a BVR engagement involves detection. Once detected, we resolve the targets ID. With a positive ID we employ weapons in such a manner as to kill without getting killed. Our goal is to utilize our BVR capabilities to kill the enemy before we have to enter the classic "furball" once inside the visual arena. If we manage to screw up bad enough and have the enemy in close, we have done something very wrong. Your last ditch engagement is one with IR missiles and guns. You really do not want to be in this position. Fighting in a phone booth is a good way to get you and your wingman killed. If you get into a high G turning fight, historically you don't last very long. You highlight yourself with afterburners and missile shots. The life expectancy in a knife fight in hostile airspace is something like 30 - 40 seconds. It's a big waste of taxpayer dollars too! We want to take advantage of our technological superiority and kill bandits at long range. We don't want the bad guy to even know what hit him. We have this capability, but it takes training and discipline to make it work. There are things to consider

during each phase of the process. Success will depend on the ability to understand some basics about geometry, radar, and missile capability. For ease of explanation we will look at three phases of a successful BVR air-to-air engagement.

## Detection

Depending on the mission, there are many ways to detect a potential target. It could be as simple as a dot on your scope, or as complicated as a data linked target on your situation displays provided by ground or airborne assets hundreds of miles away. Utilizing the radar to find and track a target routinely is only done with a lot of practice. A pilot has to be extremely proficient in the expert use of the radar and all its capabilities. Proper employment of the radar will yield a picture of the enemy threat. Targeting is done by the individual flight, based on threat assessment or by AWACS or ground controlled radar. First and foremost is how do we go about employing a weapon to kill this target without getting killed ourselves. There are a lot of unknowns in air combat. Many times a pilot must give his best guess using experience and the assets available to make decisions about how it's going. No matter how it's done, at some point you have to use your radar to get some info on the potential target. Doing this may alert the enemy and it may not, but it's a chance you must take. Radar warning gear will tell you if you are being probed or locked. The bad guy may have this information also. Once we use our radar to get this information we must assume the foe is alerted. Initial detection should build a picture of what is going on. IFF and communication with AWACS or data link will confirm whether or not our "bogey" is hostile. Once we determine an intercept is desired, we set up geometry to enable our weapons to be employed as fast as possible.



## Prosecution

Once the decision has been made to destroy the target, we move into the prosecution phase. A lot will depend on the range at detection and the target actions. What kind of aircraft is it? What type weapons is he carrying? All good questions and the fighter must assume the worst and plan on it. Two things we can do to improve our odds are climbing and accelerating. Climbing to a higher altitude will allow our missile to fly farther. Utilizing kinetic energy (missile flying downhill) and thinner colder atmosphere will allow our missile its maximum range capability. Range will vary dramatically as we change altitudes. A missile capable of a 40-mile kill at high altitudes may be hard pressed to make it to 20 miles at lower altitudes. Accelerating gives our missile that much more kinetic energy at the start of its flight enhancing

its range. It's not a lot, but you want everything you can get. At some point it will become evident to the opponent that they are being prosecuted. There are three possible scenarios. First (and most desirable) our foe continues on with no apparent action to counter our moves. Second, he turns and runs away! This may be just fine, as we will have denied the enemy the use of that airspace at that time. This may even be our mission and doing so without firing a shot is optimum. Third, he points his nose at us and turns on his high powered radar to lock us up! Lets take a look at each one and how we might handle it.



If the target runs away, we prosecute until we have successfully denied enemy use of the airspace for however long we need to. Mission accomplished. We remain on station until we need to do it again or we get relieved. In the situation where no response is noted, we press into a shot, or make him run prior to that. If you get to weapon release without a response, you will likely win the engagement barring any unfortunate failures. Unless your opponent is really lucky, he will die before he can get a missile in the air at you. Most kills even in the visual arena occur in this fashion with the foe not knowing what hit them. Our third choice becomes a much stickier wicket. If you can't get away with surprise and you have the SA (situational awareness) to continue to a missile shot, expect that your opponent will too. Your radar warning gear should be turned on and jamming used as conditions and equipment permit. You will likely expect the same thing to be used against you.

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For most of our scenarios (especially with LOMAC) you can expect the Russian aircraft will get a shot off first. Most of the ranges for these weapons are greater than western types and an experienced opponent will use this advantage. At this point our prosecution phase has usually wound up with the two fighters nose on to each other and accelerating. Having an idea about when a foe can fire will help determine what you do in the final phases of an engagement. While the miles count down we monitor our displays and shoot our first missile at maximum range. At this point we then do a very high G turn to the left or right to put the radar target at the edge of our scope. We call this a crank, or check turn. This immediately causes the opponent's missile to have to fly farther while our missile heads straight at him. This is also called an "F-pole" maneuver. If you're lucky, and there is no missile headed at you, you have a big advantage. He most likely now knows a missile is headed his way and must do something to

avoid taking it in the face. He will have to jink hard and employ countermeasures to shake your missile. Its likely he will be successful as at maximum range your missile won't have a lot of maneuvering capability left to stay with him. It's important to understand how missiles work at this point. Just because you get a "shoot" cue at max range, doesn't mean your going to kill your opponent. All a shoot cue means is the missile can make the range to hit the target if *NOTHING* changes. If the target jinks or maneuvers the missile has to also make the intercept.



This maneuvering uses energy and reduces its available G at intercept and reduces its range at the same time. The aircraft getting the first shot has a big advantage for obvious reasons. A missile has a motor that burns very quickly and then stops very soon after launch. Once the acceleration phase ends the missile is coasting to the target. The farther out it is, the slower it will be when it reaches the target. There is nothing wrong with using two missiles to kill an opponent. It's a good technique to use against an opponent that has a longer-range weapon. Disciplined pilots will hold a missile inside of max range as the closer you get the higher the odds of a kill go up. Its called P sub K or probability of kill. Closer shots yield higher energy/available G at intercept. Throwing a missile out at max range will cause an opponent to take his nose off of you and destroy his energy state trying to defeat your incoming missile. He may even lose radar contact with you. We term this "wasted" missile a "spoiler" meaning it is likely not going to hit, but it forces the bogey to react and defend against it as I mentioned above. It "spoils" his game plan.



## The Kill

Let's go back to our crank maneuver. We likely did this around 20 - 25 miles (longer if at high altitudes) and maintained our energy. We watch the missile time of flight and support it with radar energy as long as we need to. Russian weapons need to be supported longer usually and the ability to shoot multiples is not as good as in western aircraft. Supporting a missile means nothing more than maintaining a radar lock so the missile can get critical real-time information on what the target is doing. Missiles like the AMRAAM can be fired in certain modes which don't have this "support", but its optimum to provide it to the missile. Your P sub K goes up dramatically the longer that you can maintain the lock. The AIM-120 can be fired and at some point in its time of flight, the missile can complete the intercept with a high probability of kill without support. At that point, the fighter (shooter) can turn and run negating any missiles fired at it outside of 8 -10 miles. This better "fire and forget" ability is what gives western pilots an equalizing tool when it comes to dealing with the really long range missiles like the AA-10. Once we get a time out on our first missile, or no shot is detected against us we pitch back hard at the bandit. We fire another shot unless our first shot was successful. Right about now is when the BVR engagement ends and we enter the visual arena.



If you detect a missile coming at you, the only thing to do is to turn hard away from it and run. As a rule of thumb, if you think its closer than ten miles a hard turn into the missile coupled with a rolling maneuver will give you a good shot at defeating it. If you can see it visually then wait until its so close as to be uncomfortable and then a high G turn into the missile is your best defense. Chaff and or flares should be used as appropriate. Remember the longer the range you can detect a shot, the better chance you have of defeating the missile. Of course this is just a canned scenario, it won't always happen like this.



Another big problem with BVR engagements is how to tell if you got a kill or not. The bogey won't send you a personal message and there likely is no one around to confirm the kill. Inside 20 miles or so depending on the weather, you may see an explosion and you might not. It's likely that if you're still alive you killed the target, and you better watch for his wingman.

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Another key will be your radar and your warning gear. AWACS can sometimes confirm a kill as it can see better resolution than fighters radar, there may even be parts falling. Whatever happens, don't go scouting for your kill. Maintain mutual support and hurry back to your station/friendly airspace and determine your fuel state and further combat capability.



## Defense in the BVR Arena

When you press a bogey/bandit into a BVR engagement its not always going to go the way you want. As was pointed out above, if you're flying a western aircraft, you're likely at a disadvantage when it comes to the idea of a missile joust. Most Western fighters don't possess a true long-range missile (yet) like the AA-10 or AA-9. Even though the enemy may have an advantage with pure range and first shot,

it doesn't mean you can't win. There are a few basic tactics that will work to level the playing field, but remember the bad guy can employ them too.

Let's say we have detected and are prosecuting a bogey that has been confirmed to be hostile. The bandit has us locked and your radar warning is indicating a shot has been taken. You're still 12-15 seconds away from an Rmax (max range) shot on the HUD, what do you do? At this stage you don't have to give up and run. The first tactic to try is the "beaming maneuver". Simply stated, you do a high G 90 degree turn left or right to try and destroy the Doppler shift for his radar. Most likely this will break lock and the missile won't be able to engage you. The radar needs to "see" the high closure or Doppler shift values on the returned energy to maintain a lock on your jet. Be aware that some versions of the later Russian missiles, particularly the R-77 (AA-12) will have an active capability so your not necessarily out of the woods.

The beam maneuver will also work against the missile itself once its gone active. This beam maneuver, also termed "using the notch" (for the Doppler notch) should be held for a short period of time and then you reevaluate what your radar warning is telling you. If missiles are still flying at you, you turn to put the missile/bandit at your six at the same time unloading the aircraft and heading for the deck at as fast as the jet can go! If you do this outside of 10-12 miles, you will likely defeat the missile. Hopefully he won't run you down or you have some place to go which is "safer".

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If the beam maneuver works we pitch back to reacquire and hopefully have evened up the missile range problem as the bandit now is looking at a shot but so are you. At this point if you can't build enough SA to continue, head towards safer airspace as fast as possible with your head on a swivel and good mutual support.

Turning and running 180 degrees from the bandit is useful if you want to try and deplete his supply of missiles. A well-disciplined pilot won't let you do this more than once though. We use the term "drag" for the turn and run scenario, and it can work very well in a multi-plane engagement as the bandit tends to go "fangs out" when he sees this. It's an easy kill for a second flight or your wingman if the bandit does not see them yet. Conversely, don't let a bandit do this to you. If they turn and run let them! As I said previously, much would depend on what your mission is and how you accomplish it. Denying the enemy use of the airspace for a determined time, or protecting another group of aircraft may be the mission at hand. If you suck the fighters away from that goal your mission is accomplished. We all want to shoot down fighters but its not always required.

Jamming and electronic countermeasures are another great equalizer. Using good jamming gear will also help to even out the playing field, especially when it comes to missile shot parameters. You may not be able to totally defeat a missile or radar, but you will degrade it to a large extent. Sometimes this may be enough to get off that important first shot in a BVR fight. It's generally accepted that western aircraft and missiles are slightly better at this game and this helps to make it a more even game. Remember that using jammers is going to highlight your position, maybe not exactly, but it will show a general direction in which to look. Also be aware that the Russians have designed missiles which can

home on this jamming energy and can really ruin your day!



Some basic rules to live by:

1. Know how to use your radar effectively to detect and track targets.
2. Know your enemy and their capability.
3. Know your weapon envelopes and those of your opponents.
4. Use all the tools at your disposal AWACS, RWR, DL, etc.
5. Always assume the bandit carries several rounds of his best weapon.
6. Be Aggressive!

## LOMAC and BVR

I have had the chance to fly several versions of LOMAC prior to the Gold Release version. So far I have been really impressed with the BVR combat modeled in the sim. The software versions used are all pre-gold release candidates, so some features had not been implemented yet and I am sure some things may change with the final boxed version. A lot of what I know of real world ACM and BVR combat applies in this simulation. I have to say its rather daunting to go against most of the more capable Russian aircraft in this sim. Using the F-15C you are most of the time at a disadvantage in the BVR arena. The F-15C radar is very capable and you can play in full realism mode or just use the arcade mode. The arcade mode is pretty easy to use and interpret. I know a lot of folks will balk at this but here is my take on the "arcade" mode. It's definitely a "fun" mode, but I submit that with current day hardware and tactics it's actually not too far from what real F-15C pilot would actually use. The ability to data link targets and provide the same kind of display you see in "arcade" mode to real world pilots is very similar. I know the purists in the crowd will fall off their chairs on this one, but trust me, I think the displays in the real aircraft are actually *EASIER* than this. Yeah, no kidding! Can you say JTID's? Link 16? I know that you can! Just pick up a copy of *Aviation Week and Space Technology* and read it. You will see what I mean. The west has a *HUGE* advantage in the ability to find targets, track them, and prosecute them. I don't think anyone else can even begin to approach this capability at present. It gives the U.S. and some other western countries a large advantage in the air-to-air arena. Knowing where a target is, your wingman, and other flights both hostile and friendly is a definite plus. Being able to data

link this info securely and use it to sneak up on bad guys without even turning radar on is a giant advantage.

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One of the things I did a lot of in the sim was air-to-air engagements at long range. For the most part I was really impressed. I spent plenty of time watching my burning jet flutter to the ground as Su-27's and 33's danced happily by. I did get my share of kills though. On lower AI settings, the AI is definitely reluctant to shoot until very close. This allowed me to usually employ missiles first. The targets appropriately attempted to defeat my incoming missiles and did this very routinely, but they usually soaked up my second missile as they pitched back into the fight around 10 miles or so. Now push the AI slider a bit higher and hold on to your hat boys! Once you go above the "Good" setting, the AI gets tough. On Excellent they will give you fits and you are going to be really challenged. When it comes down to the visual arena, things are really good also. Going 1V1 guns is really rewarding, just like past Flanker simulations. This is probably some of the better dog fighting I have experienced in a sim in quite a while.



One thing I noticed about the BVR engagements was the fact that the AI seems to know on every engagement exactly when I fire at them. The reaction is immediate and they do appropriate defensive maneuvers for the incoming missile. They are very successful usually — and this makes it really fun — and you must stay on your toes. You can use this to your advantage though. As I said previously, when the target goes defensive they are likely not shooting at you, so if you're feeling intimidated, let a missile go even outside of max range. The bogey will go defensive and give you a chance to even out the engagement by letting you in closer. I saw this almost every time on the higher AI settings. Overall the sim is outstanding and the radar modeling and AI are top notch.

On the topic of the radar, it appears this sim is going to be very similar to Jane's F-18 when it comes to using the radar well. You will really need to *PRACTICE* this. It's an art and requires a good knowledge of how and why radar works. On the full realism settings the radar is tough to use. That's the way it is in

real life too. It's not magic and a lot of the fun comes with practicing in the sim. There are plenty of ways to get the practice too. I highly recommend the *Fast Battle Planner* to lay out lots of targets and just go to town with the different radar modes to get good at it. It's a pretty steep learning curve, but it's definitely a rewarding one.



## In Conclusion

The fun part about all of this is we have a new flight sim that allows the actual use of these tactics. LOMAC gives one a great appreciation for the complexity of air combat. An appreciation of BVR combat can be gained by learning to use all of these tools in such a high fidelity simulation. LOMAC does a good job in the BVR arena and you will get plenty of chances to kill beyond visual range. For more discussion join me in the **LOMAC Forum** and other **Forums** here at SimHQ. I love talking about this stuff!

## Test System Specs

This is the computer used in this article:

- Pentium 4, 3.0GHz
- Gigabyte GA-8IE motherboard
- Creative Audigy 2 Sound
- 512MB PC2100 DDR
- ATi Radeon 9800 128MB (non-pro)
- Windows 98SE

- 80 GB Maxtor 7200 rpm HD
- CH F-16 Fighterstick/ Pro throttle
- LOMAC Beta 15 and Gold versions

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