A look at select air-to-air missiles

An analysis of the main types and differences between Chinese, Russian and Western missiles

US Navy and Marine aviators have been using the Raytheon AIM-7 Sparrow and the AIM-120 advanced medium-range air-to-air missiles (AMRAAMs—as shown on the F/A-18C Hornet above) since their development in the 1980s. (Photo: US Navy)

This article examines the main types of air-to-air missiles (AAMs) which govern air combat. Modern air combat is extremely dynamic, and the presence/absence of capable AAMs and the skills behind their employment can make a significant difference in deciding the outcome of an air battle.

The main factors of AAMs that need to be considered are: weapon carriage capacity and the probability of kill (P_k). The P_k depends on several factors: the separation between the launch aircraft and the target aircraft; the speed, altitude and bearing/aspect of the launch aircraft relative to the target aircraft; the counter measures employed by the target aircraft; the agility of the target aircraft and the capability of the AAM itself. The no-escape zone (NEZ) of an AAM is defined as the zone in which the missile has enough energy to intercept the target aircraft, irrespective of any evasive manoeuvres performed by the target aircraft.

Specifically, there are three main types of air-to-air missiles. The first ones are "heat seeking" missiles, equipped with an infrared (IR) seeker that homes in on the heat generated by the engines of the aircraft and the friction between the skin of the aircraft and the surrounding air. Modern IR missiles are extremely agile and can even sustain turns of 50 g or more, have high off-boresight (HOBS) capability and can also be cued using helmet-mounted sights (HMS). HMS allows pilots to designate and lock the target aircraft by simply looking at them. The HOBS capability can be as high as 90 degrees, although missiles such as Israel's Python 5 and European IRIS-T also authorise a full 360 degrees launch envelope. Modern iterations also feature an imaging infrared (IIR/I2R) seeker which are programmed to recognise the expected shape of target aircraft, thus making them more resistant to countermeasures. Some IR missiles also feature multi-band ultraviolet (UV) seekers which allows for better discrimination between target aircraft and flares. Some of them are capable of lock-on-after-launch (LOAL) engagements and can be used for targets directly behind the launch aircraft (known as over-the-shoulder firing). Generally, these missiles are used for within visual range (WVR) engagements (or dogfighting), although France and Russia have also developed beyond visual range (BVR) IR homing missiles in the form of MBDA's MICA and R-27T/ET. Most prominent missiles in this category include the Russian R-73, American AIM-9 Sidewinder and MBDA's AIM-132 ASRAAM. Due to their passive nature, these missiles do not provide any indication on radar warning receiver (RWR) of the target aircraft, and their launch can only be detected either visually or with the help of missile approach warning system (MAWS). As such, WVR combat remains exceptionally dangerous.

The second category of air-to-air missiles are semi-active radar-guided missiles. These missiles require the target aircraft to be illuminated and locked in single-target-track (STT) or track-while-scan (TWS) mode by the launch aircraft's radar and then the missile homes in on the radar energy reflected from the target aircraft. STT is a technique where the launch aircraft's radar focuses all of its energy on the target in a narrow cone, thus providing the highest fidelity (resolution) tracking solution. However, this does not allow simultaneous tracking of other targets and if the target aircraft is equipped with a radar warning receiver (RWR), it will receive an indication that it is being locked. In TWS, the launch aircraft's radar tracks multiple targets simultaneous, and consequently, allows for multiple simultaneous engagements. However, since multiple targets are tracked