by Carlo Kopp

ASIA'S NEW SAMS

PART 2

Further evolution of the S-300P design took place between 1995 and 1997, yielding the S-300PMU-2/SA-10E 'Favorit' system, intended to compete directly against the Antey S-300V and Patriot PAC-2/3 systems as an AntiBallistic Missile (ABM) system.

The Favorit incorporates incrementally upgraded 30N6E2, 64N6E2 radars and a 54K6E2 command post, and the 96L6E as its early warning and primary acquisition system. While the system retains compatibility with earlier 48N6 missiles, a new extended 108nm (200km) range 46N6E2 missile was added. The Favorit's new command post has the capability to control S-300PMU, S-300PMU-1 batteries, and also S-200VE/SA-5 batteries, relaying coordinates and commands to the 5N62VE Square Pair guidance and illumination radar.

While the Favorit superficially appears like the SA-10D, it has a wide range of incremental improvements internally, and a range of optimisations to improve performance in the antiballistic missile role. Almaz, the system integrators, and Fakel, the missile designers, claim to have repeatedly caused Scud target vehicle warheads to detonate during test intercepts at the Kapustin Yar range in 1995.

The Almaz S-400 Triumf or SA-20 system is the subsequent evolution of the S-300PMU-2, trialled in 1999. The label S-400 is essentially marketing, since the system was previously reported under the speculative label of S-300PMU-3.

The principal distinctions between the S-400 and its predecessor lie in further refinements to the radar and software, and the addition of three new missile types in addition to the 48N6E/48N6E2. As a result, an S-400 battery could be armed with arbitrary mixes of these weapons to optimise its capability for a specific threat environment.

The first missile added to the system has not been named publicly, but is a long range weapon with a cited range of 215nm (400km), intended to kill high value assets like AWACS and JSTARS. Further details of this weapon remain undisclosed – some sources speculate it is a variant of the Novator KS-172 long range AAM with a bigger booster (AA 08/03).

The further missiles are in effect equivalents to the ERINT/PAC-3 interceptor missile recently introduced to supplement the MIM-104 in Patriot batteries. These are the 96M6E and 96M6E2, largely identical with the latter version fitted with a larger booster. Fakel claims the 96M6E has a range of 21.6nm (40km), and the 96M6E2 64.8nm (120km), with altitude capabilities from 15ft above ground level up to 66,000ft and 100,000ft respectively.

The 96M6 missiles are 'hittiles' designed for direct impact, and use canards and thrust vectoring to achieve extremely high G and angular rate capability – they are not unlike a scaled up R-73/AA-11 Archer dogfight missile in concept. An inertial package is used with a datalink from the 30N6E radar for midcourse guidance, with a radar homing seeker of an undisclosed type. The small 24kg (53lb) blast fragmentation warhead is designed to produce a controlled fragment pattern, using multiple initiators to shape the detonation wave through the explosive. A smart radio fuse is used to control the warhead timing and pattern. It is in effect a steerable shaped charge.

The S-300V/S-300VM/Antey-2500 is the world's only truly mobile Anti Ballistic Missile system, and later variants are claimed to be capable of intercepting 4.5km/sec re-entry speed targets. The large size of the Grill Pan phased array and TELAR command link and illuminator antennas is evident. The system provides the capability to engage very low RCS aircraft at ranges in excess of 100nm (185km). (Rosvooruzheniye)

The smaller size of these weapons permits four to be loaded into the volume of a single 48N6E/5V55K/R launch tube container – a form fit four tube launcher container is used. So a single 5P85S/T TEL can deploy up to 16 of these missiles, or mixes of 3 x 48N6s/4 x 96M6E/E2s, 2 x 48N6s/8 x 96M6E/E2s, or 1 x 48N6/12 x 96M6E/E2s. The stated aim of this approach was to permit repeated launches against saturation attacks with precision guided weapons – in effect trading 96M6 rounds for incoming guided weapons. Fakel claims a single shot kill probability of 70% against a Harpoon class missile, and 90% against a manned aircraft.

What future developments can be expected for the S-300P/S-400 series? With the exception of further evolutions in missile and radar technology, and active radar or dual mode seekers, it is likely that additional passive targeting sensors such as wideband interferometers/ESM receivers (external Kolchuga ESM systems are an option already) and FLIR/IRST (already an optional retrofit for S-125/SA-3, 2K12/SA-6) could find their way on to the 30N6E Flap Lid. Modern ruggedised multi-GigaHertz COTS computing hardware is clearly an option for the 54K6E and other system components. At some point, Almaz will transition to active phased array technology, but cost will remain a challenge given the maturity of the current design.

In summary the S-300P/S-400 is in its latest variants a highly capable and modern dual role SAM/ABM system, with exceptionally good mobility and resistance to jamming. While its radar and back end data processing systems may not match the technology in the latest western products, the excellent kinematics of the missiles, and large power aperture capability of the phased array radars make these formidable weapons.

Variant	Designation	Surveillance Radar	BM Acquisition Radar	Engagement Radar	Mobile TELAR	Mobile TEL/TL	Missile	Options
SA-12A	S-300V	9S15 Bill Board	9S19 High Screen	9S32 Grill Pan	9A83	9A85	9M83	-
SA-12B	S-300V	9S15 Bill Board	9S19 High Screen	9S32 Grill Pan	9A82	9A84	9M82	-
SA-12A[1]	S-300VM	9S15M Bill Board	9S19M High Screen	9S32M Grill Pan	9A83	9A85	9M83M	-
SA-12B[1]	S-300VM	9S15M Bill Board	9S19M High Screen	9S32M Grill Pan	9A82	9A84	9M82M	-

Table 1: Antey S-300V/S-300VM Surface to Air Missile System (Note [1]: Antey 2500 NATO designation as yet not disclosed).

THE ANTEY S-300V/SA-12 SAM SERIES

While Antey's impressive S-300V family of SAM systems shares its earliest conceptual origins with the Almaz S-300P family, the two product lines diverged dramatically very early in their development histories. As a result, they share the same technology base but are essentially unique designs, optimised respectively for the needs of the prime customers, the V-PVO and PVO-SV.

While the PVO-SV shared some static and semi-mobile radar systems with the V-PVO during the early 1960s, the PVO-SV deployed its own unique inventory of fully mobile SAM systems, reflecting its role of providing air defence cover for highly mobile Soviet tank and motorised infantry divisions. By the end of the 1960s the PVO-SV had deployed a three tier system, with the cumbersome ramjet powered 2K11/3M8 Krug/1S12 Long Track/1S32 Pat Hand/SA-4 Ganef system providing long range area defence, the quite effective 2K12/3M9 Kub/1S91 Straight Flush/SA-6 Gainful system providing medium range area defence, and the 9M33 Osa/9K33 Romb/SA-8 Gecko, 9M31 Strela 1/SA-9 Gaskin, and ubiquitous ZSU-23-4P SPAAG providing low altitude point defence.

With the exception of the 3M8/SA-4, this package was widely exported throughout the Arab world and Africa, and while achieving some initial success against the Israelis in 1973 generally suffered grievously when applied against western airpower and electronic combat forces. By the early 1970s it was clear that a new generation of systems would be needed to challenge growing western SEAD and EW capabilities. The S-300V system was to provide the top tier in the new air defence umbrella.

Unlike first generation PVO-SV systems the S-300V would have a much broader role, encompassing both long range high altitude air defence but also defence against US tactical ballistic missiles, specifically the Lance and Pershing I/II, the FB-111A's supersonic AGM-69A SRAM standoff missile, and the new US Air Force MGM-109 Ground Launched Cruise Missile – a trailer launched nuclear armed Tomahawk variant based in the UK and Western Europe. As a result the S-300V would have to provide exceptionally good detection and tracking performance against low radar cross section targets, at very high and very low altitudes, while retaining the very high offroad mobility so typical of established PVO-SV tracked area defence SAM systems, and possessing exceptional resistance to the US EF-111A Raven jammer force.

The S-300V was the result of these pressures – an expensive, complex but highly capable dual role SAM/ABM system which remains without equivalent to this day. It was to be an 'Army level' or 'Corp level' asset, protecting the centre of gravity of the Red Army's mechanised land forces against attack by nuclear and conventionally armed systems.

The baseline S-300V entered production during the very early 1980s, and was accepted into service by the PVO-SV in 1983 under the designation S-300V-1, but was limited in capabilities. Difficulties with the complex technology delayed service entry of the fully developed package with ABM capability until 1988, under the designation S-300V.

The only export customer to date has been India who has since acquired a pair of Israeli Green Pine ABM early warning radars, as a counter to Pakistan's nuclear armed ballistic missile force. The order for six S-300VM systems remains in negotiation while the Israeli Arrow and S-300PMU-2/S-400 are evaluated. A marketing drive in the Persian Gulf some years ago fell foul of US influence in the region – Patriots being bought instead, amid Russian allegations of dishonest marketing tactics by the US.

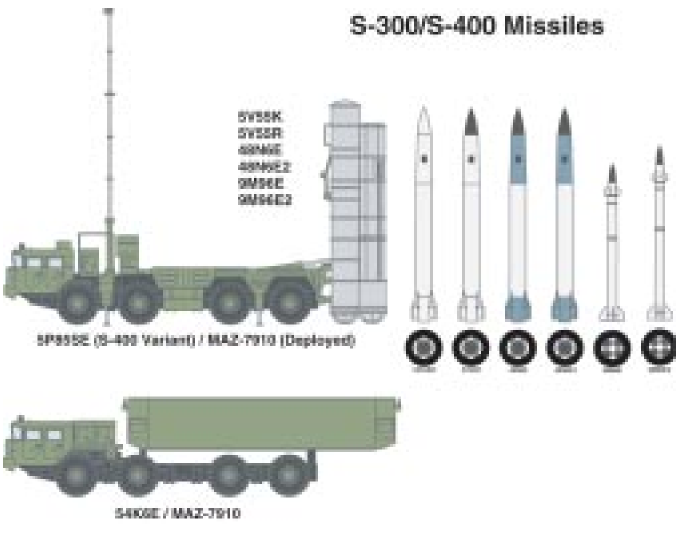
All principal components of the S-300V system are carried on the MT-TM 'Item 830' series of tracked vehicle, with gross weights between 44 and 47 tonnes per vehicle – the S-300V is not a lightweight system – and has similar offroad mobility to a medium tank.

The S-300V system comprises no less than eight vehicles, the 9S457 mobile command post, the 9S15 Bill Board acquisition radar, the 9S19 High Screen ABM early warning radar, the 9S32 Grill Pan engagement radar, the 9A82 and 9A83 TELARs (Transporter Erector Launcher and Radar), and the 9A84 and 9A85 TEL/Transloader vehicles.

The fully mobile 9S15 Obzor 3/Bill Board acquisition radar is a mechanically rotated 3D radar system, with electronic beam steering in elevation and an IFF array. It provides long range early warning of aerial threats and low end tactical ballistic missiles (TBMs) such as the Scud A and Lance.

The 9S15 has two basic modes of operation. The first is optimised for a 12 second sweep and is claimed to provide a 50% probability of detecting a fighter sized target at 130nm (240km). The second mode employs a faster six second sweep period, and is used to detect inbound tactical ballistic missiles and aircraft, with a reduced detection range of about 80nm (150km) for fighters, and 50 to 60nm (92 to 111km) for (TBMs) like the Scud A or Lance. Russian sources are unusually detailed on ECCM techniques used, claiming the use of three auxiliary receiver channels for cancelling side lobe jamming, automatic wind compensated rejection of chaff returns, and provisions in the MTI circuits to reject jamming. A facility for

The S-400 Triumf/SA-20 introduces three new missiles, two of which are highly agile equivalents to the ERINT/PAC-3 and one of which is claimed to have 200nm (370km) range. The system retains compatibility with earlier 5V55 and 48N6 series SA-10 SAMs, while the latest SA-10/20 command posts can also control very long range SA-5 Gammon batteries. (Author)



precise angular measurement of jamming emitters is included. RMS tracking errors are quoted at 250 metres in range and about 0.5 degrees in azimuth/elevation, with the ability to track up to 200 targets. The system has an integral gas turbine electrical power generator for autonomous operation – a feature of most S-300V components.

This radar provides a highly mobile 3D search and acquisition capability, but is limited in low level coverage footprint by its antenna elevation. Its limited scan rate makes it unusable for high performance IRBM acquisition and tracking, which is the role of the 9S19 High Screen radar.

The specialised 9S19 Imbir is a high power-aperture, coherent, X-band phased array designed for the rapid acquisition and initial tracking of inbound ballistic missiles within a 90 degree sector. To that effect it uses a large passive phase shift technology array, using a conceptually similar space feed technique to the MPQ-53 and 30N6 series radars, producing a narrow 0.5 degree pencil beam main lobe.

The primary search waveform is chirped to provide a very high pulse compression ratio intended to provide very high range resolution of small targets. The design uses a high power Travelling Wave Tube (TWT) source, very low side lobes and frequency hopping techniques to provide good resistance to jamming.

Three primary operating modes are used. In the first the 9S19 scans a 90 degree sector in azimuth, between 26 and 75 degrees in elevation, to detect inbound Pershing class IRBMs within a 40 to 95nm (75 to 175km) range box, feeding position and kinematic data for up to 16 targets to the 9S457 command post. The second mode is intended to detect and track supersonic missiles such as the AGM-69 SRAM, and sweeps a narrower 60 degree sector in azimuth, between nine and 50 degrees in elevation, within a range box between 10 and 90 nautical miles, generating target position and velocity updates at two second intervals.

The third mode is intended to acquire aircraft in severe jamming environments, with similar angular and range parameters to the second mode. The radar is claimed to produce RMS angular errors of around 12 to 15 minutes of arc, and a range error of a mere 70 metres (at max range 0.04%!). The peak power rating remains undisclosed.

In function the 9S19 most closely resembles much newer western X-band ABM radars, but is implemented using seventies generation antenna and transmitter technology, and is fully mobile, unlike the semimobile US THAAD X-band radar and Israeli Green Pine.

The third radar in the S-300V suite is the 9S32 Grill Pan, an engagement radar similar in concept and function to the MPQ-53 and 30N6, but larger with the antenna turret capable of slewing through +/-340 degrees. It will automatically acquire and track targets provided by the 9S457 command post, control the operation of TELAR mounted illuminators and generate midcourse guidance commands for up to 12 missiles fired at six targets concurrently. The S-300V system uses continuous wave illumination of targets and semi-active radar terminal homing, not unlike the US Navy RIM-66/67 SAM series – the illuminators are carried on the 9A82 and 9A83 TELARs.

Like the 9S19, the 9S32 is a high power-aperture, coherent, X-band phased array, but specialised for missile guidance. Cited detection ranges are about 80nm (150km) for fighter sized targets, 40nm (75km) for SRAM class missiles and up to 80nm (150km) for larger IRBMs. The radar uses monopulse angle tracking techniques, frequency hopping in all modes to provide high jam resistance, and chirped waveforms providing a high compression ratio. Three auxiliary receiver channels are used for cancelling sidelobe jamming.

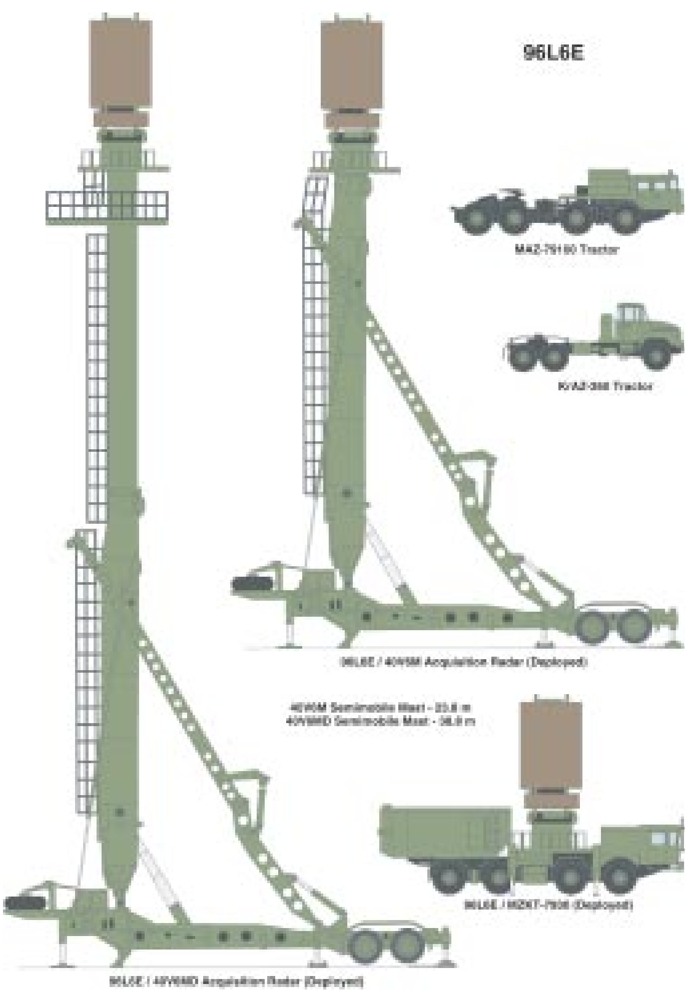
Two basic operating modes are used. In the first the 9S32 is controlled by the 9S457 command post and acquires targets within a narrow 5 x 6° field of view, alternately it can autonomously search and acquire targets within a 60° field of view. A datalink antenna is mounted aft of the array.

The 9A82 and 9A83 TELARs carry two Novator designed 9M82 Giant long range SAM/ABMs, and four 9M83 Gladiator SAM/ABMs respectively. Each TELAR is equipped with a steerable high gain antenna used to transmit midcourse guidance commands to the missiles and provide continuous wave illumination of the target for the missiles' semi-active radar seekers during the terminal guidance phase. The TELARs are controlled by the 9S32 Grill Pan using either cables or a bidirectional radio datalink, permitting the TELARs to return status information to the guidance radar.

The 9A82 TELAR is optimised for engaging targets at higher altitudes, and can slew its antenna through 180 degrees in azimuth, and 110 degrees in elevation, while the 9A83 TELAR has an elevating and telescoping mast providing antenna coverage of the full upper hemisphere – this arrangement is intended to extend the engagement footprint against low altitude targets. The TELARs are supplemented by the 9A84 and 9A85 TEL/Transloaders, essentially 'dumb' launchers which can be used only with guidance/illumination from a nearby TELAR, and equipped with loading cranes instead of antenna booms.

The smaller 9M83 Gladiator SAM/ABM is intended to engage aerial targets at all altitudes, including cruise missiles, and smaller TBMs. The much larger 9M82 Giant has higher kinematic performance and is intended to kill IRBMs, SRAM class supersonic missiles, but also standoff jamming aircraft at long ranges. Both weapons employ two solid propellant stages, with thrust vector control of the first

The new LEMZ 96L6 is intended to replace the Tin Shield and Clam Shell acquisition radars with a single high performance system and is available as an upgrade component for existing IADS. (Author)



stage (4636kg/10,225lb mass in the Giant and circa 2275kg/5000lb the Gladiator) and aerodynamic control of the 1270kg (2800lb) second stage, using four servo driven fins, and four fixed stabilisers. The guidance and control packages, and much of the weapon airframes are identical, the principal distinction being the bigger booster stage of the Giant and its larger stabilisers.

A cold start ejector is used to expel the missile from the launch tube, the first stage burns for about 20 seconds, then the missile transitions to its midcourse sustainer. During midcourse flight the missile employs inertial navigation with the option of command link updates. In the former mode it transitions to its semi-active homing seeker during the final 10 seconds of flight, in the latter three seconds before impact – a technique preferred for heavy jamming environments. Russian sources claim the semi-active seeker can lock on to a 0.05 square metre RCS target from 16.2nm (30km). The midcourse guidance system attempts to fly the most energy efficient trajectory to maximise range. A two channel radio proximity fuse is used to initiate the 150kg (330lb) class 'smart' warhead which has a controllable fragmentation pattern to maximise effect.

The engagement envelope of the baseline Gladiator is between 80ft AGL to 80,000ft, and ranges of 3.2 to 40nm (5.9 to 74km), the Giant between 3200ft AGL to 100,000ft, and ranges of 7 to 54nm (13 to 100km). The system can launch the missiles at 1.5 second intervals, and a battalion with four batteries can engage 24 targets concurrently, with two missiles per target, and has a complement of between 96 and 192 missiles available for launch on TELAR/TELs. A TELAR can arm a missile for launch in 15 seconds, with a 40 second time to prepare a TELAR for an engagement, and five minute deploy and stow times – a genuine 'shoot and scoot' capability.

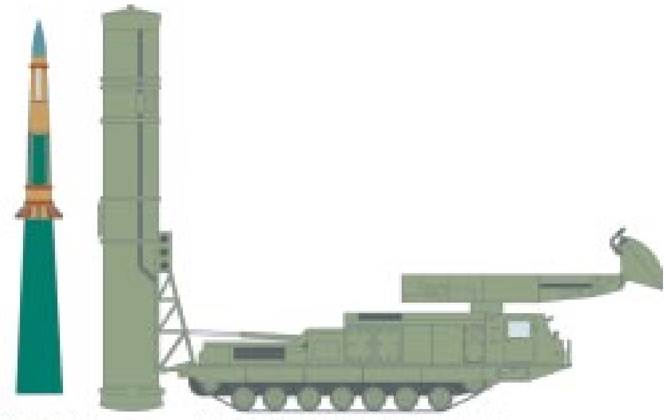
The cited single shot kill probabilities for the Gladiator are 50% to 65% against TBMs and 70% to 90% against aircraft, for the Giant 40% to 60% against IRBMs and 50% to 70% against the AGM-69 SRAM – ballistic missiles with re-entry velocities of up to three km/s can be engaged.

The Soviets were terrified of the USAF's EF-111A force and equipped the S-300V system with a facility for passive targeting of support jammers. The 9S15, 9S19 and 9S32 have receiver channels for sidelobe jamming cancellation and these are used to produce very accurate bearings to the airborne jammer, this bearing information is then used to develop angular tracks. The angular tracks are then processed by the 9S457 command post to estimate range, and the 9S32 then develops an estimated track for the target jammer. A Giant missile is then launched and steered by command link until it acquires the target.

The S-300V has been supplanted by the enhanced S-300VM, using the 9S15M2, 9S19M, 9S32M and 9S457M components, and improved 9M82M and 9M83M missiles. This system has been marketed as the 'Antey 2500', intended to highlight its capability to engage 2500km range IRBMs with re-entry velocities around 4.5 km/sec. The 9M82M has double the range of the 9M82 against aerial targets, at 108nm (200km), and increased terminal phase agility – a single shot kill probability of 98% is claimed against ballistic targets.

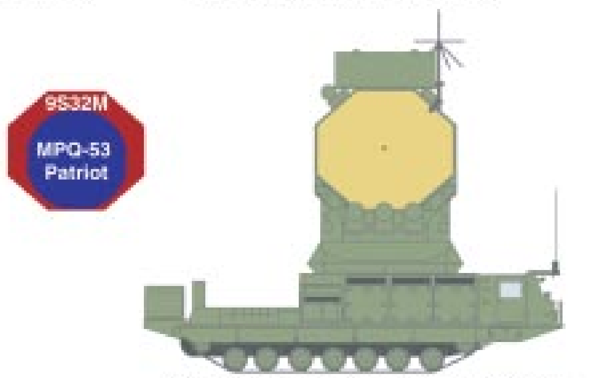
Commercially the S-300V/VM has been much less successful than the S-300P series, in part due to its higher cost and capability – the Indian sale has yet to materialise, compared to the large number of S-300P systems sold to China. Earlier this year the Russian government authorised a merger between Almaz, Altair and Antey to produce what theoretically is likely to be the world's largest SAM system manufacturer. However, in typical post soviet tradition a series of murders of corporate executives followed and it is unclear at this stage how the merger will proceed. Novator has been verging on bankruptcy for some time, ostensibly due to the inability of the Russian defence ministry to pay its bills.

In the longer term the S-300V is likely to acquire similar evolutionary enhancements to the S-300P series, if not identical should the Almaz/Altair/Antey merger proceed, increasing its range and already superb lethality. It is likely that GPS aided navigation hardware will be added at some stage to both the S-300P/S-300V to increase the accuracy of the inertial/compass navigation systems on the radars and TELAR/TELs.



9M82/9M82M 9A82 TELAR / MT-TM (Deployed)

9M83/9M83M 9A83 TELAR / MT-TM (Deployed)



9S32/9S32M (Grill Pan) / MT-TM (Deployed)
Engagement Radar

An SA-12 battery will have several fire units, each centred on a Grill Pan phased array engagement radar, and some mix of 9A82 and 9A83 TELARs and 9A84 and 9A85 TEL/Transloaders. The Grill Pan controls the TELARs' command link/illuminator antennas and remotely fires the missiles. (Author)

CONCLUSIONS

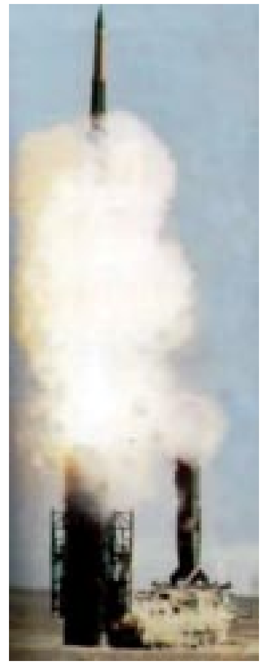
The arrival of S-300P and S-300V missile systems in the region radically changes the strategic environment, both from the perspective of the US and Australia.

These highly capable systems are not invincible, but require significant investment into capabilities to defeat them – prohibitive losses in expensive aircraft and irreplacable aircrew otherwise might occur. As they are less demanding to operate than modern combat aircraft, operators across the broader region will be able to achieve combat effective proficiency faster than with the Su-27/30.

In practical terms the S-300P/S-300V SAMs are a viable deterrent against air forces without the technological and intellectual capital to tackle them – and in many respects better value for money than the Su-27/30. Their failure to sell in larger numbers reflects more than anything poor marketing and support credibility by Russia's industry.

The US Air Force's approach to defeating these SAMs is conceptually simple: the F/A-22A exploiting its all aspect wideband stealth, supercruise, high altitude and sensitive ESM warning capability will kill the engagement and acquisition radars using guided weapons. High power standoff support jamming will be provided by B-52Hs equipped with electronically steerable high power jamming pods, and standoff ISR support will be provided by systems such as the RC-135V/W, E-8C and forthcoming E-10 MC2A. Standoff or highly stealthy ISR capabilities will be necessary – the current generation of high altitude UAVs like the RQ-1B and RQ-4A are not survivable in airspace covered by the S-300P/S-300V systems.

Conventional unstealthy, or partially stealthy (ISF) combat aircraft will have difficulty surviving within the coverage of the S-300P/S-300V – the high transmit power, large radar and missile seeker apertures, low sidelobes, generous use of monopulse angle tracking and extensive



(right) Like the S-300P, the S-300V uses the 'cold launch' technique, ejecting the missile before its motor is fired. This 9M83 SAM is being launched from a 9A83 TELAR, which uses its elevated directional antenna to provide the 9M83 with both midcourse command updates and terminal phase high power continuous wave illumination of the target. Antey claims the semi-active seeker will acquire a 0.05 square metre RCS target at 16nm (30km). (Rosvooruzheniye)

ECCM features make these systems difficult to jam effectively. Self protection jammers will need to produce relatively high X-band power output, and exploit monopulse angle tracking deception techniques – Digital RF Memory techniques with high signal fidelity are nearly essential. Even so the challenges in defeating these systems with a self protection jammer are not trivial – raw power-aperture does matter in this game.

In practical terms, low level terrain masking to remain below the radar horizon of these systems, combined with good standoff ISR, support jamming and a low radar signature standoff missile, is the only reliable defence for an aircraft with anything greater than insect sized all aspect radar signature. For instance the F-35 JSF's forward sector stealth is likely to be adequate, but its aft sector stealth performance may not be, especially considering the wavelengths of many of the radars in question – an F-35 driver runs a real risk of taking a 1360kg (3000lb) hypersonic SAM up his tailpipe if he cannot kill the target SAM engagement radar in his first pass. For the JSF, integration of a terrain following radar mode in its AESA radar is not an unusual technical challenge, incurring only modest development cost. The bigger bite will be in shortened airframe fatigue life resulting from fast low level penetration with a modestly swept wing design.

Of the current crop of fighters in western service, the most survivable are those with good TFRs – the F-111, Tornado and F-15E if fitted with the LANTIRN TFR pod – all requiring a high performance EW suite.

A weakness of both the S-300P/S-300V systems is that they are severely radar horizon limited in a fully mobile configuration. The addition of mast mounted acquisition radars to extend their low level footprint severely impairs the mobility of the battery.

The popular idea of shooting cruise missiles, anti-radiation missiles or standoff missiles at the S-300P/S-300V battery, assuming its location is known, is only viable where such a weapon has a sufficiently low radar signature to penetrate inside the minimum engagement range of the SAM before being detected – anything less will see the inbound missile killed by a self defensive SAM shot. The current Russian view of this is to sell Tor M1/SA-15 Gauntlet self-propelled point defence SAM systems as a rapid reaction close-in defensive system to protect the S-300P/S-300V battery by shooting down the incoming missile if it gets past the S-300P/S-300V SAMs.

In conclusion, current RAAF force structure plans do not provide for a robust long term capability to defeat the S-300P/S-300V class of SAMs – weapons which are very likely to be encountered during coalition operations, and most likely, regional operations over the coming two or more decades. If the RAAF wishes to remain competitive in this developing regional environment, further intellectual and material investment will be needed.