

Keeping the Skies Clear

Pechora 2M firing

This supplement to our regular issue number two of 2004 provides a round-up of the major air defence systems deployed or undergoing development around the world.

This report is broken down into different categories, starting with air-to-air, and of course their inevitable complement, the airborne early warning aircraft.

The report then drops down a few feet to examine the systems that will provide protection from the ground, logically starting from the very short range air defence systems (including barbed weapons) and all the way up to the longer range missiles.

Roy Braybrooke, Eric H. Biass

Another key factor in fighter design is stealth or low observability (LO), in which America undoubtedly retains a significant lead. European and Russian manufacturers are making desperate efforts to give pre-stealth configurations sufficient long-term credibility to warrant an outright purchase, but (unless some new radar development destroys the value of stealth) they may increasingly be forced to offer attractive short-term leasing arrangements.

On the other hand, it remains to be seen whether aircraft such as the Lockheed Martin F-35 will be offered in an LO form that attracts widespread purchases. The degree of stealth to be professed will be a political decision to be made by the then-current US Administration, and will presumably differ between potential customers, a situation that may bolster the hopes of non-US fighter manufacturers. At the extremes, it could give America an even more dominant position in the fighter market, or produce a repeat of the fiasco generated by the Carter Administration, which attempted to restrict Third World fighter purchases to the Lockheed Martin F-16A/B. Until that decision is made, doubts will persist over continuing the development of pre-stealth designs, and of maintaining such aircraft in production for domestic use.

Production and operating costs are other important drivers in the selection of a fighter, which will naturally favour lightweights. The only new-generation lightweight fighter in service is the Saab/BAE Systems Gripen. The baseline JAS39 version is already in use with four Swedish Air Force fighter wings, while the export Gripen has been ordered by South Africa (28 aircraft), is to be leased by the Czech Republic and Hungary (each taking 14 aircraft for ten years) and has been shortlisted in Brazil for the F-X-BR programme.

The Swedish Air Force now has a squadron of JAS39s available for international deployments on European Union, Nato, Nordic Defence Cooperation Pact or UN missions, to provide escort and limited reconnaissance facilities. By 2006 the squadron will have the JAS39C with colour displays, Nato-compatible IFF, in-

Fighter Aircraft



Dassault's Rafale

Most current fighters are designed from the outset as multi-role combat aircraft, although a minority (e.g., the Boeing F-15, Dassault Mirage 2000 and Lockheed Martin F/A-22) have been given outstanding 'top-end' performance (i.e., high Mach, high ceiling) for the air defence and air superiority roles.



This South Carolina Air National Guard Lockheed Martin F-16C is armed for the air defence role, with four Raytheon AIM-120s and two AIM-9s. (Lockheed Martin)

flight refuelling capability and Imperial units instrumentation, making it more suitable for international missions. Structural components for the first South African Gripen (a two-seater) are now being fabricated, with first flight scheduled for February 2006, leading to hand-over in November 2007. The first South African single-seater is to be delivered in late 2009. It will differ from the standard export Gripen primarily in having a BAE Systems Cobra integrated helmet-mounted display (IHMD) derived from the Striker to be used on the Eurofighter Typhoon.

One of the most commercially successful fighters is the Lockheed Martin F-16, production deliveries of which began in 1978. Approximately 4100 have since been delivered against orders from 24 nations, and the company has a backlog for more than 300 aircraft, with deliveries scheduled to continue until at least 2008. Recent customers include Chile, Oman, Poland and the UAE. Some 123 different versions have been produced or

are under development. The F-16 is one of four types shortlisted in Brazil.

In March 2003, an F-16 first flew with production conformal fuel tanks (CFT), carrying an additional 1390 kg of fuel without the use of underwing pylons. The lead customer for the CFTs is Greece,

«... the main threat to the Rafale and Typhoon is the Lockheed Martin F-35 JSF»

which is receiving 60 of the Advanced Block 52 version of the F-16C/D. However, development of the CFT was launched by an order for 80 F-16E/F Block 60s, placed by the UAE in early 2000. The first Block 60 had its maiden flight in December 2003, powered by a 144.5 kN General Electric F110-GE-132

engine. It also features a new avionics suite with a revolutionary Falcon Edge electronic warfare system, the Northrop Grumman APG-80 active array radar and the same company's integrated flir and targeting system. Deliveries to the UAE will begin at the end of this year.

In November 2003, Lockheed Martin rolled out the first of 102 F-16Is for the Israeli Air Force, equipped with the 129 kN Pratt & Whitney F100-PW-229 Improved Performance Engine, the Northrop Grumman APG-68(V)9 multi-mode radar with synthetic aperture radar ground mapping capability and CFTs. This batch brings Israeli F-16 orders to a total of 362. The F-16I has a maximum take-off weight of 23,587 kg, the heaviest ever achieved by an F-16. In relation to a wing area of only 27.9 metres square, it almost certainly gives the highest wing loading ever employed on a production fighter, far greater than even that of the Lockheed F-104G Starfighter. The F-16 is now crying out for more wing area, which could be obtained through use of the 25 per cent larger wing of the Mitsubishi F-2.

The RSK MiG-29 began life as a classic short-range air defence fighter with a high thrust/weight ratio and low fuel fraction. It had outstanding low-speed handling characteristics, but a high-workload cockpit and short-life engines. RSK-MiG is finally dealing with these shortcomings in an export series based on the MiG-29K developed for the Indian Navy. The single-seat MiG-29M1 was shown statically at Moscow in 2001, and the two-seat MiG-29M2 first flew that September. Both versions have been given a worthwhile air-surface capability. For the longer term, the company plans a derivative with reduced radar signature and new Klimov VK-10M engines.

The MiG-29M1/M2 series is believed to be the second favourite in the Indian Air Force contest for a lightweight fighter, of which 125 are urgently required to replace some MiG-21s and MiG-23s.

Aircraft	Saab/BAE Gripen	LM F-16C Block60	RSK-MiG -29SMT	Eurofighter Typhoon	Dassault Rafale	LM F-35	Boeing F-15E	Sukhoi Su-27SK	LM F/A-22
Powerplant	Volvo RM12	GE F110-GE-132	Klimov RD-33	Eurojet EJ200	Snecma M88-2	P&W JSF119	P&W F100-229	Saturn AL-31F	P&W F119-PW-100
Thrust [kN]	80	145	2 × 81.4	2 × 90	2 × 73.62	180	2 × 129.50	2 × 122.50	2 × 157.50
Span [m]	8.40	10	11.36	10.95	10.8	9.1	13.05	14.7	13.56
Length [m]	14.10	15.02	17.32	15.96	15.30	13.7	19.45	21.90	18.93
Height [m]	4.50	5.09	4.73	5.28	5.30	n/a	5.63	5.40	5
Wing Area [m²]	n/a	27.87	38	50	45.70	54.4	56.49	62.04	78.04
Empty Wt [kg]	7400	9750	11,000	10,995	9500	10,000	14,515	16,380	14,515
Intern Fuel [kg]	2400	3105	3555	4000	n/a	n/a	6037	9400	11,340
Clean TOW [kg]	10,000	13,175	15,300	15,000	n/a	n/a	n/a	23,140	27,250
Ext Load [kg]	5300	7225	4500	8000	9500	7700	11,000	8000	9080
Max TOW [kg]	14,000	22,680	21,000	23,000	24,500	24,500	36,740	33,000	36,350
Max Mach	2	2	2.3	2	1.80	1.80	2.50	2.35	2
Ceiling [ft]	n/a	50,000+	59,000	n/a	55,000	n/a	60,000	60,700	50,000+
Ferry Range [km]	n/a	n/a	3500	n/a	n/a	n/a	5740	3680	3250

The front-runner in this contest is the Dassault Mirage 2000, of which around 550 have been ordered by eight air forces. It is also shortlisted in Brazil.

Although the Dassault Rafale and Eurofighter Typhoon are shortlisted in Singapore, both are having problems in winning export orders. The French Government is relying on industry to fund further development of the Rafale, which needs more thrust to compete with the Typhoon. Deliveries of the first production tranche of 148 Typhoons began in mid-2003, but funding for the second tranche of 236 appears to be delayed, while the four-nation group argues over work-shares and considers whether the concept is relevant to 21st Century conflicts. The third domestic tranche of 236 aircraft appears increasingly unlikely, but last August Austria became the first



The Lockheed Martin F/A-22 Raptor combines low observability, thrust vectoring and outstanding performance. Deliveries have now begun, initially to replace the US Air Force Boeing F-15C. (Lockheed Martin)



This Eurofighter Typhoon was the first two-seat development aircraft assigned to Britain, and is now allocated to the Royal Air Force's Operational Conversion Unit, No 17(R) Squadron. (Eurofighter)

export customer, with a €1.98 billion order for 18 Typhoons.

The main threat to the Rafale and Typhoon is the Lockheed Martin F-35 JSF (Joint Strike Fighter), which combines an affordable price with a high degree of

stealth, at least in its domestic form. If sales go as planned, spares will be available globally on a commercial basis, minimising the need for individual holdings. The Stovl version with shaft-driven lift fan remains a high-risk development.

The third fighter shortlisted by Singapore is the Boeing F-15T, a further derivative of the F-15K ordered by South Korea (40 are scheduled for delivery between 2005 and 2008, with General Electric F110-GE-129 engines), in turn based on the multi-role F-15E, which is still in low-rate initial production for the US Air Force. The F-15T is expected to have an active electronically scanned array version of the Raytheon APG-63 radar installed.

As Asian economies boom, sales of the Sukhoi Su-27/30/35 series continue to expand, assisted in India and Malaysia by Thales avionics. The upgraded Su-27SM made its debut at Dubai last year. A win for the Su-35 in Brazil would represent a significant breakthrough into the Latin American market.

At the top of the fighter range, the stealthy Lockheed Martin F/A-22 Raptor is unlikely to be widely exported. The first of 276 planned for the US Air Force (which retains a requirement for 381) was delivered in September 2003. Initial operational capability is scheduled for the end of 2005.

Air-to-Air Guided Missiles



R73E Vypel

In providing air defence, the primary weapon for fighters is now the air-to-air missile (AAM), although fast-firing cannon still provide a useful last-ditch supplement. This type of missile is conveniently discussed in terms of short-, medium- and long-range categories, although the distinctions are sometimes blurred. Despite the ending of the Cold War, major advances are still taking place in such missiles, often inspired by Soviet developments that began over 20 years ago.

Considering firstly short-range AAMs, this type of development began as a replacement for aerial cannon, aimed at combining increased firing range with high kill probability, primarily to put a bomber out of control before it could release an atomic bomb. Since a series of firings from a comparatively small fighter was envisaged, the missile had to be lightweight, the correspondingly small warhead leading to the use of infrared homing for minimal miss distance.

First-generation weapons (such as the Sidewinder AIM-9B) were designed for air defence against docile targets, and for simplicity had uncooled seekers operating on short infrared wavelengths. They could thus detect only very hot emitters, such as turbine blades, which restricted firings to small angles off the target axis. Second-generation missiles (e.g., the Rafael Shafrir) were much more



The introduction of the Raytheon AIM-9X Evolved Sidewinder wears some new features, such as a focal plane array seeker and thrust vectoring, but retains the motor, fuze and warhead of the existing AIM-9M. (Raytheon)

manoeuvrable, increasing effectiveness in dogfights.

Third-generation missiles (e.g., Raytheon Sidewinder AIM-9L/M) have cooled infrared seekers operating on longer wavelengths, allowing them to home on to the target exhaust. Such seekers in principle make possible launches from all around the target (i.e., tail-chase, head-on and beam attacks). Fourth-generation missiles (e.g. the Vypel R-73 and Rafael Python 4) can engage targets at large angles off the axis of the launch aircraft, the pilot using a helmet-mounted sight to 'cue' the weapon seeker.

Fifth-generation missiles (e.g., the Raytheon AIM-9X, BGT Iris-T, Kentron A-Darter, MBDA Asraam and Rafael Python 50) have imaging seekers, giving much better discrimination against decoy flares, and (in principle) making it possible to attack a preselected part of the target, such as the front fuselage.

The earliest of the fifth-generation short-range AAMs was the Vypel R-73 (AA-11). Employed with an Urals Optical-Mechanical Plant helmet-mounted sight, it can be fired at targets up to 30 degrees off-axis, and can track them at twice that angle. It employs both thrust vectoring and canard surfaces for pitch and yaw control. A new export version is expected to combine a laser fuze (which is already on the Russian Air Force version) and 120-degree off-axis target acquisition capability. Maximum range is to be increased from 30 to 40 km, and reports suggest that the R-73 has potential for rear-hemisphere defence.

In view of the inferiority of the AIM-9M to the R-73, the Pentagon decided to upgrade the former in some respects, while retaining the existing motor, fuze

and warhead. The resulting Raytheon AIM-9X Evolved Sidewinder has a 128×128 element focal plane array seeker, and thrust vectoring to engage close targets at high angles off. It can be directed at such targets either by the aircraft radar or the Vision Systems International (Kaiser/Elbit) JHMCS (Joint Helmet-Mounted Cueing System). The US services plan to



The Kentron A-Darter is South Africa's contender for the fifth-generation, short-range, air-to-air guided missile market, but the completion of development may depend on overseas support. (Kentron)

buy 10,097 AIM-9Xs over a 17-year period, and Raytheon expects to produce around 5000 for export. Since November 2003, the AIM-9X has been operational on the US Air Force F-15C. Carriage on the US Navy/Marine Corps F/A-18C/D will follow shortly, and it will be on the US Air Force F-16C in 2006. Poland, South Korea and Switzerland have chosen the AIM-9X.

South Africa's fifth-generation Kentron A-Darter is still under development, and completion may depend on its winning an export order. It has an imaging-IR seeker by Kentron, a wingless airframe with body strakes, thrust vectoring and tail controls. It can lock on to targets after launch.

The MBDA Asraam employs the same Raytheon seeker as the AIM-9X. It is wingless and does not have thrust vectoring, its design emphasising speed and range rather than sharp turns directly after launch. Depending on launch conditions, it has up to three times the range of the AIM-9M. Production deliveries began in 2002, initially for the British RAF Tornado F3, but it will later equip British Typhoons and F-35s. The Asraam has also been selected for Australia's F/A-18. Later versions will have the ability to lock on to the target after launch.

Germany, Greece, Italy, Norway, Spain and Sweden are collaborating on the Iris-T, developed by a team led by Germany's BGT. It is a fully European missile, using a low-cost 128×4 array seeker with reduced susceptibility to laser countermeasures. Iris-T can lock on to targets at more than 90 degrees off axis, cued either by the launch aircraft radar or a helmet-mounted sight. It combines thrust-vectoring and tail controls, and can lock on after launch. Iris-T is being integrated on the F-16, F/A-18, JAS39 Gripen, the Tornado and the Typhoon. In late 2003, a six-

nation Memorandum of Understanding was signed on the series production of approximately 4000 rounds.

Medium Ranges

The current standard for medium-range AAMs was set by the Vypel RVV-AE (AA-12, reported Russian service designation R-77), which has a maximum range of 100 km and is distinguished by its lattice-type tail controls. It employs three-phase guidance; the first inertial phase being later refined by target updates from the launch aircraft prior to active radar terminal homing. Deliveries to the Russian Air Force began in 1993, and it has been exported to China, India,

Missile	Raytheon Aim-9X	MBDA Mica	Kentron A-Darter	Vypel R-73	MBDA Mica	Rafael Derby	Raytheon Aim-120C5	Vypel RVV-AE	Vypel R-27RE
Launch Wt [kg]	85.3	88.0	89.0	105.0	112.0	118.0	156.8	225.0	350.0
Warhead [kg]	N/A	N/A	N/A	7.4	N/A	N/A	22.0	22.0	39.0
Length [m]	3.0	2.9	2.98	2.9	3.1	3.62	3.65	3.70	4.7
Diameter [m]	0.127	0.166	0.166	0.17	0.16	0.16	0.178	0.20	0.26
Span [m]	0.445	N/A	0.488	0.51	0.49	0.64	0.445	0.39	0.80
Range [km]	N/A	N/A	N/A	30	55+	N/A	N/A	100	130



Test firing of a Raytheon Aim-120 Amraam (Advanced Medium-Range Air-Air Missile) from a Boeing F-15C. The Amraam entered service in 1991, and is also used as a surface-air missile. (Raytheon)

Malaysia and Peru. Vypel is reportedly developing an infrared-homing RVV-TE and a passive radar homing RVV-PE.

The RVV-AE was designed to replace the Vypel R-27 (AA-10) series, which is identified by its reverse-taper ailerons. In R-27RE/TE extended-range form the missile employs semi-active radar or infrared homing respectively, and has an unrivalled maximum range of 130 km. This may well justify it being retained in service alongside the RVV-AE, as it allows a Russian-built fighter to fire first in a head-on engagement with a non-stealthy Western-built fighter armed with the AIM-120.

If funded, the rocket-ramjet powered RVV-AE-PD will provide a range of 160 km. As an interim measure, Vypel is reportedly working on a version of the RVV-AE designated K-77M, using a ballistic trajectory to extend range. China is working on its own Project 129 derivative for use on the Su-30MKK, using a dual-pulse rocket motor to increase range and terminal manoeuvrability. An SD-10 export version has been seen on a mock-up of the FC-1 lightweight fighter project.

The Raytheon AIM-120 Amraam employs a similar three-stage guidance system to that of the RVV-AE. It entered service in 1991, and more than 12,000 have been delivered to 25 nations. The new AIM-120C5 has an improved warhead, an extended rocket motor and cropped aerofoils to suit internal carriage. Future developments include a further lengthened rocket motor, an improved datalink and a Raytheon-funded high off-boresight capability.

Europe's most advanced medium-range AAM is the MBDA Mica, which is also effective at short range. It employs thrust vectoring, and is available with a dual-wavelength imaging-infrared or active radar seeker. The Mica is operational with the French and has been sold to Greece, Qatar, Taiwan and the UAE.

Some European air forces want increased firing range and more manoeuvrability in the terminal phase. Such demands have led to the MBDA Meteor, with a ducted rocket ramjet, multi-stage guidance and a maximum speed of over Mach 4. It is being developed by a six-nation team, which includes Eads-Casa, Eads-LFK and Saab Bofors Dynamics. The development contract was signed at the end of 2002, with this work scheduled to be completed by 2010 leading to service on the Typhoon, Rafale and JAS39 Gripen. Boeing is proposing external installation on the F-15 and F/A-18.

Work on long-range AAMs is comparatively limited, but at the 2003 Dubai Air Show Novator showed a model of its Type 172 as an inboard underwing installation for the Su-35. This dates from a Soviet requirement of the late 1980s, calling for a range of 400 km against high-value radar platforms and tankers. Reports refer to an export version with a range of 300 km, but the status of the programme is unclear.



The ramjet-powered MBDA Meteor is being developed by a six-nation European team that is determined to provide outstanding range and manoeuvrability in the terminal phase of an engagement. (MBDA).

AEW&C Aircraft



The US-led Coalition's overwhelming success in the 1991 Gulf War was due in no small part to the use of airborne early Warning and Control aircraft.

The oldest of in-service AEW&C aircraft is the 25-tonne Northrop Grumman E-2C Hawkeye II. The current Group II standard has a Lockheed Martin APS-145 radar, cruises between 25,000 and 31,000 ft, and has a maximum endurance of six hours. The E-2C is operated by the US Navy and has been exported to Egypt, France, Israel, Japan, Singapore and Taiwan.

In 1999, the US Navy's production programme for the new Hawkeye 2000 was launched, based on a planned total of 27 new-build aircraft, plus 54 Group IIs to be upgraded to the same standard. All of the service's E-2Cs will be fitted with the eight-blade Hamilton Sundstrand NP2000 propeller introduced with the Hawkeye 2000.

The Advanced Hawkeye (AHE) is currently in the SDD (system development and demonstration) phase, which is to lead to initial operational capability in 2011. Its next-generation UHF radar is meanwhile being developed by Lockheed Martin,



The Boeing E-767, based on the B767-200ER, replaces the E-3 Awacs, the B707 line having closed in 1991. So far only Japan has ordered this aircraft. (Boeing)

The Elta Phalcon radar employs a series of phased array antennas attached to the fuselage, in some cases augmented by nose and tail radomes. Israel and South Africa are believed to operate Phalcon systems based on the B707. In addition, Chile has one such aircraft, designated Condor, equipped with a nose radome and two front fuselage arrays. Israel has ordered three Gulfstream G550s with Phalcon nose and tail radomes and two fuselage arrays feeding six consoles. Similar aircraft have been proposed for South Korea, which has a requirement for four units.

Australia and Turkey have selected the 77-tonne Boeing B737 AEW&C, based on the B737-700IGW airframe and the Northrop Grumman Mesa (Multi-role Electronically-Scanned Array) radar with dorsal-mounted linear antennas. The baseline version has a two-man flight crew and six mission specialists. Both countries have ordered four aircraft.

Dorsal-mounted linear-array antennas are also used by the Ericsson Erieye radar, which was first adopted by the Swedish Air Force (six aircraft), using the Saab 340B as the aerial platform, and later by Brazil (five), Mexico (one) and Greece (four), all using the Embraer EMB 145 series. Reports suggest that by April 2004 Malaysia will have signed a contract for four EMB 145s equipped with the Erieye radar.

teamed with Northrop Grumman and Raytheon. L-3 Communications is responsible for the electronically-scanned antenna and BAE Systems for the IFF system. The US Navy plans to have all of its E-2Cs (around 75 aircraft) brought to AHE standard by 2020.

The AEW&C hero of the 1991 Gulf War was the 152-tonne Boeing E-3 Awacs, which is equipped with a Northrop Grumman APY-1/2 radar. It typically has 14 mission consoles, a maximum endurance of over eleven hours and a cruise altitude of around 30,000 ft. The US Air Force purchased 34 E-3s, and 18 were later ordered by Nato, five by Saudi Arabia, seven by the UK and four by France.

In 1991 Boeing announced that, following the closure of the B707 line, further Awacs production would be based on the B767-200ER. Japan has purchased four 175-tonne E-767s, equipped with General Electric CF6-80C turbofans. The E-767 has a two-man flight deck, nine operator consoles (five more if required), a cruise altitude of 34,000 to 40,000 ft, and a 13-hour endurance at 550 km radius.

Russia's equivalent of the E-3 is the 190-tonne Beriev A-50, based on the

Ilyushin Il-76MD transport and with Rybinsk D-30 turbofans. The A-50 has a four-man flight deck and eleven operator consoles. Heavy avionics restricts fuel load, limiting endurance to four hours at 1000 km radius. Cruise altitude is 26,000 to 33,000 ft. The A-50E is an export version with improved Russian avionics, and six of these have been ordered by China. Three A-50Is with Israeli (Elta Phalcon) avionics have been ordered by India.



Less expensive than the Boeing B737 AEW&C ordered by Australia and Turkey, the Embraer EMB 145 with Ericsson Erieye radar has won orders from Brazil, Greece and Mexico. (Embraer)

Aircraft	Embraer EMB 145	Northrop Grumman E-2C	Boeing B737 AEW&C	Boeing E-3 Awacs	Boeing E-767 AEW&C	Beriev A-50
Powerplant	Rolls-Royce AE3007A	Rolls-Royce T56-A-427	CFM Int CFM56-7	CFM Int CFM56-2A-2	General Electric CF6-80C	Rybinsk D-30KP
Max TOW [kg]	23,400	25,000	77,000	152,000	175,000	190,000
Thrust [kN]/Power [kW]	2 × 31.32	2 × 3800 [kW]	2 × 101	4 × 106.80	2 × 273.60	4 × 117.70
Span [m]	20.04	24.56	34.32	44.42	47.57	50.50
Length [m]	29.87	17.60	33.63	46.61	48.51	46.60
Height [m]	6.75	5.58	12.55	12.73	15.85	14.80
Wing Area [m²]	51.18	65.03	124.5	273.40	283.4	301.20
Antenna Dia/Length [m]	8	7.32	10.7	9.14	9.14	10.50
Altitude [ft]	30,000	25 to 30,000	n/a	25 to 30,000	34 to 40,000	26 to 33,000
Max endurance [h]	9.00	n/a	n/a	11	n/a	n/a
Time on station [h@km]	n/a	5.3 @ 370	8.0 @ 550	n/a	13 @ 550	4.0 @ 1000
Max range [km]	2650	2855	5560	9250	10,370	5000

Vshorad Missiles



Boeing Avenger

Very short-range air defence systems (Vshorad) may for practical purposes be defined as engaging their targets at less than ten kilometres. Operational flexibility favours very lightweight missiles, since these allow a foot soldier to become a self-contained firing unit, at least in clear weather/daylight conditions. Greater kill probability can be achieved by placing a number of such weapons on a pedestal mount for salvo firing, and the mount may be linked to an external cueing system.

Although manpads (man-portable air defence systems) have gone through at least three generations of development, some older models (such as the KBM 9M32M Strela-2M or SA-7) remain a somewhat limited threat, primarily to unprotected commercial aircraft. Russia's second generation is represented by the Strela-3 (SA-14) and KBM 9M310 Igla-1 (SA-16), both with cooled seekers to suit longer infrared wavelengths and allow all-aspect engagements. The third Russian generation is exemplified by the KBM 9M39 Igla (SA-18) with a two-wavelength seeker to discriminate against decoys. The latest KBM 9M342 Igla-Super combines a heavier warhead, a laser proximity fuze and improvements to the rocket motor and flight control system.

America's equivalent of the Igla series is the Raytheon Fim-92 Stinger, which is widely used in manpads form, and is also available in a variety of other installations, including the company's Dual Mount Stinger (DMS) with flir sensor and radar cueing. Eads-LFK has developed a two-round Tripod-Adapted Stinger (Tas) mount and a Pedestal-Mounted Stinger (PMS) system for 4 x 4 vehicles. The Stinger is also used on the US Army's AM General Hummer-based Boeing Avenger and the Bradley-Linebacker fighting vehicle. Recent sales include the Lithuanian purchase of Raytheon Lasams (Low-Altitude Sam System) with Hummer vehicles and Thales Raytheon Systems

TPQ-64 Sentinel radars. In addition, Stinger forms the initial armament of the German Army's LeFlaSys, a joint venture by Rheinmetall Defence Electronics and Krauss-Maffei Wegmann, using the MaK Wiesel 2 tracked vehicle. The LeFlaSys combines up to eight Ozelot weapon platforms (each with four ready-to-fire missiles) and a command post mounting the Ericsson Hard 3D radar and a Thales Optonics Adad Irst system.

Designing down to a weight suitable for manpads capability restricts the effectiveness of the missile warhead. Some services prefer a somewhat heavier round, despite the consequent need for a tripod mount. A good example of this

approach is the 20 kg MBDA Mistral, which carries a 2.95 kg warhead, compared to the 1.2 kg of the Igla. The Mistral is available in a wide variety of ground- and naval-based installations, and more than 15,000 have been ordered by the armed forces of 25 nations.

Due to its extreme accuracy, infrared homing is perhaps the obvious choice of guidance systems. However, Saab Bofors Dynamics' man-portable RBS70/90 system employs laser beam-riding, in combination with a very effective blast/fragmentation warhead and an unjammable laser proximity fuze. The company's Bolide is a further development, aimed at defeating more difficult targets, and employs a new sustainer motor, giving increased range and reduced time-of-flight. The Bolide is also used in the vehicular Asrad-R system, a joint venture by Saab Bofors Dynamics and Rheinmetall Defence Electronics. Finland has ordered both the RBS70 and Asrad-R.

Laser guidance is also employed by the Thales Air Defence Starstreak high velocity missile. This attained operational capability in 1999 with the British Army in Armoured Starstreak form, based on the Alvis Stormer tracked vehicle, which carries eight ready-to-fire rounds and twelve reloads. The British Army also uses the missile on the tripod-mounted, three-round Lightweight Multiple Launcher. In either case the target is tracked optically, and the system generates laser guidance signals to the three hypersonic 'darts', which the missile projects toward the target. For Finland, Thales developed a vehicle-mounted automatic aiming system for Starstreak. The company has recently unveiled a new fully automatic target tracking and missile control system for use with a variety of day/night sensors and a laser ranger, and suitable for ground-, palletised- and vehicular-applications. A single-dart Starstreak is under consideration by Thales as more suitable for small targets such as UAVs.

The MBDA Jernas is the export version of the towed Rapier FSC (Field Standard C), which in 1996 entered service with the British Army and Royal Air Force (RAF). A system consists of three trailers carrying a firing station with eight



Unveiled in 2000, the China National Precision Machinery Import & Export Corporation's FN-6 is believed to have been the first Chinese Manpads with built-in Identify Friend Foe provisions. (Armada/RB)



One of the most popular man-portable Sams is the MBDA Mistral, shown here with a Thales MITS-2 thermal imaging sight, allowing long-range target detection. (Thales)

Rapier Mk 2 missiles, a 3D surveillance radar and a high-resolution tracking radar. Guidance is based on automatic Command-to-Line-Of-Sight (Clos). The Rapier series is in service in ten countries, some of which are upgrading to FSC.

The Euromissile Roland also employs Clos guidance (based on radar, infrared or optical tracking), and was first installed on tracked vehicles for battlefield air defence. The need for easy overseas deployment led to the development of a shelter version, which can be operated on the ground, or on a trailer or truck. Over 26,000 missiles and 644 firing posts have been delivered to eleven nations. A major advance was provided by the VT-1 missile, which increased range into the Shorads area (i.e., over ten kilometres). The Enhanced Roland combines various upgrades and introduces the Glaive optronic fire control system and the BKS digital management system, developed jointly by Euromissile and Eads-LFK.

Hybrid (gun and missile) systems include the KBP/Ulyanovsk Tunguska-

M1, which is armed with eight Fakel/KBM 9M311 (SA-19) missiles and two 30 mm cannon.

Turning to naval Vshorads, the MBDA Mistral is in service as the manually-operated twin-round Simbad and the six-round Sadral, which has a stabilised mount and day/night cameras, but can take target data from the parent vessel's radar and/or optronic system. The company has also developed the four-round Tetral, which has a stabilised mount and a thermal camera – this to suit installation on stealth vessels.

The Rafael Barak-1, developed as a joint venture with Israel Aircraft Industries, was one of the first systems to employ vertical launching and thrust vectoring, making possible 360-degree Vshorads cover from a single installation. A system typically consists of two eight-round launchers and a fire control system, which is based on a twin-band Elta EL/M-2221 tracking radar and a thermal imager, and cued by the ship's search radar. The Barak employs semi-active

radar homing, and is capable of engaging targets flying as low as two metres over the sea. The missile is in service with the navies of Israel, Chile and Singapore, and with the Indian Army. In late 2003 the Indian Navy was reportedly about to sign an order for Barak.

The RIM-116 Ram (Rolling Airframe Missile) or Mk 31 Guided Missile Weapon System is a Sidewinder-derived Vshorads for defence against anti-ship missiles (ASM), developed jointly by Raytheon and Germany's Ramsys consortium. It was first deployed in 1993, and is being fitted to over 80 US Navy and 28 German Navy ships. The Ram is fired from the 21-round Mk 49 launcher. The Block O Ram was designed to defeat



The replacement for the ZSU-23-4 Shilka is the KBP/Ulyanovsk Tunguska-M1 vehicle, which carries eight of these Fakel/KBM 9M311 (SA-19) missiles and two 30 mm cannon. (Armada/RB)

Missile	Launch Wt [kg]	Warhead [kg]	Length [m]	Diameter [m]	Max range [m]	Max Alt [ft]
KBM Strela-3 (SA-14)	9.80	1	1.42	0.072	4000	10,000
KBM Igla (SA-18)	10.60	1.15	1.67	0.072	5200	11,500
KBM Igla-S	12.60	2.50	1.67	0.072	6000	11,500
Raytheon Stinger-RMP	10.40	1	1.524	0.07	4500	11,500
MBDA Mistral	18.70	3	1.86	0.09	6000	n/a
Saab Bofors Dynamics RBS 70/90	16.50	n/a	1.32	0.106	8000	16,500
Thales Starstreak	13.60	n/a	1.40	0.127	7000	n/a
KBM 9M311 (SA-19)	42	9	2.632	0.076	10,000	20,000
MBDA Jernas	43	n/a	2.24	0.13	8000+	n/a
Euromissile Roland 3	65	n/a	2.40	0.163	8000	13,000
Rafael Barak-1	98	22	2.134	0.183	10,000	n/a
Raytheon Rim-116A Ram	73.48	11.36	2.80	0.127	n/a	n/a

ASMs that employ active radar guidance. The nose mounts a passive radar sensor on either side of a Stinger infrared seeker. Cued by the ship's search radar, it is fired toward the ASM, initially employing passive radar homing. The infrared seeker then acquires the ASM and takes control, giving more precise guidance in

the terminal phase. The Block 1, which is now in full-rate production, was developed to counter ASMs that do not use active radar guidance, by introducing a new imaging-infrared seeker. Although the radar-to-infrared capability is retained, the Block 1 can use all-the-way infrared homing. The new seeker also



The Ram (Rolling Airframe Missile) is a joint US-German development by Raytheon and the Ramsys consortium. It is shown here being fired from a 21-cell launcher. (Raytheon)



As MBDA has done with the Mica, BGT and Eads-LFK developed a VL launch system using the air-to-air Iris-T, which was unveiled at the ILA 2002 exhibition. (BGT)

improves capability against fixed- and rotary-wing aircraft. In the Raytheon Sea Ram, the Gatling gun of the Phalanx close-in weapon system is replaced by an eleven-round Ram launcher.

Guns



Oerlikon Contraves Millennium Gun (without armoured fairing)

Belonging to the very short range segment of air defence, barrelled weapons had somewhat fallen out of favour in the recent decades. This was perhaps due to the fact that guns carried an out-of-fashion connotation but the development of smart rounds and fire controls is giving the barrel a new lease on life.

Unquestionably, the Bofors 40mm is still regarded as a reference in terms of air defence artillery, primarily because of its extensive use during the second world war to the point that it is difficult to find a western country that hasn't had it in its inventory; even the Russians made their own copy of it, but as a 37mm calibre, of course while Hungary built it under the 40mm 36M designation.

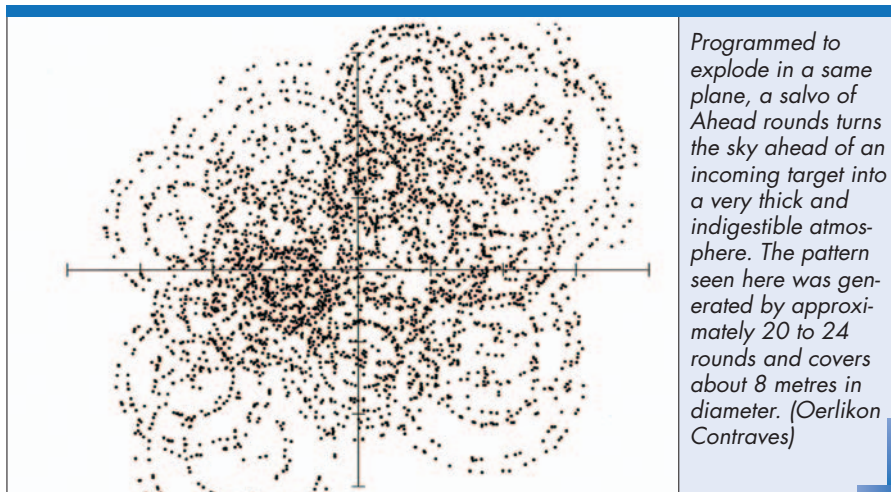
To address the new threat – no longer only aircraft, but now also cruise missiles, gliding dispensers and drones – Bofors developed the programmable 3P round in the late 1980s. Initially developed for L/70 40 mm guns, the concept was also transferred to the naval 57 mm calibre, which was recently adopted by the

United States. Each 3P round fuze is programmed individually when it is chambered according to the specifications received by the fire control computer and range sensors (radar and/or laser range finder). Basically, the system initiates a clock that will trigger the round at a specific distance from the gun (and therefore from the target, and will literally spray the air around it with 1100 pellets, plus the fragment produced by the casing itself. Quite clearly, a burst of four or six rounds will leave very little free space for even a small target to survive. There are six modes:

► Gated proximity (against missiles, attack aircraft, dispensers and helicopters)

- Gated proximity with impact priority (against large transport aircraft and helicopters)
- Continuous proximity (default mode for guns not equipped with the programming system)
- Time (enables the gun to fire horizontally above an area of soft targets – basically anti-personnel)
- Impact (against truck, personnel carriers, small boats)
- Armour-piercing impact (light armoured vehicles, buildings).

The time programme function of the 3P is of course immune to any type of countermeasure. The Bofors L/70 is traditionally operated in conjunction with the famous Saab Utaas fire-control system. Saab has also developed the LVS fire control system more particularly as an upgrade for virtually any motor-controlled air defence gun. It is mainly made up of five modules: the target acquisition and tracking unit, the gyro, azimuth trans-



Programmed to explode in a same plane, a salvo of Ahead rounds turns the sky ahead of an incoming target into a very thick and indigestible atmosphere. The pattern seen here was generated by approximately 20 to 24 rounds and covers about 8 metres in diameter. (Oerlikon Contraves)

ducer, control and display and the computer. However, a sixth module can be plugged into the system, namely the training simulator unit.

Oerlikon Contraves also has a long historical background with barrelled weapons, but is now more renowned for its 35 mm Twin Gun Systems. One of the firm's forte is its outstanding ability to upgrade virtually any of its customer's older systems to enable them to exploit the latest state-of-the-art fire control systems. Oerlikon might have been taken over by Rheinmetall, but the almost stubborn Swiss quest for quality and impeccable service has remained.

The latest addition to the firm's catalogue in terms of barrels is the 35 mm revolver cannon. Associated with Oerlikon's latest air defence radar and fire control system, this modular and palletised system is known as the Skyshield 35. What is best, the Skyshield 35 can also be mated to a missile launcher for longer

range defence, a typical candidate being the Adats from Oerlikon Aerospace.

In fact, the Skyshield 35 system includes four distinct components: the

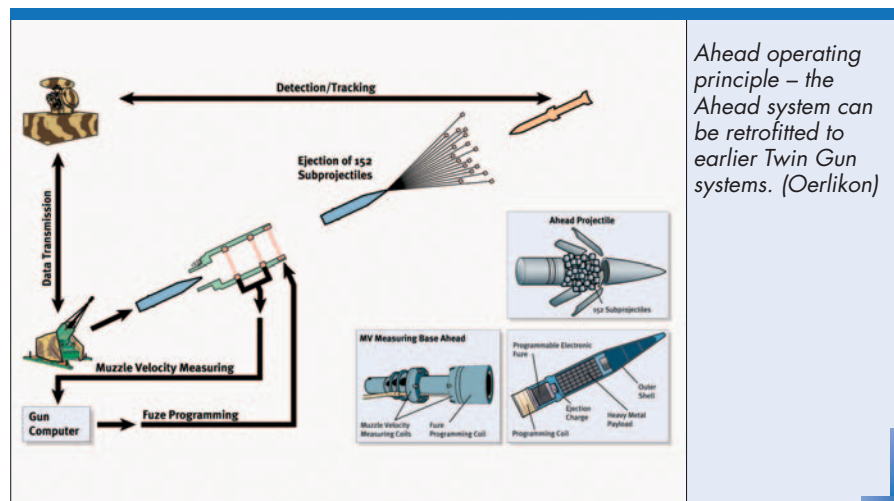
gun, the radar/fire control, command post, and the Ahead munition.

The revolver gun itself is known as the 35/1000, which in fact indicates the weapon's calibre and its rate of fire. Once set up (levelled, fed with 228 rounds and its precise co-ordinates optically fed into the fire control system), the gun rests unattended on its ISO pallet.

The sensor suite is also palletised and consists of an X-band multiple-beam search radar and tracking radar. Upon detection, the target is automatically handed over to the tracking sensors consisting of a TV, laser and infrared module located in the command post shelter.

Less than 4.5 seconds will have elapsed from target acquisition to fire.

This brings us to the round, known as the Ahead, but this is also a programmable round, but pushes the art a step further than the Swedish 3P, as it is programmed once it has left the muzzle of the gun, meaning that the actual speed of every



Ahead operating principle – the Ahead system can be retrofitted to earlier Twin Gun systems. (Oerlikon)



Using the Skyshield 35 as a foundation, Oerlikon is currently working on the concept of a self-propelled battlefield air defence system using the revolver-Ahead combination with a tactical command post equipped with the company's new 25 to 50 km-range X-Tar 3D radar (at right in background). The aim is to make the units C-130 transportable. (Oerlikon Contraves)

single round is used into the programming equation. To do this, the barrel of the gun is equipped with three induction coils: the first detects the outgoing round and starts the computer's timing clock, the second stops the clock as it detects the passing round and allows the computer to work out the exact round speed while the third then injects the timing information into the fuze (see diagram herewith) based on the range and closing speed of the target as well as the speed of the round which always varies slightly. This degree of accuracy is necessary if one wants to 'organise' the moment and position in the air at which the rounds of a same burst are to explode – either in a 'string', as would be suited for an anti-personnel salvo, or in a same plane in the case of an aerial target, for example. One Ahead round radially expels 152 razor-edged cylindrical tungsten subprojectiles able to cut through any light alloy airframe and wreck havoc on anything hiding internally.

On the purely naval application, there is also the famous Phalanx close in weapon system from Raytheon. Based on the six-barrel M61A1 Gatling gun, it fires 20 mm rounds at a rate of 4500 rounds per minute. Since its inception in the



While a Skyshield 35 fire control system can control two guns, or two guns and a missile launcher, it could handle up to four guns; however, such a combination would simply result in an overkill, such is the effectiveness of the 35/1000 firing the Ahead. (Oerlikon Contraves)

mm guns and missile launchers. The Tunguska can be very unhealthy for any object flying in its vicinity. It detects at a range of 18,000 and tracks at 16,000 and automatically reacts within eight seconds to either launch one or several of its four ready-to-fire KBP 9M311-1M missiles to a range of 10,000 metres or cause its two canon to belch fire at a combined rate of 5,000 rounds per minute. The Tunguska has a range of no less than 500 km.



The Shilka dates back to the Soviet era, but the upgrade developed by Ulyanovsk enables it to be suitably integrated into a modern information system (Armada archives)

1970s, the Phalanx has undergone a number of improvements and upgrades, the latest being the Block 1B. It was successfully tested in this guise by the US Navy in 2002 onboard the Navy's Self-Defense Test Ship and against a supersonic sea-skimming missile. Configurations on the SDTS fully integrate the Phalanx sensors and weapon with Raytheon's Ship Self-Defense System (SSDS) Mk 1 combat suite. During this test the Phalanx search radar passed missile detection data to SSDS which in turn designated the Phalanx CIWS to engage the incoming missile. Post-test analysis reveals the target missile was hit by one of the first projectiles fired by Phalanx with subsequent target destruction occurring at a range double that of previous testing.

The former Soviet Union has generated a plethora of gun-based air defence systems, the better known being the Shilka and the Tunguska from the Ulyanovsk Mechanical Plant. The Shilka – also well known as the ZSU-23-4 is mounted on a tracked vehicle and is almost self contained (it carries its own radar and fire control system) if one excludes the Sbornka-M1 surveillance radar and command post unit. Ulyanovsk has come up with a modernisation pro-

gramme generally aimed at digitising the computer and fire-control suite of the weapon system as well as installing modern data-links. Thus equipped the four-barrel Shilka can engage aircraft flying at altitudes comprised between 25 and 1500 metres and at ranges of 2500 metres.

The Tunguska-M1 is also mounted on a tracked vehicle, but combines two 30



Up to six 34-tonne Ulyanovsk Tunguska-M1 systems provide a complete combat unit in conjunction with a Tar 9C18M1 long range radar and battery command post, all mounted on the same tracked chassis. (Armada archives)

Shorad Missiles

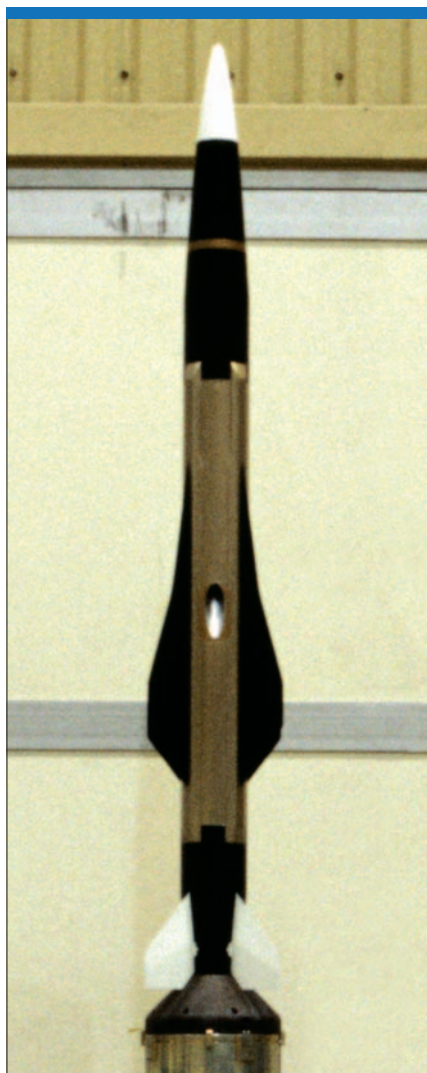


Rafael Python 5

The somewhat heavier Shorad guided missiles fill the gap between Vshorads and medium-range systems that provide engagements beyond 20 kilometres. However, as illustrated by the Euromissile Roland, which has developed from the Vshorad to the Shorad category, the distinction between the two is sometimes blurred.

The Rafael Python 5 air-to-air dogfight missile is now proposed for the Shorads role, with a range of approximately 20 km. Rafael has offered the Indian Army a surface-to-air Python and Derby air defence system (designated Spyder), based on a four-canister trainable launcher on a 6 × 6 truck. A second vehicle will carry a mast-mounted Elta search radar, and the complete system is designed to be deployed in an Il-76 transport. Fitted with a boost motor from the company's Barak missile, the Derby (basically a medium-range air-to-air missile) is estimated to have a maximum range of 40 km. The first launches from a Spyder vehicle are to take place in June 2004.

Russia's hybrid KBP/Ulyanovsk Pantsir-S1, based on an 8 × 8 vehicle, is armed with twelve Fakel/KBM 9M335 missiles and two 30 mm cannon.



The Saab Bofors Dynamics RBS23 Bamse missile has a large tandem booster for excellent altitude coverage. It has also been designed to intercept smaller targets. (Armada/RB)

The Raytheon Aim-120 Amraam is employed in the airfield Shorad role in Kongsberg's Norwegian Advanced Surface-Air Missile System (Nasams), which combines six-round towed firing units and Raytheon MPQ-64 surveillance and TPQ-36A tracking radars; the latter augmented by thermal imaging cameras. Kongsberg has also supplied four Nasams to Spain. Nasams II is a mid-life upgrade by Kongsberg and Raytheon, mainly of the sensors and fire control system. The US Marine Corps Claws (Complementary Low Altitude Weapon System) places four Aim-120s on a Hummer vehicle, to complement the Stinger-armed Avenger. The Claws is scheduled to be operational by 2005, and the US Army has a comparable requirement, designated Slamraam (Surface-Launched Amraam).

The Saab Bofors Dynamics RBS23 Bamse system appears to have been developed to provide better altitude coverage than existing Shorads, and to intercept smaller targets. The Bamse battery consists of a surveillance co-ordination centre (SCC) with a telescopically mounted Ericsson Giraffe radar, and up to four fir-

ing units, each with four ready-to-fire missiles. The firing units are towed by cross-country vehicles, which carry reloads and an Ericsson tracking radar, and are typically positioned ten kilometres from the SCC. The tracking radar also provides Clos guidance for the missile, which is launched by a large tandem booster.

Russia's first significant mobile Shorad system was the Antey 9K33 Romb or Osa (SA-8), which first appeared in 1974 and is based on a 6 × 6 amphibious vehicle. The initial drawback was that a whole battery could be put out of action by attacking the vehicle carrying the search radar, but each launch vehicle was later given its own complete fire control system. The Antey 9K330 Tor (SA-15) is based on a tracked vehicle, and each firing vehicle carries eight vertically launched Fakel 9M330 missiles, plus search and tracking radars. The later Tor-

«Russia's first significant mobile Shorad system was the Antey 9K33 Romb or Osa (SA-8), which first appeared in 1974...»

M1 introduced the improved 9M331 missile with a more effective warhead, and an automatic tracker was added to the electro-optical channel.

The missiles used in the Tor system are employed in the naval Klinok, using three or four under-deck eight-round modules. The system is also able to control the fire from 30 mm gun mounts.

The Raytheon RIM-7P Nato Sea Sparrow Missile System has progressed



The Kentron Umkhonto-IR is the production version of the Sahv-IR shown here. It is being integrated on South Africa's Meko-class corvettes and has been ordered by Finland. (Armada/RB)

Missile	Launch Wt [kg]	Warhead [kg]	Length [m]	Diameter [m]	Max Range [m]	Max Alt [ft]
Euromissile Roland VT-1	76	13	2.60	0.17	11,000	0,000
KBM 9M335 (Pantsir-S1)	71	20	3.20	0.09	18,000	33,000
Raytheon AIM-120	88	n/a	2.90	0.166	n/a	n/a
Saab Bofors Dynamics RBS23 Bamse	n/a	n/a	2.50	0.11	15,000+	50,000
Antey Osa-AKM (SA-8)	128	15	3.14	0.21	10,000+	16,500
Antey Tor-M1 (SA-15)	167	14.80	2.90	0.235	12,000	20,000
Raytheon Aim-7P Sea Sparrow	231.50	38.60	3.66	0.203	20,000	n/a
MBDA VL Mica	112	n/a	3.10	0.16	10,000+	n/a
Kentron Umkhonto-IR	127	23	3.32	0.18	12,000	33,000

through a multitude series of stages, including the vertical-launch Sea Sparrow and the RIM-162 Evolved Sea Sparrow Missile (ESSM). The latter is a kinematic upgrade, with a larger diameter motor, a new tail control section and thrust

vectoring. The ESSM also wears an upgraded warhead.

Other naval Shorads include the MBDA Vertical Launch Seawolf and Mica. The former has demonstrated its ability to intercept 4.5-inch shells. The

vertical-launch Kentron Umkhonto-IR is being integrated on South Africa's Meko-class corvettes and has been ordered for Finland's Squadron 2000 vessels. It employs an infrared seeker derived from that of the U-Darter air-to-air missile.

Medium-range Missiles



Raytheon Mim-23 Hawk system

Between Shorad and long-range missiles, engagements in the 20 to 75 km category are provided by medium-range weapons. Europe is now entering the scene with the Aster-based family of missile systems

The classic Western example is the Raytheon Mim-23 Hawk, which entered service in 1960. It is currently used by the US Army and Marine Corps, and the services of 20 other nations. The Hawk is a semi-active radar homing weapon that is fired from a wheeled trailer. The system has gone through a series of upgrades, leading to the present day Phase III, which can also provide some capability against short-range ballistic missiles. Future plans centre on combining the Hawk with the Amraam, to retain the longer range and higher altitude performance of the former, while exploiting the enhanced capability of the latter against multiple high-speed low-level targets. The Hawk-Amraam programme is a joint effort by Raytheon and Kongsberg.

As mentioned earlier, the Rafael Derby is another medium-range AAM that is now being developed for the Sam role, in this case its large tandem booster giving a range of 40 km.

Russia's Ulyanovsk-built 9K12 Kub (SA-6) is comparable to the Hawk, but based on tracked vehicles. The missile employs rocket and ramjet propulsion, and command guidance followed by semi-active radar homing in the terminal phase. Although it first appeared in 1967, the Kub remains in service with over 20 armed services, and Ulyanovsk is still marketing upgrades, including the 3M9M3 missile, which provides up to 25 per cent more range and doubles the intercept ceiling to 46,000 ft.

In 1979 Ulyanovsk switched production from the Kub to the 9K37 Buk (SA-11), which also replaced the even older 9K8 Krug (SA-4). The improvements

provided by the Buk included the installation of an illumination and tracking radar on each firing unit. The missile for the 9K37M1 Buk-M1 is the 9M38M1, designed by the Dolgoprudny Research Production Enterprise (DNPP), and boasting a peak velocity of Mach 3.5. The 9K37M1-2 or Buk-M1-2 (SA-17) that was fielded by the Russian Army in 1998 combines the DNPP-designed 9M317 missile and a new fire control system, giv-

«An important advance in the land-based medium-range category is [...] a member of the Franco-Italian Future Surface-to-Air Family...»

ing some capability against anti-radiation and tactical ballistic missiles.

An important advancement in the land-based medium-range category is represented by the Eurosam (MBDA/Thales) Samp-T (Sol-Air Moyenne Portée – Terrestre), a member of the Franco-Italian Future Surface-to-Air Family (FSAF) of ADS. It is a truck-



The Eurosam Samp-T is an easily deployed launch unit that is based on standard army trucks, more specifically the French Renault TRM and the Italian Astra/Iveco, as illustrated here. (MBDA)

mounted, air transportable system based on the vertical-launch MBDA Aster 30 missile and the Thales Arabel and AMS Zebra radars. The command module controls up to six launch units, each with eight missiles. The Aster 30 has a large tandem booster that launches a 'dart' with a blast-fragmentation warhead. The dart employs inertial guidance, updated by datalink, and active radar terminal homing. The Block 1 Aster 30 has some capability against 500 to 600 km ballistic missiles such as Scud (SS-1), and Block 2 is being studied to counter missiles in the 1000 to 2000 km category.

In late 2003 the Italian Senate approved the commencement of Phase 3 for the FSAF programme, which will provide the Italian Army with six Samp-T systems and 288 Aster 30s to equip two air defence regiments. Later production batches will be shared with France.

Approved at the same time were two naval system programmes: the point defence Saam (Surface-to-Air Anti-Missile) and the area defence Paams (Principal Anti-Air Missile System). The Saam combines the Aster 15 in an eight-round Sylver vertical launcher with the Thales Arabel or AMS Empar radar,

while the Paams (for the French, Italian and UK navies) employs both the Aster 15 and Aster 30 in Sylver launchers, and either the Empar or the AMS Sampson radar. The first application for the Saam was aboard the French nuclear carrier *Charles de Gaulle*, but the same system has also been adopted for the Saudi Sawari II frigates. Initial Paams production will go to Royal Navy Type 45 and French Navy Horizon frigates, with the Italian Orizzonte class to follow. It has also been adopted under the name Raven (with Thales Celia radar) for an unidentified Asian navy.

Long-range Missiles



The Almaz S-300PMU1

Beyond 75 km, engagements require a very heavy missile with multi-stage guidance, a system supported by surveillance radars of extreme range. Perhaps because of its immense size and the perception that it was surrounded by enemies, the Soviet Union led in the development of long-range air defence missiles, and in many respects is maintaining that lead today.

trailer-mounted S-300PT and the self-propelled S-300PS. They employed the vertically launched, command-guided Fakel 5V55K missile, and later the long-range 5V55R with semi-active radar guidance. Following the 1991 Gulf War, Almaz developed the S-300PMU (SA-10C) with the 5V55U round, using track-via-missile guidance to produce a limited capability against theatre ballistic missiles. The further improved S-300PMU1 with the Fakel 48N6E missile has been sold to China, Cyprus and India (and possibly else-

«Soviet designations sometimes appear to have been allocated with a view to confusing Western intelligence...»

where). The S-300PMU2 was unveiled at Moks '97, and uses the Fakel 48N6E2 missile with a range of 200 km. The S-400 Triumph system (scheduled for use around Moscow) is believed to combine the medium-range 9M96E and the long-range 9M96E2 missiles.

The Antey S-300V was designed for army use over the battle area and is trans-

The classic example of Soviet long-range developments was the Almaz-developed S-200 Angara (SA-5), a massive seven-tonne weapon with four wrap-around boost motors and a range of approximately 250 km. Although initially aimed at defending key cities, it was later deployed with passive radar terminal guidance as a counter to the Nato E-3 Awacs, and was sold to Syria for use against Israeli E-2Cs. Both active and passive radar versions have command guidance for the mid-course phase.

Soviet designations sometimes appear to have been allocated with a view to confusing Western intelligence, as illustrated by the case of the S-300 family, which was used for army, air defence forces and naval systems, and expanded from medium- to long-range operation. The Almaz S-300P (SA-10) for Soviet air defence forces was based on wheeled vehicles, and appeared in 1978 in the form of the

Missile	Launch Wt [kg]	Warhead [kg]	Length [m]	Diameter [m]	Max Range [m]	Max Alt [ft]
Raytheon MIM-23B Hawk	635	n/a	5.03	0.37	40,000	n/a
NIIP 2K12 Kub (SA-6)	580	n/a	6.19	0.33	24,000	n/a
NIIP 9K37M Buk-1M (SA-11)	690	70	5.55	0.40	42,000	72,500
NIIP 9K40 Ural (SA-17)	710	70	5.55	0.40	48,000	n/a
MBDA Aster 15	310	n/a	4.10	0.18	30,000+	n/a
MBDA Aster 30	445	n/a	4.80	0.18	100,000	n/a
Almaz* (SA-10D) S-300PMU1/48N6E2	1800	145	7.50	0.50	200,000	90,000
Antey* (SA-12A) S-300V/9M83	1000	150	4.69	0.80	75,000	82,000
Antey* (SA-12B) S-300V9M82	1500	150	6.10	0.80	100,000	100,000

* Almaz and Antey are now combined in the Almaz-Antey Air Defence Concern.



The Lockheed Martin Pac-3 missile is to be used by both Patriot and Meads. Although relatively small, it provides enhanced capability against ballistic missiles. (Lockheed Martin)

ported using tracked vehicles. It employs the Novator 9M83 (SA-12A) missile against manoeuvring targets, and the company's 9M82 (SA-12B) against theatre ballistic missiles and docile aircraft. Both have inertial mid-course guidance with datalinked target updates and semi-active radar terminal homing. The S-300VM represents a major upgrade, with extended range 9M82M and 9M83M missiles and improved radars. The export version is designated Antey-2500.

The Antey-2500 is marketed as a rival to the Raytheon MIM-104 Patriot, which has been exported to nine countries. The current Pac-2 missile was fielded in early 1991, in time for the Gulf War, and it is

being superseded by the Pac-3. The Pac-3 Configuration 3 introduces the Lockheed Martin Vought Systems hit-to-kill missile, a much smaller round, which allows the existing Patriot launcher to carry 16 (rather than four Pac-2s).

The Lockheed Martin Pac-3 missile has also been adopted for the Meads (Medium Extended Air Defence System) programme, which is being jointly developed by the US, Germany and Italy, represented by Lockheed Martin, Eads-LFK and MBDA. As things stand, production of the Meads (which is intended to be much more easily deployed than Patriot) will not start until 2012, which is regarded by Italy as undesirably late. Another

problem is that it is intended to deal with a wide range of targets, which suggests the need for a less expensive missile to complement the Pac-3.

The third form of the S-300 is the Altair 3M41 S-300F Fort (SA-N-6), which is exported under the name Rif. In essence, this is a maritime derivative of the Almaz S-300P, based on the Fakel 5V55 missile. The upgraded S-300FM or Rif-M employs the long-range Fakel 48N6.

The US equivalent of the S-300F is the Raytheon Rim-66 Standard Missile series, which is operational with 13 navies. The latest air defence version is the Rim-67D SM-2 (ER), employing semi-active radar guidance.

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Head Office: ARMADA INTERNATIONAL
Thurgauerstrasse 39, CH-8050 Zurich/Switzerland
Phone: (+41 1) 308 50 50, Fax: (+41 1) 308 50 55
e-mail: mail@armada.ch
Web Site: www.armada.ch

Publisher: Caroline Schwegler

Publishing Director: Peter Stierlin

Editor-in-Chief: Eric H. Biass

Editor: Johnny Keggler

Art Work: Johnny Keggler

Regular Contributors: Roy Braybrook, Doug Richardson, Brian Walters

Administration: Thomas Schneider, Marie-Louise Huber

Advertising offices:

Austria, Finland, Germany, Scandinavia, Switzerland, Spain
Hans-Ruedi Fröhlich, Franz-Rittmeyer-Weg 5,
CH-6300 Zug/Switzerland
Phone: (+41 41) 760 72 78, Fax: (+41 41) 760 72 79
e-mail: fairspace@topweb.ch

France, Belgium, The Netherlands, Luxembourg
Peter Stierlin, Thurgauerstrasse 39, CH-8050 Zurich
Phone: (+41 1) 308 5050

United Kingdom Aerospace Media, Michael Elmes,
Flatford Lane, East Bergholt, Colchester CO7 6UJ, England
Phone: +44 (0) 1206 299211, Fax: +44 (0) 1206 299212
e-mail: mike.elmes@aerospacemedia.co.uk

Commonwealth of Independent States (CIS)
LAGUK Co. Ltd., Yuri Laskin, Novorizanskaya Street 31/7,
App. 96, RF-107060 Moscow, Russian Federation; Phone:
(+7 095) 912 1346, Fax: (+7 095) 912 1260
e-mail: yalarm-lml@mtu-net.ru

USA - Special Reports Gene Selven & Associates, Inc., Gene
Selven, Kim Newman, 7291 Coronado Drive, Suite 8, San Jose,
CA 95129, Phone: (408) 996 7400, Fax: (408) 996 7871
e-mail: gselven@aol.com

Western USA - West of the Mississippi River
Diane Obright,
810 Val Sereno Drive
Olivenhain, CA 92024
Phone: (858) 759 3557, Fax: (858) 759 3552
e-mail: blackrockmedia@cox.net

Eastern USA - East of the Mississippi River
Margie Brown & Associates, Margie Brown,
4775 Mallard Court,
Warrenton, Virginia 20187-2500
Phone: (540) 341 7581, Fax: (540) 341 7582,
e-mail: margiespub@erols.com

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