BVR combat

As you might expect, beyond-visual-range, or BVR, combat is the term used to describe aerial engagements when neither aircraft is able to detect the other with the naked eye. Air Power Association President, **Air Marshal (ret'd) Greg Bagwell CB CBE**, examines what's required to 'reach out and touch' an enemy aircraft.

In a previous article I discussed the finer arts of dogfighting, a situation in which two or more aircraft engage in visual combat – see *Fighter agility*, August, p84-86. Usually this state of affairs arrives either because the aircraft haven't seen each other earlier or the rules of engagement have necessitated a visual identification. Of course, dogfighting was borne of an era when aircraft were only able to engage each other in combat using relatively short-range guns or cannon, normally in fixed installations. Now, we see combat aircraft carrying a much more varied and capable suite of missiles that are able to 'reach out and touch' another aircraft, dozens or even hundreds of miles away. Air combat today is a very different proposition than it was during the early days of air power. This includes the use of either third-party cueing (such as an airborne or ground-based radar) or onboard methods such as radar or infrared search systems.

The simple aim of BVR combat then is to engage and destroy a confirmed enemy aircraft before they do the same to you. This type of combat can be

***Above:** Flying over the Gulf of Mexico, 1st Lt Charles Schuck fires an AIM-7 Sparrow medium-range air-to-air missile from a 71st Fighter Squadron F-15C. The Eagle was supporting a Combat Archer air-to-air weapons system evaluation programme mission at Tyndall Air Force Base, Florida.* USAF/Master Sgt Michael Ammons ***Left:** An F-35A assigned to the 31st Test and Evaluation Squadron from Edwards Air Force Base, California, unleashes an AIM-120 AMRAAM missile against a QF-16 target during a live-fire test on June 12 last year.* USAF ***Right:** While Russian fighters have featured onboard infrared search and track sensors for many years, this technology is now being added to Western fighters in the form of pod-mounted systems that provide a passive detection capability in addition to radar. Seen on an F-16, Lockheed Martin's Legion multi-sensor pod includes an IRST in the nose.* Lockheed Martin/Alexander H Groves ***Far right:** An aviation ordnanceman takes a moment to rest on an AIM-7 Sparrow during flight operations aboard the aircraft carrier USS 'Abraham Lincoln' (CVN 72) in the Persian Gulf during Operation Southern Watch in 2003. Despite the appearance of more modern 'fire and forget' types, semi-active missiles like the Sparrow remain in many Western inventories.* US Navy/Photographer's Mate 3rd Class Philip A McDaniel

Above: ***A B-2A stealth bomber from the 509th Bomb Wing, Whiteman Air Force Base, Missouri, flies behind a KC-135R during a training mission over England on September 16. Among the challenges to BVR engagements is the proliferation of increasingly stealthy aircraft using radar-reduction measures to frustrate long-range detection. The B-2 was the product of cutting-edge design to defeat sophisticated air defence radars, whether ground-based or airborne.*** *USAF/Senior Airman Kelly O'Connor* *Below:* ***A 'wall' of F-15Cs ripple-fire AIM-7 Sparrow missiles at a tactical air-launched decoy off the coast of Hawaii during the Rim of the Pacific Exercise 2006. The F-15s were from the Hawaii Air National Guard's 199th Fighter Squadron from Joint Base Pearl Harbor-Hickam, Honolulu.*** *USAF/Tech Sgt Shane A Cuomo*

split into four simple phases, namely: detection, identification, engagement and disengagement. Let's investigate each in turn.

Detection

This is all about the use of any means at your disposal to try to pinpoint a potential foe. Since the Battle of Britain and until very recently, long-range detection was almost exclusively through radar detection (the reflection of radio waves from an aircraft's skin). However, while radars have become increasingly sophisticated, so has the design of aircraft to limit their reflectivity through stealth techniques that include optimal shaping of the airframe and the use of less reflective materials.

More recently, new techniques have come to the fore, which include infrared, sound or electronic detection of emitted signals. All of these have become increasingly effective and some can even be exploited by space-based assets. Ideally, today a BVR fighter would want as early a detection range as possible, but typically this might be between 50 and 100 miles (80 and 161km) against a non-stealthy combat airframe, and double that for a large aircraft.

Identification

This can be quite a challenge in BVR conditions, for obvious reasons, but a combination of intelligence from multiple sources may enable an almost forensic-like gathering of information, such as origin, tracks, behaviour and signatures, all of which begin to build a picture of just who that blip or blips on the radar might be.

Increasingly, modern aircraft will have a number of technologies on board that will aid early identification. Often referred to as non-co-operative target recognition or NCTR, these, as the name suggests, do not require

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***Right:** An E-3 from the 961st Airborne Air Control Squadron during a training exercise out of Kadena Air Base, Japan, last July. In most planned scenarios, Western fighters would be able to call upon the surveillance capabilities of airborne early warning and control platforms to aid in detection of aerial targets at long range, while advanced data links mean that third-party cueing is becoming an increasingly relevant option.* USAF/Airman 1st Class Matthew Seefeldt ***Below:** An F-22 positively identifies a Russian Tu-95MS bomber west of Alaska on September 11 last year. A combination of multifunction low-probability-of-intercept AN/APG-77 radar and long-legged AIM-120 AMRAAM missiles means the stealthy F-22A is well equipped to tackle airborne threats at considerable standoff range. In practice, however, a fighter will often have to get close to its (potential) quarry to determine its true intent.* NORAD

"Rather than firing first, it's who fires with the best probability of kill who prevails."

***Above left:** Two F-15Es from the 90th Fighter Squadron, from Elmendorf AFB, Alaska – a unit that has since traded its Eagles for Raptors – fire a pair of AIM-7Ms during a training mission off the coast of Florida. Despite its primary offensive mission, the Strike Eagle can, if required, call upon Sparrow and AMRAAM missiles for the BVR fight.* USAF/Maj Gary ***Above right:** Modern multi-role fighters like this Swedish Air Force JAS 39C Gripen are able to undertake BVR engagements that were once restricted to dedicated long-range interceptors, while at the same time carrying out precision strike and other missions. This Gripen carries a mixed payload of Small Diameter Bombs and a targeting pod, plus short-range IRIS-T and ramjet-powered Meteor AAMs.* Saab/Stefan Kalm

the 'target' aircraft to assist in the process.

Of course, knowledge of exactly what that return is might still be insufficient and their 'intent' will also often be key in deciding if they can be engaged or not.

Engagement

Assuming a hostile aircraft has been identified and it meets the criteria for engagement, the next phase is quite simply the act of shooting them down before they (or any other 'hostiles' in the area) can do the same to you.

But firing first and immediately isn't the default action. Increasingly, fighter aircraft are equipped with active missiles that are capable of homing on to a target autonomously; on the other hand, the older semi-active missiles require the target to be constantly illuminated (usually by the radar of the aircraft firing the missile) throughout missile flight. The major disadvantage of semi-active missiles, therefore, is that the illuminating aircraft has to continue pointing at (and therefore getting closer to) the target throughout the missile flight time. In contrast, active missiles, more commonly known as 'fire and forget', allow the launching fighter to begin its escape manoeuvre long before the weapon has reached its target.

But even active missiles will have some limitations on the range at which they go active, plus their kinematic performance (energy) will degrade as distance increases. So, there will be some rules of thumb when employing such weapons that give the best possible probability (or even certainty – known as a no-escape zone) for a 'kill'. Rather than firing first, it's who fires with the best probability of kill that prevails.

Disengagement

This involves more than just heading off and looking for the next fight; it's an integral part of the endgame of the one you have just left. If the enemy aircraft you have just engaged is also equipped with active missiles then escaping their shot is just as critical as trying to maximise the probability of a kill for yours. BVR can often resemble a game of cat and mouse, where each aircraft aborts an attack or several attacks while seeking to gain an advantage. And, of course, you must never discount the likelihood of other aircraft being in the area and the need to be constantly vigilant.

In this article I have dramatically shortened and simplified a skill which takes years to learn and refine, and relies on a complex fusion of sensors, where artificial intelligence can already aid the identification of the highest-priority targets. But no two engagements will be the same, and with the speed of closure typically being up to 20-30 miles (32-48km) a minute you have to think and act very quickly. The best and simplest way to describe BVR combat is that it's like 3D, supersonic, long-range chess, where you first have to find the other side's pieces, and where only the victor lives to fight another day. AFM

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