

# M-MRCA: the contending missiles



Diehl BGT's short range IRIS-T AAM.

Every major purchase of modern military aircraft is accompanied by purchase of associated missile armoury and the Indian Air Force's requirement for Medium-Multi Role Combat Aircraft (M-MRCA) is no exception. Air-to-Air Missile (AAM) technology defines the depth of the air battle. "Whoever has the longest reach controls the engagement," comments fighter analyst Ben Lambeth of the Rand Corporation. In the IAF's case not only do Beyond Visual Range Air-to-Air Missiles (BVRAAM) remain a key requirement but close combat missiles are obligatory because of proximity of potentially hostile air bases nearby, just across the international border. To add to the complication, the threat of cruise and ballistic missiles (technology shared by adversary nations in direct violation of Missile Technology Control Regime restrictions) demand missiles capable of intercepting the hostile projectiles either from the ground or from the air.

The following assessment takes a "look" at various AAMs which includes the Raytheon AIM-120 AMRAAM, Raytheon AIM-9X Sidewinder, MBDA Meteor and MICA, Rafael Python, Rafael

Derby and Diehl BGT IRIS-T as they may well be included in the package of the selected M-MRCA. This author would love to have included next-generation Russian AAMs namely RVV-SD and RVV-MD in the list, however as reports of their developments are sparse it will perhaps be premature to analyse them under present circumstances.

## Raytheon AIM-120 AMRAAM

"With AIM-120 Advanced Medium Range Air-to-Air Missile or AMRAAM in flight air superiority is soon to follow", was proudly stated in a Raytheon media clip approved for public release (refer "Customer Success is Our Mission" RSAS MS 6/06 4108697). Of aerospace giants competing for the M-MRCA, the American entities are in a privileged position to offer combat proven (a significant factor) aircraft and associated missiles. Combat proven Beyond Visual Range Air-to-Air Missile (BVRAAM) AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM) was used for the first time on 27 December 1992, when a United States Air Force F-16D shot down an Iraqi MiG-25 that violated the southern 'no-fly-zone', and

subsequently scored more victories over the skies of Iraq, Bosnia, and Kosovo. The operational reliability of AMRAAM is measured in thousands of hours, with Mean-Time-Between-Failure (MTBF) rates in excess of 1,500-hours of operation. With state-of-the-art Active Radar Homing (ARH) guidance, AMRAAM packs unprecedented performance into a lightweight (the AIM-120C-7 weighs only 161.5-kg with 20.5-kg warhead) package. Incorporation of the latest digital technology and microminiaturised solid-state electronics makes the weapon more reliable and maintainable, resulting in the highest dependability at the lowest cost of ownership throughout the intended service life of the missile.

Capable of all-weather day and night performance and multi-shot capability, the AMRAAM offers unprecedented air combat flexibility. In Beyond Visual Range (BVR) engagements, AMRAAM is guided initially by its inertial reference unit and microcomputer. During the midcourse phase of flight AMRAAM receives target position updates directly from the launch radar system. However, in the terminal phase of flight, without further reliance on the launching aircraft,

the internal ARH seeker acquires the target and independently guides the missile to the target. The last mentioned autonomous guidance capability provides the pilot with critical range - preserving launch and leave capability substantially improving overall survivability by allowing immediate manoeuvre following missile launch, faster engagement of follow-on targets, as well as the option to maximise his separation from the original engaged threat. The missile is further blessed with critical attributes including quick fly out, robust Electronic Counter Counter Measures (ECCM) and improved capability while attacking low-altitude targets against the background of ground 'clutter'. The low smoke, high-impulse advanced solid-fuel rocket motor effectively reduces visual signature of the missile to catch the adversary pilot by surprise prior his aerial platform's destruction. The missile also features the ability to 'Home on Jamming,' giving it the ability to switch over from ARH to passive homing on jamming signals from the target aircraft. At short ranges (minimum range is said to be in the region of 2-km) the missile is launched in ARH mode from the outset, requiring no further assistance from the armed aircraft.

Specific variants are developed for cruise and ballistic missile interception well behind enemy lines in combination of suitable Airborne Early Warning & Control (AEW&C) platforms, thereby partially at least eliminating a threat that has emerged in disturbing proportions because of rampant violation of Missile Technology Control Regime (MTCR) restrictions by the China-Pakistan-North Korea axis. In United States Navy (USN) and USAF service F/A-18E/F fleets operating alongside F-22 Raptor and F-35 Lightning II fleets at medium altitudes around 25,000-30,000-ft "at different layers", are projected to operate in an extended picket line to track cruise missiles from a beam aspect where cruise missiles are susceptible to detection because of their lack of "positional stealth" from that aspect. The primary weapon under such circumstances is a specific variant AIM-120C AMRAAM, the AIM-120C-6 BVRAAM with an improved seeker and an updated TDD (Target Detection Device) to optimise the explosive cone of destruction for small, slow targets in

head-on engagement and incorporates improved fusing through a new quadrant target-detection device. The 'set-piece moves' of the USAF and United States Navy fighters are to approach a wave of cruise missiles head-on, get in a first shot and then turn for a second and third shot from behind. The follow-on AIM-120C-7 (P3I Phase 3) incorporates improved ECCM with jamming detection, an

upgraded seeker and longer range.

The AIM-120D is an upgraded version of the AMRAAM with improvements in almost all areas, including 50-percent greater range over AIM-120C-7 and better guidance over its entire flight envelope, yielding an improved kill probability (PK). On 5 August, 2008, the company reported that an AIM-120D launched from a two-seater F/A-18F Super Hornet passed within lethal distance of a QF-4 target drone at the White Sands Missile Range, and has now entered full production at Raytheon's Tucson, Arizona, facility. Important from India's point of view and key requirement, Raytheon is also working with the Missile Defence Agency to develop the Network Centric Airborne Defense Element (NCADE), an Anti-Ballistic Missile (ABM) derived from the AIM-120. This weapon will be equipped with a Ramjet engine and an Infra Red (IR) seeker derived from the Sidewinder close-combat missile. In

place of a proximity-fused warhead, the NCADE will use a kinetic energy hit-to-kill vehicle based on the one used in USN RIM-161 Standard 3. AMRAAM is slated to serve with the USAF, the USN, and the United States Marine Corps (USMC) until at least 2020 when the Joint Dual Role Air Dominance Missile (JDRADM) would potentially enter service. AIM-120 AMRAAM remains operational on the F-22 Raptor, F-15, F-16, F/A-18, Eurofighter Typhoon, the German F-4F, the Royal Navy (RN) Sea Harrier, Tornado, Harrier II Plus, the JAS-39



Raytheon AIM-120 AMRAAM.

Gripen, and the Norwegian Advanced Surface-to-Air Missile System (NASAMS). Raytheon is currently integrating AMRAAM on the F-35 Lightning II and AMRAAM is likely to enter IAF service if India selects Boeing F/A-18IN Super Hornet or F-16IN Super Viper as the M-MRCA of choice. As apparent AMRAAM has set the global BVRAAM standard and with more than thirty-three countries procuring the missile, "AMRAAM has attained a level of international procurement that enriches interoperability, ensures commonality, and improves overall logistic support which ensures effective coalition operations."

### Raytheon AIM-9X Sidewinder

Close-combat effectiveness and punch is provided by the incorporation of Boeing-developed Joint Helmet-Mounted Cueing System (JHMCS) and Infra Red (IR)



Raytheon AIM-9X Sidewinder.

guided Raytheon AIM-9X next generation Sidewinder close-combat missile, which retains the same rocket motor, fuse and warhead of the AIM-9M, but with lower drag has improved range and speed. Developed as a counter to both the Russian R-73 close-combat missile and improved Infra Red Counter Measures (IRCM) features, this next-generation Sidewinder missile passed operational evaluation in November 2003 and was approved for full-rate production in May 2004. The AIM-9X uses an extremely agile thrust-vector controlled airframe along with a mature staring Focal Plane Array (FPA) sensor to facilitate extremely high off-boresight acquisition and launch envelopes, greatly enhanced manoeuvrability and improved target acquisition ranges (in clear sky or clutter) to provide a “first shot/first kill” advantage. For future enhancements, the digital design architecture of the missile provides inherent growth capability. The missile also features high resistance to IR countermeasures, thanks to its reprogrammable Infra Red Counter Measures (IRCCM) capability. The AIM-9X can be employed in both Near Beyond Visual Range (NBVR) and close combat arenas. In addition to the F/A-18C/D and the F-15C, AIM-9X will be integrated on the USN F/A-18E/F and the USAF F-15E, F-16, F-35, and the F-22 during ‘Follow-on Test and Evaluation’. In addition several nations have already selected AIM-9X as their next close-

combat missile and potential exists for procurement by numerous other coalition nations. Like the AMRAAM, AIM-9X Sidewinder is likely to enter IAF service if India selects the Boeing F/A-18IN Super Hornet or F-16IN Super Viper as the M-MRCA.

### MBDA Meteor

MBDA’s Meteor BVRAAM provides an ultra-long range interception capability against fighter-sized targets, critical in attaining “first look-first shoot-first kill” capability alongside fulfilling the BVR role for “outer-air battles”, increasingly necessary for the IAF in response to proliferation of BVRAAMs in its ‘neighbourhood’ including United States AIM-120C-5 variant of the AMRAAM in Pakistan Air Force (PAF) service. A stealthy, low drag, lightweight (160-kg+) BVRAAM design from the MBDA stable, the 80+ nautical miles ranged Meteor with a more linear velocity profile is presently undergoing integration phase with the Gripen. Born out of the multi-national Project S225X examining the future BVRAAM technologies and designed for a network-centric warfare (NCW) environment, the Meteor has a data-link capability to be guided not only by the launching aircraft but also by another fighter or even by Airborne Early Warning & Control (AEW&C) platforms. The extended range is ensured by Meteor’s solid boron fuelled Variable-Flow Ducted

Ram-rocket (VFDR) propulsion system also referred to as Throttle-able Ducted Rocket (TDR), along with a speed of more than Mach 4 and high terminal velocity. Thus even when launched from extreme stand-off ranges, the missile will retain the energy in the end game to defeat fast, manoeuvring targets. The control system consists of four small moving tail surfaces but at inherently high speed sufficient to perform sharp manoeuvres. The engine’s two air intakes, positioned on the both sides of the lower part of the missile’s body, are shaped to reduce the missile’s radar cross-section.

The need for controlled airflow (by the missile’s electronics) to the ramjet ducts ruled out the ‘skid-to-turn’ manoeuvring of a conventional rocket-powered missile, as it will risk masking an intake and, instead, ‘bank-to-turn’ manoeuvring is adopted. The Meteor is capable of engaging wide range of airborne targets autonomously, including cruise missiles with less than 1-metre square Radar Cross Section (RCS). For mid-course navigation guidance Meteor utilises Inertial Navigation System (INS) combined with update commands provided by the launch, or any friendly aircraft via the two way secure microwave data-link, to adequately offset Identification Friend or Foe (IFF) complexities or challenges at long ranges. During the terminal phase the Ku-band (NATO: X band) active-radar homing seeker (advanced version of the MICA RF ‘4A’) employs advanced proportional based navigation software (rumours persist that the system can operate passively in the K-band given the consortium’s previous research interests). The seeker is said to be more resistant to electromagnetic jamming and operates in stealthier mode than do seekers of the MICA RF and Aster. To ensure total target destruction, the missile is equipped with a combination of SAAB Dynamics laser proximity and impact fuses and a fragmentation warhead that is detonated at the optimum point to maximise lethality.

As Meteor is designed for a NCW environment, it is suitable for the futuristic concept of



The “game changer”: MBDA’s Meteor with Gripen.

‘Cooperative Fighter Operations’ or Mixed Fighter Force Concept (MFFC) that is essential for future BVR engagements and optimum performance and results. Conceptually in IAF service, pairs of Sukhoi Su-30MKIs will be data-linked; as one illuminates the other launches the missiles against the targets. In such engagements the ‘striker’ fighter will be able to impart the greatest kinetic energy to the Meteor BVRAAM by accelerating up to Mach 2 and then manoeuvring out of the engagement. The illuminator with its powerful radar capable of performing like a mini-AEW&C would remain firmly subsonic keeping a decent distance from the target, and providing either command-guidance updates alongside illuminating the target. Since Meteor represents a six-nation project, back during Aero India 2007 MBDA officials withheld any formal comment on its possible integration with IAF Sukhoi Su-30 MKI fighters, yet there were sufficient hints to this *Vayu* correspondent by senior MBDA officials that integration is very much possible in response to formal request by the Indian Government and IAF. As apparent, the Meteor BVRAAM will assist the IAF Sukhoi Su-30MKI fleet to reach its full combat potential in BVRAAM combat scenarios that may prove critical in any confrontation with the Chinese Peoples Liberation Army-Air Force (PLA-AF) especially at the opening stages of conflict and may well prove decisive

in the long run. Meteor incidentally represents the primary BVRAAM of three M-MRCA competitors, being the Eurofighter Typhoon, Dassault Rafale and Saab Gripen.

### MBDA MICA

The MICA BVRAAM forms the standard armament of Dassault’s Rafale and is also presently selected for upgradation package of the IAF’s Mirage 2000H/TH fighters. MICA was originally designed as a ‘multi-aircraft’ missile that could easily be integrated onto any modern fighter aircraft, without significantly reducing the aircraft’s speed or negatively affecting its aerodynamic characteristics. MICA is capable of both BVR (60km+) and close range interception thanks to dual active radar (as in MICA RF) and Imaging Infra Red (as in MICA IR) seeker and Lock On Before Launch (LOBL) as well as Lock On After Launch (LOAL) capability.

Carried under the aircraft fuselage or under wings and fired by ejection or rail-launched MICA is “permitted” to be ejected from the airframe points up to 4g while wings pylons can release MICA up to 9g. Products of research & development during 1990s and after, both MICA RF and MICA IR have a range in excess of 60km, the MICA IR version receives mid-course update commands from the radar to compare the target location with that of its seeker’s track for LOAL engagements. In case of MICA RF after the target has been

designated by the host aircraft’s radar, it makes the first phase of its fight in inertial guidance mode, and then latches onto the target in flight in fire and forget mode using its “4A” active-radar homing head. MICA remains well reputed for its general level of sophistication and reliability in terms of “kill percentage” even in European adverse meteorological conditions alongside dense electronic warfare environment infested with saturation jamming as the missiles in turn embeds a formidable ECCM system to burn through hostile jamming.

Excellent manoeuvrability is aided by combination of long chord wings, efficient tail control surfaces while at short range Thrust Vector Control (TVC) facilitates High Off-Boresight Angle (HOBA) engagements. Interestingly the MICA IR seeker may also be utilised for discrete optronics monitoring prior launch. Again MICA IR with its excellent angular resolution will be able to mount stealthy strikes at unsuspecting opponents especially if the launch platform gets well pre-positioned by friendly AEW&C platforms like the IAF’s A-50EI PHALCON (PHased Array L-band CONformal) aircraft the lethal warhead being triggered by a Doppler radar proximity fuse. Surprise had always been the key to successful execution in air combat, with as much as 50-percent of the shot down pilots totally unaware of the fact that they were even under attack!



MBDA MICA underwing the Rafale M.

### Rafael Python 5

Like India, Israel is surrounded by hostile neighbouring nations and thus its air force has always put strong emphasis in close-combat, air-to-air since the adversary air bases are located nearby which makes close-combat scenarios a certainty. IDF-AF combat record registers more than 95-percent ‘kills’ with close-combat missiles and have emerged as masters of within visual range close-combat in numerous Arab-Israeli air wars during the second half of the past century with combat experience and expertise second to none. This impressive attribute is effectively backed by a highly sophisticated and rigorous training schedule of extensive



Rafael Python 5.

flight-hours alongside a firm respect for the adversary's Russian MiG designs without any room for complacency, thus consistently maintaining a favourable high kill-to-loss ratio. In addition surprise was the key Israeli element during these encounters with classic slashing attacks out from behind a cloud or 'out of sun' into a firing pass leaving very little duration or room for the adversary to react.

Ancestry of the Python 5 Near Beyond Visual Range Air-to-Air Missile (NBVRAAM) can be traced back to development of the all-aspect Python 3 close-combat missiles. Introduction of Python 3 during the later half of the 1970s coincided with the extensive transformation of the IDF-AF with F-15s entering service in 1976 to be followed by F-16s in 1980 and importantly the E-2C Hawkeye AEW&C platforms prompting swift development of new tactics and operational procedures. Python 3 with large delta canard controls had a slightly tapered body housing an Infra-Red (IR) seeker cell of exceptional sensitivity and wider look-angle in relation to contemporary technology. This had a plus or minus 30-degree gimbal angle operable in boresight, uncaged, or radar-slaved mode. The missile was regarded superior in most aspects to contemporary models such as AIM-9L Sidewinder in terms of speed (Mach 3.5), turning radius and range (up to 15-km).

The conventional rod-type high-explosive warhead weighs 11-kg. The effect of newer generation fighters

and AEW&C platforms and other enhancements were apparent during the war between Israel and Syria over the Beka'a Valley in 1982, when the Israelis mercilessly decimated the Syrian Air Force with their excellent battle management system exemplifying a "classic exploitation of AEW&C asymmetry". The IDF-AF, as per their claim, destroyed 92 Syrian aircraft including 36 MiG-23s armed with potent R-23 (AA-7 Apex) BVRAAM without conceding a single loss. Israeli pilot Amir Nahumi became the first F-16 ace with six more victories after having opened his "account" in 1981. Python 3 incidentally was credited with over 50 Syrian aircraft kills during the Beka'a Valley campaign albeit in its pre-production rounds form.

As newer generation of Russian MiG-29 fighters with Helmet Mounted Sight (HMS) slaved with R-73 (AA-11 Archer) missiles with considerable off-boresight capability were transferred to Syria during mid 1980s, the Israelis identified the threat seriously and embarked on fast development of the Python 4 mated with third generation Display & Sight Helmet (DASH) intended to catch up, if not exceed, the specified parameters. Python 4 was in operational service by 1994 and with numerous canard control surfaces and destabilisers was designed around an IDF-AF philosophy of a visual identification pass coupled with a close-in High Off-Boresight Angle (HOBA) capability missile. Python 4 has an all-aspect gimballing multiple detector array seeker

with the ability to look 90-degrees off-boresight with a lateral squint capability and a high tracking rate thanks to digital signal processing techniques in the seeker, as well as a microprocessor-based digital flight control system. Powerful 6-inch diameter rocket motor endow it more impulse to get through the energy sapping manoeuvres of a HOBA launch, with enough speed remaining for good kill distance.

The Python 4 thrust is initially low to let the missile turn large angles at relatively slow speed before accelerating for the chase. The long burn motor has a tailored thrust profile to achieve optimal acceleration for close-in engagements and high energy for terminal phase homing or end game engagement. The intent of the designers was to produce a missile which can not only be launched from a wider range of angles than earlier missiles, but which can also maintain track on a highly manoeuvrable high-g target engaged during the merge or opening phase of an engagement. A passing target on a reciprocal heading can be engaged in most of the forward hemisphere. If the Python still fails its first opportunity to hit, track will be maintained on the target to continue a tail chase geometry pursuit, running down the target for a tail-aspect impact.

Effectively mated with the Elbit-developed third generation DASH HMS for optimum performance and lethality, Python 4 can be launched at a range of over 15-km. The missile employs a blast

# Diehl

fragmentation 11-kg warhead, which is triggered by an active laser proximity fuse with a backup impact fuse. It was no surprise that in the year 2000 when United States Marine Corps (USMC) F/A-18 Hornets from Balkans theatre armed with then standard models of AIM-9 Sidewinder engaged in mock air combats with IDF-AF fighters armed with Python 3 and Python 4 missiles in conjunction with DASH helmet mounted sight, they were “handled roughly”, the IDF-AF reportedly prevailing in 220 out of 240 engagements. Interestingly, Python 4 is rumoured to be in service with the IAF for some time yet never officially confirmed and it may be speculated that these are test batches to secure major follow-on orders for the new Python 5.

The intent of IDF-AF to retain ascendancy with close-combat missiles is well reflected in their fifth-generation Python 5, promising performance in the extreme corners of the flight envelope.

With a speed of Mach 4 and 20-km range, 360-degrees performance is facilitated by Lock-On After Launch (LOAL) capability, to deal with rear hemisphere threats. More importantly the missile seeker uses staring Focal Plane Array (FPA) seeker technology that was first introduced in the United States AIM-9X Sidewinder that has inherently better Infra-Red Counter Counter Measures (IRCCM) and is readily programmable for ever expanding IRCCM techniques. This particular staring focal plane array technology provides greater ability to reject flares and other countermeasures while the extended range with LOAL mode gives it an added NBVR capability to its inherent close-combat attributes.

Additionally, the dual-wavelength, focal plane array-imaging seeker is able to acquire low-signature targets even in look-down mode, against adverse backgrounds and cloudy environment and possibly has discriminatory capability against multiple

targets. Like the Python 4, the fuselage of Python 5 consists of dual canards and rear fins with an improved motor. It also incorporates advanced computer architecture, inertial navigation system, IRCCM and flight-control algorithms and is designed to strike against the most critical and vulnerable areas of its target to ensure destruction. The Python 5 NBVRAAM achieved operational status under wings of the F-16I *Soufa* (Storm) in addition to AIM-120 AMRAAM. The first unit, the *Negev* Squadron, was reformed at Ramon on 27 July 2003 to operate the two-seat example developed on basis of the F-16ES (Enhanced Strategic) long-range interdictor.

### Rafael Derby

The IDF-AF well realised the value and operational flexibility of BVRAAM long back as it was repeatedly frustrated by high-altitude over flights by MiG-25 (*Foxbat-B*) reconnaissance models



Israel Air Force Rafael Derby BVRAAMs.

of the Soviet Expeditionary Force between October 1971 and March 1972. Soviet MiG-25Rs, based at Cairo, covered the Israeli-held coastline Haifa to Port Said and flew the length of Sinai Peninsula involving 500-km penetration of Israeli airspace. With a speed of Mach 2.5 to 2.8 at a cruising altitude of 80,000-ft they successfully evaded formidable Israeli defences including F-4 Phantoms thus gathering valuable “real time” intelligence and transmitting them to ground-stations through secure data-links for further analysis. Counter IDF-AF BVR tactics underwent development and during June 1982, two Syrian MiG-25s were destroyed by the IDF-AF with carefully planned and executed “snap up” attack by the F-15 fighter/AIM-7 Sparrow BVRAAM combination emphasising growing maturity of the BVR tactics and procedures of the IDF-AF pilots. For the first time the formidable high-altitude MiG-25 interceptor, hitherto regarded as “untouchable” the was shot down.

Although subsequently, the IDF-AF acquired an active-radar homing BVRAAM in shape of the United States Raytheon AIM-120 AMRAAM, Israeli desire to retain full control of BVRAAM technology especially in relation to Electronic Counter Counter Measures (ECCM) modes led to development of indigenous Derby BVRAAM developed by Rafael’s Missile Division. The 118-kg active-radar homing BVRAAM shares design commonality with Python 4 (including warhead and proximity fuse and even sharing same launcher) with the addition of mid-body wings while its own ‘no escape zone’ overlaps that of the Python 4. The Derby is fitted with an ARH seeker with a compact gimballed antenna, developed by Israeli Aircraft Industries’ MBT Division. Derby has Look-Down/ Shoot-Down capability and advanced programmable and adaptable ECCM to operate under dense electronic warfare environments and is reconfigurable with the emergence of new threats. For BVR engagements, a LOAL mode is adopted in which the missile initially fired using cues from the launch aircraft’s fire control radar, or perhaps an Infra-Red Search & Track (IRST) system employing inertial guidance immediately after launch until the ARH

seeker is activated at appropriate distance to home in on the target with substantial kinematics performance allowing ‘end game’ manoeuvrability thanks to the slightly enhanced rocket motor.

For greater accuracy over extended ranges, the ‘Derby Uplink’ capability allows targeting data to be transmitted from the launch aircraft to provide accurate mid-course guidance while dealing with fast-moving or manoeuvring targets. The missile also has the ability to receive data-link updates from other platforms besides the launch aircraft thereby permitting ‘stealthy’ engagements. According to Rafael, the “multi-shot capable” Derby has a launch-range in excess of 63km if launched at Mach 0.9 at 25,000-ft against a head-on target, although its maximum range, or its effective seeker range, remains highly classified. During Aero India 2007 on being suggested so by this *Vayu* correspondent on aspects of Derby’s maximum range, top Rafael officials along with their aides burst into laughter which intended to retain the veil of secrecy by reaffirming it as “a mystery”. Derby also has a very low minimum range and an option for Lock-On Before Launch (LOBL) mode thus also capable of being employed for short-range engagements with Derby’s seeker slaved to the aircraft’s radar or the pilot’s helmet mounted cueing system. During short range engagements, Derby’s capabilities are regarded as similar to the Python 3 close-combat missile trapping enemy aircraft in the “killing fields” 60km inwards. Subject to assistance from Original Equipment Manufacturers (OEM) the combination of Python 5 and Derby can be integrated on all M-MRCA contenders. Reportedly the Python 5 and Derby are also set to arm squadrons of India’s own Light Combat Aircraft (LCA) Tejas prior to availability of the indigenous Astra BVRAAM. In fact, the Derby BVRAAM already arms the Indian Navy’s Sea Harriers to provide a combination of both BVR and close-combat capability.

### **Diehl BGT IRIS-T**

Highly agile, the IRIS-T (Infra Red Imagery Sidewinder Tail-controlled) is an international initiative to replace the current AIM-9L/M Sidewinder CCM. Diehl BGT is the prime contractor for the programme and Germany is the lead

nation. The mass, length, diameter and interface of the IRIS-T missile are very close to its predecessor, achieving a high degree of compatibility which is a must for the IRIS-T programme. The missile combines a solid-propellant rocket motor which utilises a smokeless propellant arranged in a star-shaped formation within the combustion chamber (this section also provides the attachment point for four wings providing additional lift) with advanced aerodynamics and Thrust Vector Control (TVC) in a tail-controlled airframe to achieve “outstanding performance.” The TVC nozzle that provides for flight control utilises four vanes placed within the exhaust. By directly controlling the position of these the thrust can be vectored in any required direction providing a large increase in achievable manoeuvrability, with turns possible in excess of 50 g.

IRIS-T features a BGT (Bodenseewerk Geratechnik)-designed scanning imaging Indium-Antimonide infra-red sensor roll-pitch seeker (128x128 pixels) with 90-degrees look angle (combined with digital signal processing) for high off-boresight angle missile engagements. Engagements against targets in the rear hemisphere can be done successfully with the missile’s Lock-On After Launch (LOAL). Overall, IRIS-T delivers increased agility, target acquisition range, hit accuracy, a more effective dual-layer High Explosive (HE) fragmentation warhead and considerably improved protection against countermeasures compared with the AIM-9L/M models of Sidewinder missile. An active radar based fuse provides both range and range-rate information allowing the missile to detonate its warhead at a pre-determined distance from the target. During the flight tests, the IRIS-T achieved direct impact on the target even with IRCM presence.

The highly manoeuvrable IRIS-T missile will be integrated onto Eurofighter Typhoon, Gripen, F-16, Tornado, and F/A-18 fighters. In October 2003, Spain joined the IRIS-T programme ordering 700 missiles to be integrated with the Spanish Air Force Typhoon and F/A-18 fighter aircraft. Overall, the IRIS-T programme represents around 4,000 missiles for the armed forces of Germany, Greece, Italy, Norway, Spain and Sweden.

*Sayan Majumdar*