MISSILES
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T oday, offensive missiles are the primary armament of fighter aircraft, with missile types spanning a wide range of specialised niches in range, speed, guidance technique and intended target. With the Pacific Rim and Indian Ocean regions today the fastest growing area globally in buys of evolved third generation combat aircraft, it is inevitable that this will be reflected in the largest and most diverse inventory of weapons in service. At present the established inventories of weapons are in transition, with a wide variety of legacy types in service, largely acquired during the latter Cold War era, and new technology 4th generation missiles are being widely acquired to supplement or replace existing weapons. The two largest players remain the United States and Russia, although indigenous Israeli, French, German, British and Chinese weapons are well established in specific niches. Air to air missiles, while demanding technologically, are nevertheless affordable to develop and fund from a single national defence budget, and they result in greater diversity than seen previously in larger weapons, or combat aircraft designs.

Air-to-air missile types are recognised in three distinct categories: highly agile Within Visual Range (WVR) missiles; less agile but longer ranging Beyond Visual Range (BVR) missiles; and very long range BVR missiles.

While the divisions between the latter two categories are less distinct compared against WVR missiles, the longer ranging weapons are often quite unique and usually much larger, to accommodate the required propellant mass.

In technological terms, several important developments have been observed over the last decade. The first is the transition from primarily analogue electronics in missile seeker and guidance systems to digital software based designs, resulting in significantly smarter

Asia-Pacific

guidance algorithms, more refined flight path energy management, and smarter techniques for defeating opposing countermeasures.

The second development has been the transition in radar-guided weapons from mostly semi-active homing guidance to largely autonomous active homing guidance, permitting fighters to break away from a target much earlier, but also permitting concurrent multiple engagements.

The third development has been the arrival of solid propellant ramjets in medium range missiles, providing much higher endgame manoeuvrability as well as more range - the oxidiser for the propellant being drawn largely from inlet air.

Seeker technologies have seen the most dramatic changes in WVR missiles, with the shift from mechanically scanned optical seekers to staring Focal Plane Array chips, and infrared analogues to the widely used CCD TV imaging devices. Offering greater sensitivity, vastly better countermeasures rejection and the ability to specifically target portions of the target airframe, FPA seekers add significant lethality to already impressive 70G+ class fourth generation weapons.

Retrofits of new technology seekers and guidance to legacy missile stocks are also a feature of the current market, although not on the scale many might expect.

This analysis will survey types available in the Asia-Pacific-Indian region, with a focus on newer types arriving in the inventory.

Raytheon AIM-7 Sparrow

The AIM-7 Sparrow remains widely used by US supplied nations. A semi-active radar homing BVR missile, the AIM-7 was produced in a wide range of variants. The most common current variants are subtypes introduced during the 1980s to arm teen-series fighters with a BVR weapon for air combat and air defence intercepts. The final AIM-7Ps with improved low altitude guidance, improved fusing, a midcourse guidance uplink were introduced by the US Navy during the 1990s. The intended final AIM-7R variant, which incorporated a dual mode seeker exploiting AIM-9M Sidewinder components was cancelled during the late 1990s. While the AIM-7M/P has been largely replaced by AIM-120 AMRAAMs, many US clients that do not qualify for the AMRAAM continue to use the AIM-7.
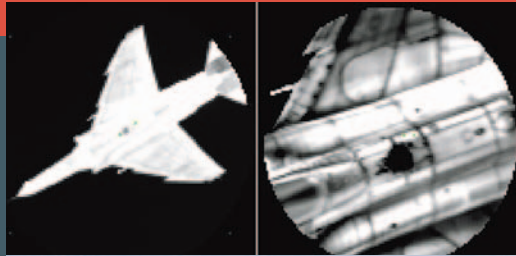
Raytheon AIM-9 Sidewinder

The AIM-9 missile began its existence as a contemporary of the AIM-7, initially used as a short-range heat-seeking weapon for bomber intercepts. The early AIM-9B was used by US Navy and Air Force, and widely licensed or cloned. By the mid 1960s the AIM-9 line split into unique Navy and Air Force variants, the Navy opting for gas cooled detectors in the D, G and H models, the Air Force thermo-electric cooling in the E and J models. The subsequent AIM-9L was a common variant, with all-aspect capability and gas cooling, introduced during the late 1970s, and based on the AIM-9H. The AIM-9P, based on the AIM-9J, remained in concurrent production. The last of the 'classic' Sidewinders, the AIM-9M was an improved evolution of the AIM-9L and remains widely used in AIM-9M-8 or -9 configuration, introduced during the 1980s. The replacement for the AIM-9M in US service is the substantially new AIM-9X variant, sufficiently re-engineered to actually merit a unique designation, and planned for the F-15C/E, F-16C, F/A-18 series, F/A-22A and JSF. While the AIM-9X shares the rocket motor and warhead of the AIM-9M, it uses new fixed canards, a new digital seeker with an InSb FPA detector, and coupled steerable cruciform tails and exhaust vanes for thrust vector control. The FPA detector uses a Stirling cryogenic refrigerator rather than Joule-Thompson gas cooler. Launched from the LAU-127 or LAU-142, the AIM-9X uses a Mil-Std-1760 interface and is intended for use with the Joint Helmet Mounted Cueing System (JHMCS) helmet-mounted sight. While the AIM-9X will eventually replace the AIM-9M throughout the US inventory, many users of the legacy models will continue to operate them into the foreseeable future.

Raytheon AIM-54 Phoenix

The large AIM-54 Phoenix was developed for the F-111B, but transplanted to the F-14A as a long range weapon for intercepting cruise missile armed Badgers, Backfires and Bears – and indeed the Kh-22 (AS-4) and KSR-5 missiles they carried. After the analogue AIM-54A was compromised in 1979, the digital AIM-54C was introduced. With the impending withdrawal of the F-14B/D from service, a shift to littoral rather than blue water operations, the AIM-54 will soon be withdrawn from fleet service.

Raytheon AIM-120 AMRAAM

The AMRAAM is the result of an ambitious 1980s plan to replace the AIM-7 with an active radar-guided BVR weapon with much greater range performance. The program experienced extensive difficulties in development and cost overruns. The earliest AIM-120A entered service during the late 1980s with US Air Force F-15C units, the weapon was first used during Desert Storm and subsequent No Fly Zone operations. It has now replaced the AIM-7 in most US units and has been widely exported to close US allies, including Australia. As the AIM-120 uses inertial guidance with midcourse datalink updates transmitted by the launch aircraft, integration of the weapon requires extensive radar upgrades. The LAU-127A/A, LAU-128A/A and LAU-129A/A launchers are used with digital Mil-Std-1760 interfaces.

The earliest AIM-120A was 'hard-wired', requiring hardware upgrades to change the embedded code in the WGU-16B. The improved AIM-120B introduced the WGU-41/B seeker with Electrically Erasable Programmable Read Only Memory storage, permitting the missile seeker code to be upgraded in the field. The current AIM-120C variant with the WGU-44/B seeker was designed for the F/A-22A and JSF, with reduced span wings and controls for internal carriage, and a range of other improvements. The AIM-120C-6 includes fusing changes to improve capability against cruise missiles. Variants with larger rocket motors have been tested. The AIM-120 will remain the primary BVR missile in US service in coming decades.

MBDA ASRAAM

The ASRAAM is the result of a failed European-US collaborative effort to develop a common high performance WVR missile to replace the AIM-9, US variants to be designated the AIM-132. BAe Dynamics developed the missile before the merger with Matra, for the RAF and export customers. The ASRAAM is unique in current WVR missiles, using a very high impulse motor to accelerate the missile to speeds faster than any WVR missile, and providing range performance competitive with many BVR missiles. Like the AIM-9X, the ASRAAM uses an InSb FPA detector with high countermeasures resistance and sensitivity. While the missile does not use thrust vector control, its high acceleration permits similar tight turns post launch, allowing 'over-the-shoulder' shots from aircraft equipped with HMS. The missile is compatible with AIM-9 analogue interfaces and AIM-120 digital interfaces.

While the ASRAAM is classed as a fourth generation WVR missile, its significant BVR performance and inertial midcourse guidance technique allow it to be used as a supplement for the AMRAAM. Australia is the only regional operator, using it on the F/A-18A HUG, with integration on the F-111 now unlikely if early retirement plans are followed through.

MBDA MICA

The MICA (Missile d'Interception, de Combat et d'Autodefense - Dogfight/Self-Defence/Interception Missile) was developed by the French to arm the Mirage 2000 and the new Rafale. It is designed to cover both WVR and BVR combat envelopes, and incorporates extended fuselage strakes to improve turning ability, and thrust-vectoring vanes to enhance post launch turn rates.

Unique among Western missiles, the MICA was designed with both infrared and active radar homing seeker-equipped variants from the outset. Like the equivalent US AMRAAM, the MICA uses midcourse inertial guidance with datalink updates, and RF and impact fusing. The active homing variant, the MICA-RF, is equipped with a monopulse pulse Doppler seeker, the infrared variant, the MICA IR, with a scanning infrared seeker. Indian and Taiwanese Mirage 2000 aircraft carry MICA variants.

Rafael Python 4 / Python 5

Rafael's Python 4 WVR missile was the first Western fourth generation weapon in production. The Python 4 was a radical departure from earlier Israeli WVR AAMs, designed from the outset to combine exceptionally high sustained G capability with a long duration burn motor, then unique to WVR missiles. The Python 4 airframe uses dual nose canards to permit high angle of attack flight, and uses a pivoting cruciform tail with extended strakes to maximise lift in all regimes. The missile was intended for use with DASH series helmet mounted sights. The basic Python 4 uses a scanning infrared seeker, the subsequent Python 5 replaces this detector scheme with a two-colour FPA detector, similar to the AIM-developed QWIP FPA, a generation beyond the single colour InSb FPAs in the ASRAAM and AIM-9X. In addition, the Python 5 guidance system includes a FOG inertial package to permit 'over the shoulder' shots. The Python 4 has been exported to Singapore, with claims that the weapon will also be supplied to India for retrofit on the Sea Harrier, and possibly other legacy types.

Rafael Derby

The Derby is the Israeli equivalent to the US AIM-120, drawing extensively on the technology developed for the Python 4. The Derby uses an improved higher impulse derivative of the Python 4 motor, a Python 4 warhead, fusing system and other components. The active radar seeker, inertial midcourse and datalink package are new; the canard controls and roll stabilisation vanes are derived from the Python 4. Rafael claim the Derby outranges the AIM-120, and is optimised for smaller fighters. The canard design was used to provide the missile with good close-in performance, in addition to its primary BVR role, Rafael claiming the weapon outperforms earlier AIM-9 variants in WVR engagements.

This February the Indian Navy ordered its first batch of Derby missiles to arm its Sea Harriers with a BVR weapon.

Vympel R-3/R-13, Luoyang/Hanzhong PL-2/PL-5 (AA-2 Atoll)

The R-3 and R-13 missiles were the first clones of the Sidewinder, based on captured examples of the early AIM-9B. The initial R-3S/K-13A/K-13T was a direct clone entering production during the early 1960s and widely exported to Soviet clients. A semiactive homing variant, similar to the AIM-9C on the F-8 Crusader, the K-13R/R-3R entered production during 1966. The subsequent R-13M/R-3M/K-13M and improved R-13M1 were introduced during the 1970s, equivalents to the AIM-9G.

The Soviet R-13 was cloned by China as the PL-2, which later evolved into the PL-3 and PL-5 missiles. No less than four variants of the PL-5 are identified. The PL-5A was equivalent to the K-13R, but the program was cancelled during the 1980s. The PL-5B did not enter production until the 1980s, despite initial development starting two decades earlier. The PL-5C is an improved PL-5B widely used by PLA-AF and PLA-N units. The latest PL-5E is an attempt to outperform the AIM-9L/M series, using an all aspect seeker, AIM-9L style double delta canards, a 40 degree off boresight capability, and 40G manoeuvre capability. PL-5 variants are used on the J-7 Fishbed, J-8 Finback, FH-7 and Q-5 Fantan, J-7s and Q-5 having been widely exported in Asia.

Zhuzhou PL-7 / Matra R550 Magic

The PL-7 is a reverse engineered Matra R550 Magic WVR AAM, which entered production during the 1980s. The basic Magic I occupies the same niche as contemporary Sidewinders, but the missile uses a characteristic paired canard arrangement to improve turn rates. The seeker is nitrogen gas cooled.

While the PL-7 has been displayed at airshows, there have been no reports of significant production numbers or exports. The R550 was exported to India for the Mirage 2000.

Luoyang PL-8 / PL-9

The PL-8 is a licensed copy of the Israeli Rafael Python 3 WVR missile, the predecessor to the Python 4. Production commenced during the late 1980s, the weapon has been integrated on a wide range of aircraft, including the J-7E Fishbed, J-8B/D Finback and new J-10. Comparable to the AIM-9L in basic performance, the PL-8 is an all aspect WVR missile designed for close combat, and credited with a 35 G capability. Chinese sources claim it has been integrated with a helmet mounted sight.

The PL-9 is conceptually closest to the AIM-9P and appears to be an evolution of the PL-5 series missile, although Chinese sources claim the missile outperforms the AIM-9L/M. Production status of this missile remains unclear.

SAST PL-11

The PL-11 is derived from a licensed copy of the Selenia Aspide, itself an improved variant of the AIM-7E Sparrow. China had initially experimented with cloning the AIM-7B as the Luoyang PL-4, with a heat-seeking and semi-active radar variant planned. This project was abandoned during the 1980s, in favour of the improved PL-10, itself abandoned later in favour of the licensed Aspide.

While it is known that Selenia withdrew support for the Aspide licence following 1989, the PL-11 was nevertheless deployed in the 1990s, on the indigenous J-8B Finback. Three variants are cited: the basic semi-active homing PL-11 equivalent to an AIM-7F, the improved PL-11A with more range and a midcourse inertial unit, and the PL-11B or PL-11AMR, claimed to be equipped with an active radar seeker and equivalent to the defunct UK BAe Active Skyflash - itself another AIM-7 derivative.

LETRI SD-10/PL-12

While some confusion remains about designations, most sources identify the SD-10 and PL-12 as the same missile, China's equivalent to the AMRAAM. This weapon is in sizing and configuration very similar to the AIM-120A, but employs a unique tail planform. Equipped with an active radar seeker, and datalink aided inertial midcourse guidance, this missile is a credible player against the AMRAAM and R-77 series. The indigenous AMR-1 active seeker is identified with the PL-12, and numerous reports exist claiming that it is a derivative of the Russian Agat 9B-1348E seeker package used in the R-77 series. The production status of the PL-12 is unclear, but the missile has been claimed as a future weapon for the indigenous J-10 fighter and the Su-27SK and Su-30, replacing imported R-77s on the latter. There is little doubt that the PL-12 closes most of the technology gap between Chinese built BVR missiles and in service Western BVR missiles.

Vympel R-60 (AA-8 Aphid)

The R-60 missile was developed during the early 1970s as a more agile and effective replacement for the R-13 series of WVR weapons. It is the forerunner of the AA-11 Archer and this is reflected in its airframe design, which combines canard strakes and control canards. The weapon was integrated on a wide range of Soviet aircraft and widely exported in Asia, remaining in service with users of older MiGs and Sukhois. The baseline R-60 was superseded in 1978 by the improved R-60M and export R-60MK, with a gas cooled all aspect seeker, a 20 degree off boresight capability, and radio-frequency proximity fuse replacing the original optical fuse. An APU-60-I or -60-II launcher is used. While the Aphid compares in capabilities to legacy in service Sidewinder variants, it remains an important type by virtue of the large inventories remaining in service with users of Soviet era export fighters.

Vympel R-73/R-74 (AA-11 Archer)

The R-60 was superseded in frontline Soviet units during the 1980s by the R-73 missile, at that time the most capable WVR missile in service and the first fourth generation design. The R-73 introduced key design innovations, including thrust vectoring for post launch agility, canard vanes for high turn performance, a gimballed agile MK-80 seeker capable of 45 degree off boresight acquisition, and an interface to the Shchel 3U series helmet mounted sight. The AIM-9X, ASRAAM and Python 4 were developed to counter the early models of the R-73. The R-73 has been primarily deployed on the MiG-29 Fulcrum and Su-27/30 Flanker, and is part of the standard weapons kit supplied with either fighter for export. R-73 missiles are carried on APU-73 launchers. The R-73 has further evolved. The R-73EL introduced a laser proximity fuse during the mid 1990s, replacing the radio-frequency fuse in earlier models. The R-73M increased range and improved off boresight capability to 60 degrees. The latest R-74 includes digital processing techniques, and is claimed to have a 75-degree off boresight capability. It is likely that future R-74 derivatives will include FPA seeker technology.

Vympel R-27 (AA-10 Alamo)

The Vympel R-27 was introduced as a BVR missile to arm the MiG-29 Fulcrum and Su-27/30 Flanker, making it a contemporary to the R-73 missile. Much larger than the competing AIM-7 series, the R-27 outranged the AIM-7 by a respectable margin. Unlike the Sparrow, the R-27 is supplied with two distinct rocket engine configurations, and a range of seekers. R-27 missiles are thus divided into 'short burn' and 'long burn' variants, recognised by the length of the missile fuselage. In terms of seekers, the baseline semi-active radar guided variants are equipped with a 9B-1101K seeker, these being the short burn R-27R1 credited with 43 NMI range, and the long burn R-27ER1 credited with 70 NMI range. These employ midcourse datalink support, but require terminal illumination. The R-27T1 and R-27ET1 employ derivatives of the R-73's MK-80 agile infrared seeker, compatible with a helmet-mounted sight. The R-27P and R-27EP employ a 9B-1032 X-band passive anti-radiation seeker, intended to force an opposing fighter to go 'nose cold'. The most recent enhancement to the R-27 series is the upgrade option of fitting an Agat 9B-1103M active radar seeker and supporting midcourse guidance package, based on the 9B-1348E seeker in the R-77. A fully digital derivative of this seeker, with improved acquisition performance, is available, using Texas Instruments TMS320 processing hardware. Upgraded missiles are designated the R-27A and R-27EA. The R-27 despite its size and 1970s origins remains a formidable missile, and with the diversity of seekers possible presents genuine issues for a defending aircraft's countermeasures suite. The weapons is in service with all regional operators of MiG-29 and Su-27/30 series fighters, and Chinese sources claim the R-27P has been sighted on the J-8II Finback.

Vympel R-77 (AA-12 Adder)

The R-77 was developed as a counter to the AMRAAM, and is often dubbed the AMRAAM-ski. This weapon uses large strakes for lift enhancement, and unique lattice tail controls, derived from an TBM design. Developed during the 1980s, it entered service a decade later on the MiG-29 and Su-27/30 series fighters.

The R-77 employs conceptually similar guidance to the AMRAAM, with an inertial unit, datalink uplink receiver and a terminal seeker, specifically the 9B-1348E, in the baseline active radar variant. The missile is credited with an A-pole range of 54 NMI, the capability to defeat a 12G target, can be launched at 8 G, and requires an AAKU/AKU-170 launcher.

More recently reports have emerged of new seeker options for the missile, following the pattern in the R-27. The R-77T uses an MK-80M seeker from a later model Archer, the R-77P a variant of the 9B-1032 X-band anti-radiation seeker.

A rocket-ramjet variant of the missile has been in development since the 1990s, as a counter to the EU Meteor. Designated the RVV-AE-PD, and often labelled the R-77M, this weapon is claimed to achieve an A-pole range of 86.5 NMI. It is unclear what the production status of this model is.

Variants of the R-77 have been exported to most current operators of late model MiG-29 and Su-27/30 series fighters, and there are claims the missile may have been licensed by China.

Vympel R-33 (AA-9 Amos)

The Vympel R-33 is the Soviet equivalent to the AIM-54, bearing more than a striking resemblance to the US weapon, compromised by the fall of the Iranian Pahlavi regime at the time the R-33 was being developed. Like the AIM-54 this missile uses semiactive radar midcourse guidance with inertial support, the Agat 9B-1388 active seeker locking on for terminal homing. The R-33 is carried only by Russian Air Force MiG-31 Foxhounds, as it designed around the large N007 Zaslon phased array radar. It primary role is like that of the AWG-9/AIM-54 system, bomber and cruise missile interception.

Vympel R-37 (AA-13 Arrow)

The new R-37 was developed during the late 1980s to provide a very long range BVR missile for a range of Soviet fighters. It is not as commonly believed a dedicated replacement for the R-33, although the upgraded MiG-31M Super Foxhound was the trials platform for test shots - Russian sources indicate the missile was envisaged for the Su-35, Su-37, I.42 MFI and future types.

The role of the R-37 also differs from the R-33 - it was devised to kill large ISR and IW/EW platforms at long ranges, specifically the E-3 AWACS, E-8 JSTARS, RC-135V/W Rivet Joint, EC-130 Compass Call and EC-130 Commando Solo. The missile uses large midbody strakes for enhanced lift, and folding cruciform tail controls for semiconformal carriage. A variant of the Agat 9B-1388 active seeker is employed, claimed to be capable of acquiring a 5 square metre target at 21.5 NMI. Range performance varies with the flight profile, from 80 NMI for a direct shot, to a maximum of 215 NMI for a cruise glide profile. In 1994 a trial round killed a target at 162 NMI, a record for a BVR missile. The production status of the R-37 remains unclear at this time, but the missile remains a candidate for advanced Sukhoi users.

Novator R-172

The R-172, previously designated the KS-172, is a departure from the established focus of Novator, designers of the S-300V (SA-12) system's long range SAMs. Like the R-37, the R-172 was developed as an 'AWACS killer'. The missile employs an active radar seeker and inertial midcourse guidance. Two configurations are known, with and without a booster pack. With the booster the missile is claimed to achieve a range of 215 NMI, without 160 NMI. Cited seeker performance is similar to the R-37. While the R-172 is less mature than the R-37, India has recently negotiated an arrangement to fund final development and licence produce the weapon, not unlike the extant deal to licence the Yakhont as the BrahMos.

Zvezda Kh-31 (AS-17 Krypton)

The Kh-31 family of missiles entered production as a fast supersonic anti-radiation missile, designated the Kh-31P. Its L-111E seeker employs a unique antenna arrangement with an interferometer array of six spiral antennas on a steerable platform. Two fuselage configurations are known, the 'shortbody' variant claimed to achieve a 60 NMI range. The missile uses a liquid ramjet with a solid booster stage, achieving sustained high altitude cruise speeds in excess of Mach 4. China has licensed the Kh-31P as the YJ-91, with Chinese source claiming its intended use as an 'AWACS killer' and conventional anti-radiation weapon. An active radar seeker equipped version also exists, designated the Kh-31A and intended for anti-shipping applications. Russian sources claim an adaptation of this seeker allows the weapon to also be used as an 'AWACS killer'.
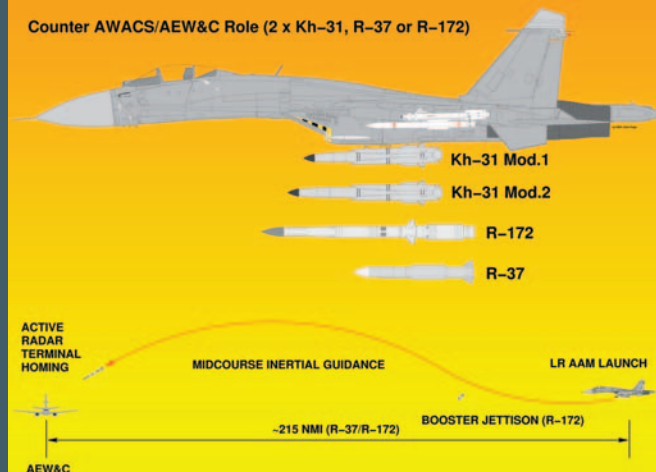
Issues for the ADF

The unpalatable reality of this decade is that the ADF faces a genuine 'rainbow threat' environment across the wider region. The sheer diversity of missile types in service or being introduced, be they of US, Russian, EU, Israeli or regional origin, and the prospect of evolving regional clone variants and derivatives, presents a genuine long term problem in intelligence gathering, analysis and countermeasures library maintenance.

Two key issues are arising during this decade. The first is the large scale export of advanced variants of the Russian R-74, R-27 and R-77, arming MiG and Sukhoi fighters. These weapons are highly competitive against US and EU sourced AAMs operated by the RAAF, and can be expected to further evolve over time. With diverse mixes of seeker types in the BVR missiles, defending against them will present real challenges. A robust approach will require investment in training, including simulation, tactics development, and adequate electronic and infrared countermeasures on RAAF aircraft.

The second issue to arise is the export of very long range 'AWACS killer' missiles, which are the poor man's equaliser against an opponent with an advantage in AEW&C capabilities. Much of the current force structure plan is predicated on the RAAF holding an asymmetric advantage in AEW&C capability over any opponent, indefinitely. Missiles such as the R-172, R-37 and Kh-31 variants allow any Sukhoi operator to threaten an opposing AEW&C aircraft from a safe distance.

There can be no doubt that a future RAAF force structure will have to be planned around missile capabilities now developing across the region, and compromises are simply not an option in the long term.

Perhaps the most important recent evolution in regional missile proliferation is the arrival of counter-ISR or 'AWACS Killer' missiles in the region, with India licensing the R-172 and China the Kh-31 (Author).

Counter AWACS/AEW&C Role (2 x Kh-31, R-37 or R-172)

Kh-31 Mod.1
Kh-31 Mod.2
R-172
R-37

ACTIVE RADAR TERMINAL HOMING
MIDCOURSE INERTIAL GUIDANCE
LR AAM LAUNCH
~215 NMI (R-37/R-172)
BOOSTER JETTISON (R-172)
AEW&C