Military technology

SAM System mobility

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The Surface to Air Missile (SAM) remains one of the most lethal threats to modern combat aircraft, a threat which is evolving at a faster rate than combat aircraft. Since the mid 1960s when SAMs first appeared in combat in large numbers a range of technologies and techniques were developed to defeat them. Manufacturers of SAM systems have responded, and the ongoing improvements in mobility across the latest generation of SAMs present greater difficulty in defeating SAMs.

Fixed SAM sites versus the conventional approach

The earliest SAMs were developed in Germany during the latter half of World War II. The most mature design was the LFK Wasserfall, an evolution of the earlier A-4/V-2 ballistic missile, used extensively to bombard Britain, Holland and Northern France in 1944.

The Soviet SA-1 Guild or SA-25/S-25 Berkut was an evolved Wasserfall, and retained the battery deployment scheme devised for the German SAM. Wasserfall SAM batteries were modeled on the scheme devised for the A-4/V-2 missile. The SAM was carried on a trailer, elevated by gantry and emplaced on a relocatable launch pad, then pumped full of toxic and corrosive inhibited fuming nitric acid oxidizer and a triethylamine/xylidine fuel. A launch control centre vehicle was hooked up by cables to the missile and to the guidance station. The whole battery required a large convoy of trucks to move, and took several hours to deploy for operation.

High mobility 5P85SE Transporter Erector Launcher from an SA-10C SAM battery.

The Soviet SA-1 in practice ended up being deployed at fixed hardened sites, with all of the electronics, communications and other vans being sited inside underground bunkers. Only missiles and radar heads were exposed, usually mounted on concrete pads.

The SA-2 Guideline or SA-75/S-75 Dvina were deployed initially to Cuba in the early 1960s, and in large numbers later to North Vietnam. It was here that the SAM made its combat debut, defending critical targets against US aircraft executing raids in the Rolling Thunder bombing campaign.

The SA-2 was much more mobile, with the battery components built into a trailer, on a trailer, or to be carried by a trailer – to facilitate rapid deployment. It was used to great effect in Vietnam. An SA-2 battery comprised six towed SM-63 or SM-90 missile launchers, an SNR-75 Fan Song series engagement radar to guide the SAMs, and a P-12 Spoon Rest series acquisition radar to search for targets and cue the Fan Song for a missile shot.

The menagerie of support equipment resulted in several hours time to set up or tear down the battery. With the SA-2 the Soviets introduced the model of semi-hardened prepared SAM sites, with revetted pads for the radars, vans and launchers, and additional earthwork berms added to protect most battery components.

In operation, a single battery might have operated with up to half a dozen prepared SAM sites, with the battery setting up on a site, waiting in ambush for aircraft to attack, and then relocating to another site immediately after the engagement was finished, to avoid a counterattack.

In Vietnam an additional twist was added, as Flak traps with 23 mm, 37 mm and 57 mm artillery pieces were set up around immediately vacated

Late model SA-2 SAM in Vietnam.

SA-2 PR-11A transloader and SM-63 launcher.

SA-2 Fan Song engagement radar.

F-105G Wild Weasel armed with anti-radiation missiles.

SAM sites, to ambush US aircraft counterattacking the SAM site. In early engagements these Flak traps killed more US aircraft than the SAM batteries did using missiles.

The Soviet approach with prepared SAM sites presented huge problems, since catching a battery with a strike package became very difficult without real time intelligence as to where the battery was sited.

Frustrated by the breakdown in conventional tactics, the Americans innovated with technology. To disrupt the Fan Song radar tracking and missile uplinks jamming equipment was introduced on Air Force EB-66 Destroyer and Navy EKA-3B Whale electronic warfare aircraft, and later B-52D Stratofortress bombers. The Air Force introduced specialized SAM killing F-100F and later F-105G and EF-4C 'Wild Weasel' fighters, equipped with homing receivers to track the transmissions from the Fan Song radars. The Navy introduced the A-6B 'Iron Hand' Intruder variant equipped with a similar homing system, and later introduced the specialized EA-6A jammer, which evolved into the EA-6B Prowler.

Initially, SAM sites were attacked with rockets, dumb bombs and cluster bombs but this usually exposed the aircraft to Flak batteries. A key innovation introduced by the US Navy was the AGM-45 Shrike anti-radiation missile, equipped with a passive homing seeker that guided the missile into the Fan Song. It was later followed by the larger and longer ranging AGM-78 Standard ARM.

The new technology proved effective, with the Soviets countering later by putting optical tracking telescopes on the Fan Song to permit angle tracking when jammed, and adding the specialized jam resistant RD-75 Amazonka rangefinding radar to batteries. Fan Song crews would often shut down once a Shrike was detected, with the Shrikes often effecting shut downs rather than kills.

This model of SAM deployment and Suppression of Enemy Air Defences (SEAD) still remains in use today. In the 1991 Desert Storm bombing campaign, the Iraqis deployed nearly all of their SAMs in this manner, and the Coalition forces jammed and destroyed most of these sites in much the same fashion as the latter years of the Vietnam air war. In the 1999 Allied Force campaign against Serbia most of the semi-mobile Serbian SAM batteries were killed by Coalition aircraft – but most of the fully mobile SAM batteries survived.

Mobility as a Defensive Measure

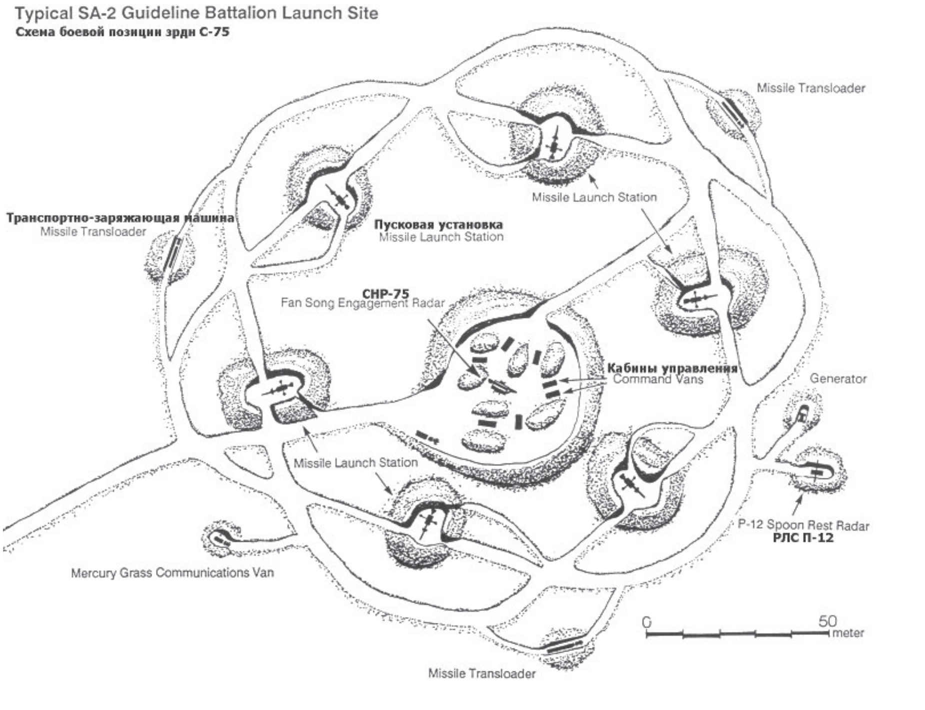
While the Soviet PVO (air defence forces) tested their SA-2s in live combat, the Red Army developed their first SAM systems. Because the Red Army was wholly wedded to the idea of massive tank armies, they imposed the then challenging requirement for full mobility in SAM batteries. All components of the missile battery had to be capable of prosecuting a missile engagement within five minutes of coming to a halt during battery movements.

The idea was that fully mobile 2K11 Krug / SA-4 Ganef SAM batteries would move across the battefield in concert with the tank divisions, effectively producing a mobile air defence umbrella over the land manoeuvre force.

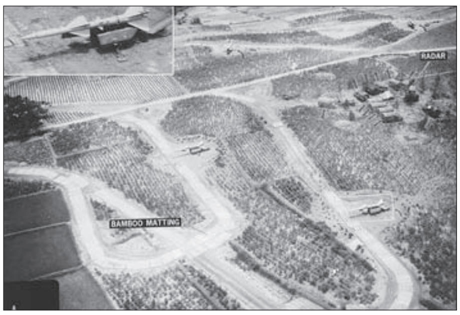
While battery components could be interconnected with cables at fixed sites, radio datalinks were introduced. These allowed target tracks to be relayed from the Long Track to the Pat Hand radars, and allowed the missileers to elevate and point the 2P24 launchers, and issue launch commands over a wireless channel.

The 'shoot and scoot' in five minutes mobility requirement was applied to the 2K12 Kub or SA-6 Gainful medium range SAM system, and the 2K33 Osa or SA-8 Gecko short range SAM system, both of which were deployed to the Middle East during the early 1970s.

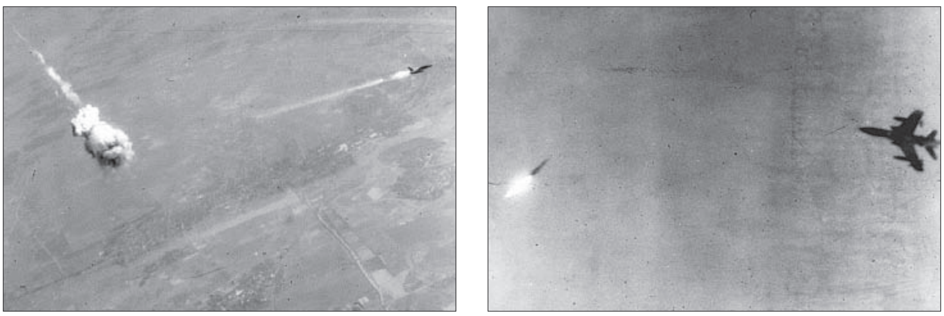
Curiously enough, Arab operators of the SA-6 did not make use of the mobility of this system



Layout of typical PAVN SA-2 Site.



North Vietnamese SA-2 SAM Site.



US Air Force F-105D Thunderchiefs evading SA-2 SAMs over North Vietnam.

Late model 92N6 Grave Stone engagement radar.

Late model self propelled 30N6E Flap Lid B radar.

Fully mobile 54K6 command post.

Early model towed 5N63 Flap Lid A radar.

during the 1973 and 1982 conflicts, preferring to park the missile batteries in revetted sites. This facilitated the rout of Syrian forces in Bekaa Valley by the Israelis, who had by then mastered the full gamut of SAM suppression tactics and technology developed by the US over a decade earlier.

While Arab SAM forces were being annihilated by the Israelis the Soviets understood the tactical value of mobility in evading defence suppression aircraft.

In the late 1970s the PVO introduced the long range SAM system, S-300P/PT or SA-10A Grumble, a Soviet analogue to the US MIM-104 Patriot. A fast, long ranging and lethal SAM with a jam resistant 5N63 Flap Lid high power phased array engagement radar mounted on a trailer or a 24 metre mobile mast, the SA-10 was a dangerous addition to the Soviet arsenal, and a key imperative driving the development of the F-117A Nighthawk stealth fighter and later B-2A Spirit strategic stealth bomber.

While the SA-10A was more mobile than the SA-2 Guideline, Soviet planners concluded that tactical mobility was key to survival against marauding NATO defence suppression aircraft, typified by the late model F-4G Wild Weasel IV equipped with a sophisticated 360-degree coverage APR-38/45 emitter locating and homing system.

The result was the new S-300PS ‘self-propelled’ SA-10B Grumble. It was designed around a similar five minute ‘shoot and scoot’ requirement.

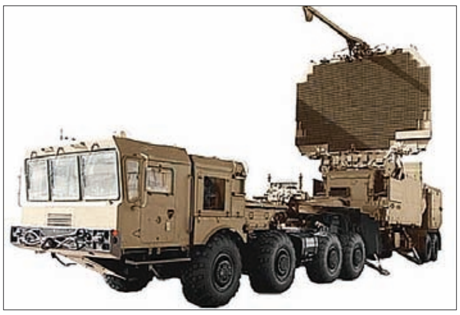
In the S-300PS these key battery components, and the battery 54K6 command post, were transplanted onto the MAZ-7910 ‘Scud launcher’ chassis.

The new S-300PS / SA-10B batteries were a genuine ‘shoot and scoot’ design, using radio datalinks to connect the command post, Flap Lid engagement radar, and the new 5P85S and D TELs. The 300P/SA-10 used cylindrical missile launch tubes, which doubled up as transportation containers for solid propellant 5V55 missile rounds. A transloader truck with a hydraulic hoist could reload a TEL from its own carried rounds, or a semi-trailer transporter, in a matter of mere minutes.

The tactical model developed for this system built on the experience gained in 1972, 1973 and 1983. The SAM batteries would be dispersed to pre-surveyed locations, covered with radar and infrared opaque netting, and wait in ambush until an aircraft flew into range. The Flap Lid would then light up, lock on to the target, and the SAMs would be launched. Once the engagement was complete, the battery could be stowed in five minutes, and immediately head off for the next site.

This model presents genuine difficulties for aircraft tasked with SAM suppression. Unless the aircraft armed with anti-radiation missiles are in formation with the strike package, they are likely to have difficulties locating the Flap Lid, as its short transmission duration, narrow ‘pencil-beam’ transmission and low antenna sidelobe emissions are not easily detected.

In 1999, Serbian 2K12/SA-6 Gainful batteries used these tactics and most survived the protracted air campaign. More than often the HARM anti-radiation missile armed F-16CJ and Tornado ECR fighters would be vectored to engage a missile battery, only to find that in the several minutes it took to get near enough for a missile shot, the radar had stopped emitting and more than often vacated the site.



Late model fully mobile 91N6 Big Bird search radar.

Late model S-300PMU2 transloader.

S-400 / SA-21 battery on the move.

The only modern combat aircraft capable of penetrating state of the art SAM defences and surviving are the US Air Force B-2A (below) and F-22A (left).

Rennaissance of the SAM

The success of the high mobility S-300P series and Serbian SA-6 batteries forced a fundamental policy change in Russia over the past decade, with high mobility and wheeled vehicles now imperative for all air defence equipment.

The latest generation of air defence acquisition and early warning radars are now mobile, and some qualify as 'shoot and scoot'. A good example is the Belarus made KBR Vostok E, which can deploy or stow in a mere six minutes, compared to the one to two hours for its predecessor, the P-18 Spoon Rest. Other newer radars – like the VNIIRT 67N6 Gamma DE, the NNIIRT Nebo M, the NNIIRT 91N6E and the LEMZ 96L6E Cheese Board – can all stow and deploy in anything between five and 15 minutes. Any modern Russian or former Soviet Bloc air defence package purchased today will be fully mobile.

The former Soviet industry is also providing integrated or co-deployed defensive countermeasures packages for radars, which provide high fidelity decoy emitters, millimetric band chaff ejectors, infrared opaque smoke generators, GPS jammers, and often flare dispensers – the intent being to decoy or blind smart munitions, especially anti-radiation missiles.

The latest advance in Russian tactics and technology has been the deployment of terminal defence weapons to protect SAM sites and radars from smart munitions, using 30 mm gunfire and short range SAMs. The latter include redesigned variants of the SA-15 Gauntlet and SA-19 Grison, now on wheeled vehicles, and fitted with agile beam phased array radars. Smart munitions, especially anti-radiation missiles, will have to penetrate a wall of short range defensive SAMs, and then gunfire, to get to their targets, upon which they will have to overcome an array of countermeasures.

In the West these important developments have been mostly ignored. The development of replacement jamming pods for the EA-6B Prowler / EA-18G Growler has been in limbo since 2003, the program to develop standoff jamming pods for the "EB-52H" cancelled. The only program to survive was the AGM-88 Block 6 HARM, redesignated the AGM-88E AARGM, which adds GPS guidance and an active millimetric band radar seeker in attempt to provide a capability against radars which have stopped emitting, or are departing a site.

The collective impact of these developments in improving SAM system survivability is that conventional tactics using anti-radiation missiles are becoming increasingly irrelevant. If an aircraft does not have the 'all aspect' stealth capability to bypass a SAM belt, it will have to shoot its way through, with a concealed fleeting opponent who will be extremely difficult to locate, and if located, no less difficult to kill. In short, technological evolution in Russia and China has effectively obsoleted Western legacy fighter aircraft fleets, and neutered the F-35 Joint Strike Fighter before it has even reached production.

News Brief

End in sight for Caribou

After 45 years service to the Australian Defence Force in Australia the DHC-4 Caribou fleet will cease flying later this year, ending an era in tactical airlift that will likely never be matched.

In its tactical airlift role the Caribou had it all: the ability to operate from remote airfields in Australia and the Asia Pacific region where other aircraft types could not go, the stubborn reliability to continue flying in the worst remote areas when more modern aircraft systems would 'fall over', and a continuing squadron 'can do' attitude originated in Vietnam that just gets the job done.

With the Caribou gone by end of year the ADF needs an interim tactical airlift capability until a replacement aircraft type is identified under a Defence project known as AIR 8000. The RAAF will operate five leased Hawker Pacific B300 King Air aircraft in the light air transport role until a new aircraft type is identified. Three King Air 350 aircraft currently operated by Army will also transfer across to 38 Squadron (see separate article).

In recent years the Caribou's service life has been extended in anticipation of a replacement being identified but a combination of limited capability along with maintenance and combat survivability issues forced a December 2009 withdrawal date.

Commanding Officer of 38 Squadron, WGCDR Tony Thorpe said that while the squadron is sad to see the Caribou go it looked forward to new capabilities and better survivability in areas where the new tactical airlifter will be required to operate.

"While the King Air is not a Caribou replacement it will serve as a light transport capability and enable crews to train in an aircraft with modern systems such as 'glass' cockpit and digital avionics, as we transition to a new type," he said.

Where the Caribou will be missed is operating into remote airfields in Papua New Guinea where pilots train landing and taking off from unsurfaced airfields in the highlands that could be cut into a hillside.

"The combination of operating from remote airfields in mountainous terrain in variable weather conditions means that anything in Australia is easy by comparison," WGCDR Thorpe said.

Two Caribous have been identified for retention: A4-140 to the Air Force Museum at Point Cook and A4-152 to the Australian War Memorial in Canberra.

The DHC-4 Caribou has flown for 45 years with the RAAF. (Defence)