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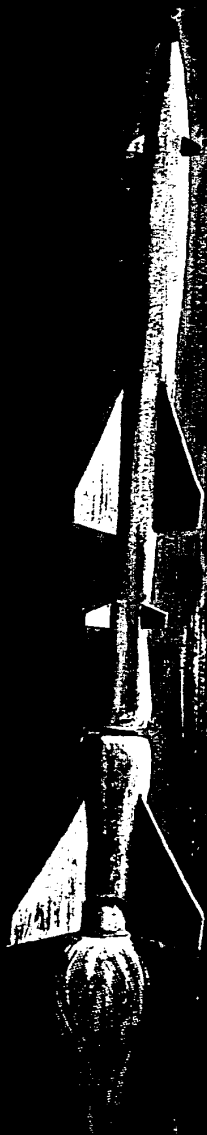


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DEFENSE INTELLIGENCE AGENCY

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SOVIETS CONTINUE TO EXPAND SAM AIR DEFENSE SYSTEM



SINCE the early 1950's, the Soviets have been engaged in an extensive research and development program on surface-to-air missile (SAM) air defense systems. This effort has resulted in the development and subsequent deployment of three distinct SAM systems. They are:

- The SA-1 (Guild).
- The SA-2 (Guideline).
- The SA-3 (Goa).

The SA-1

This missile system has been deployed only in the Moscow area, and it is expected to be eventually phased out in favor of other SAM systems. The SA-1 has a maximum operational range of 20 to 25 nautical miles, a maximum effective altitude of 60,000 feet, and a minimum altitude effectiveness of about 3,000 feet. It would have a limited effectiveness up to 80,000 feet, especially if equipped with a nuclear warhead. The SA-1 site is handicapped by a limited field of fire of about 60 degrees, but it can direct a high rate of fire against a large number of targets simultaneously. Furthermore, the SA-1 is operationally inflexible and has a limited capability against high-speed targets.

Beginning in 1954, the same year the missile became operational, the Soviets initiated construction of a ring of SAM sites around Moscow. In the late 1950's, two rings had been completed—an inner ring of 22 SA-1 sites having a radius of about 25 nautical miles from the center of Moscow and an outer ring of 34 sites having a radius of about 45 nautical miles.

Each SA-1 site has a herringbone pattern of transverse concrete roads nearly 15 feet wide and contains 60 launch pads (see diagram on page 6). A basic load of four missiles per launcher is estimated to be available either at the site or nearby.

The SA-2

The SA-2 system is estimated to have achieved an initial operational capability in 1957. Currently, approximately 1,100 SA-2 sites are believed to be deployed for point and area defenses throughout the USSR and other Warsaw Pact countries.

The SA-2 system with the C-band Fari Song radar has about a 25-nautical-mile maximum operational range and is effective against aircraft flying at speeds up to about mach 1.2 to 1.4. The system can have a 360-degree field of fire and is capable of engaging targets at altitudes between 3,000 and 90,000 feet with some effectiveness above 90,000. This missile has provided the Soviets with a good medium- and high-altitude air defense weapon with a limited low-altitude capability. Thus, the SA-2 is not the ultimate air defense weapon against manned aircraft.

Each SA-2 site contains six drive-through launch revetments laid out in a generally circular pattern approximately 500 feet in diameter with launchers being about 250 feet from each other. A service road surrounds the six revetments, its perimeter forming a circle approximately 900 feet in diameter. Most sites have three hold revetments, each capable of holding two missiles. An estimated four missiles per launcher are available as a basic load (two on site and two in the support area), but the reload capability has the same shortcomings as the SA-1.

SA-3 (Goa) system

Operational deployment of the SA-3 system is believed to have started in the latter part of 1961. Currently, slightly more than 100 SA-3's are deployed primarily around Moscow, Leningrad, and in certain border areas most susceptible to low-altitude attack.

Air defense posture of Warsaw Pact countries now includes a total of more than 1,200 surface-to-air missile sites; currently the Soviets have three SAM systems: SA-2's are widely deployed in the Pact countries, SA-1's and SA-3's also are deployed in the Soviet Union with SA-1's only in Moscow area

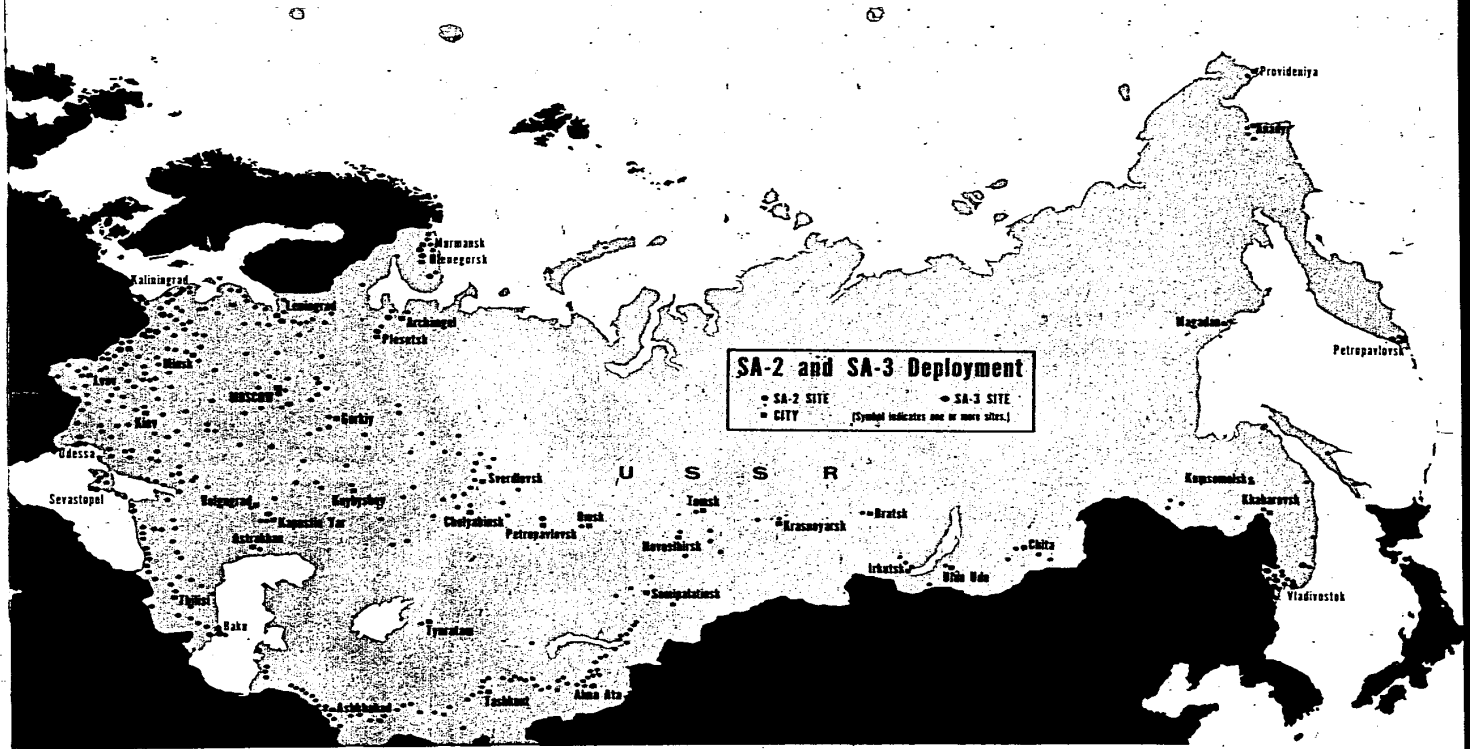
The SA-3 missile, which has a maximum operational range of between 10 to 15 nautical miles, is believed designed to cope with low altitude attacks, that is, at about 1,000 feet, although there is no evidence as to its actual low-altitude effectiveness. Its maximum effective altitude is between 25,000 and 50,000 feet.

A typical SA-3 site has a trapezoidal

configuration with four launch pads about 200 feet apart. Each pad is connected by access roads to a central reverted guidance area about 100 by 60 feet in size. Roads also connect this guidance area to a 140-by-80 foot missile holding location which is about 600 feet from the forward launch area.

Deployment of SAM's

SAM deployment in the USSR embraces a combination of barrier and point defenses. The early pattern of SA-2 deployment in the Soviet Union was classic for a short range air defense weapon. Point defenses initially appeared at Moscow, Lenin-grad, and other large cities, the vital

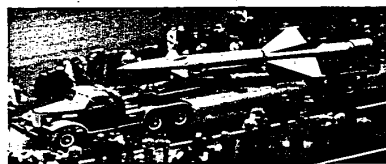
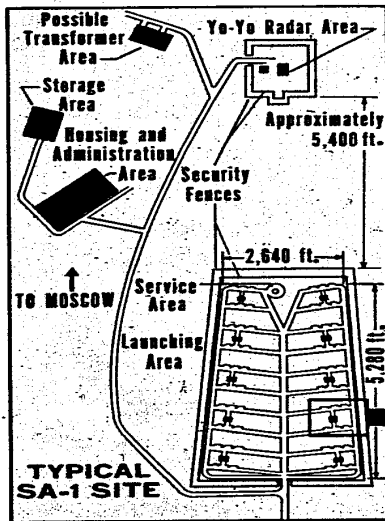
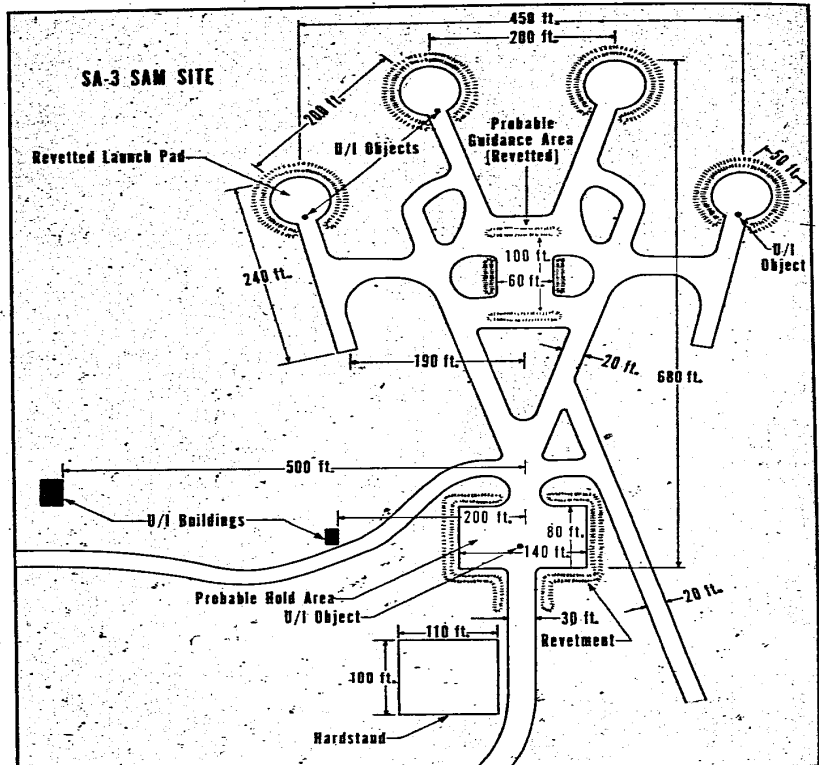


links in civil and military command/control and the backbone of basic war materiel production. As SAM production mounted, dual- and single-site defenses of major cities developed into ringed defense. In some cases, multiple ring defenses were deployed.

Deployment soon spread to surface-to-surface missile sites, nuclear weapons storage areas, and along the peripheral areas of the Soviet Union. As the number of defended points increased, individual target protection began to overlap, and perimeter and coverage became by-products.

Concurrently with this massive buildup inside the USSR, the SA-2 deployment in the Eastern European Warsaw Pact countries followed a parallel path, capital cities first, then other large industrial centers. More than 150 sites have been identified in the European Warsaw Pact countries, and the point defenses are merging into area coverage in some locations.

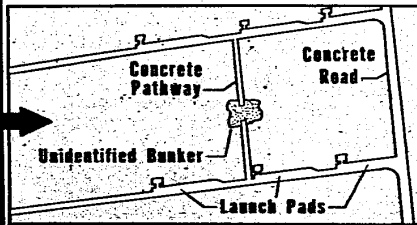
A barrier of SA-2 sites in the USSR is deployed in a line from the White Sea area and the Kola Peninsula in the northwest, southward along the western borders, eastward along the Black Sea and through the Caucasus, and along the southern border of Kazakhstan as far east as Semipalatinsk. In addition, a large number of SA-2's are deployed in point defense around significant military



SA-1's are deployed only in Moscow area and are expected to be phased out. [S]



SA-3 site (above) is believed designed to cope with low altitude attacks. [S]



and industrial targets and population centers.

The SA-3 system is complementary to the SA-2 system and normally is deployed in close proximity. SA-3's currently are deployed with only minor exceptions, in point defense of ports and naval cities, and in the SAM barrier along the Polish border. SA-3's have been deployed, however, in the outer ring of the SA-1 sites northwest and southwest of Moscow, and further deployment is expected to

continue around the ring. Future SA-3 deployment can be expected to reinforce the SA-2 barrier along the western and southern borders of the USSR as well as point defense in the interior.

The large gaps in defense along the far eastern borders and along the northern perimeter of the country indicate an apparent Soviet doctrine that does not provide barrier-type defense coverage as a primary goal. Moreover, a number of points in the interior of the USSR received SAM defense prior to many places along the perimeters. The western and southern SAM barriers, however, are exceptions. The area or zonal defense patterns, for example, assumed by the SAM sites along the border areas are believed to play a vital role in defending MRBM positions which, because of their range restrictions, are near the border and are vulnerable to enemy air attack.

The deployment pattern in each of the Eastern European Warsaw Pact countries appears to be directed primarily toward the defense of that country's resources; however, the overall deployment reinforces the western and southwestern air defenses of the Soviet Union.

Defense of centers and installations

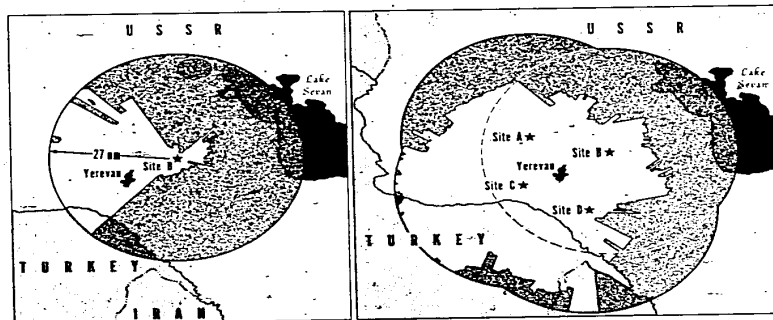
The USSR has undertaken a large and rapid deployment of surface-to-air missile systems for the point defense from air attack of important military installations, industrial complexes, and population centers. The Soviets probably will continue to provide SAM defense for an installation or center that is large or vital to the nation's economy or to the military. This deployment includes installations whose operations require a long lead time in either personnel training and development of skilled manpower or the development of the area's resources. Such centers or installations may be grouped as follows:

- Long-range offensive installations or centers. Included here are the ICBM complexes and the IRBM/MRBM sites; the principal long-range bomber bases; nuclear weapons storage sites such as those in Dolon, Ukraina, and Engels; and submarine bases and construction centers such as Leningrad,

CAPABILITY OF SAM SITES RESTRICTED BY MASKING

The effective minimum-altitude capability of individual SA-2 sites varies, although inherent characteristics of associated hardware are static. The differences in altitude capability depend upon masking effects of local terrain,* radar conditions, and target characteristics. The current estimated minimum effective altitude is 3,000 feet, but under certain optimum conditions, the SA-2 is believed to possibly have a limited capability below 3,000 feet. Of 40 representative Soviet installations evaluated, 10 were masked in 75 percent, and 20 in 50 percent, of their field of fire. No site was found free of limitation.

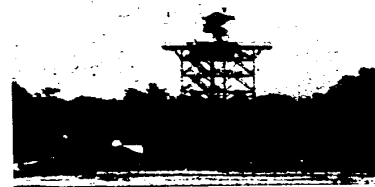
The masking effects of the SAM defense complex at Yerevan, Armenian SSR, are shown below. The diagram on the left illustrates, for a single site, the extent of radar masking or the limits of radar line-of-sight within a 27-nautical-mile radius at 3,000 feet above the elevation of the SAM site, which is about 5,360 feet. For this site, an aircraft entering the unshaded area would be in the line-of-sight of the radar. Lock-on may not occur, however, as radar capabilities may be handicapped by ground return which could obscure a moving target.



The large masked area for the single site clearly illustrates the need for additional defense installations. Evidently, the Soviets are aware of the masking problem and have deployed three other SAM sites to increase defense coverage.

The diagram on the right, which is a composite of the four sites—A, B, C, and D—greatly increases radar line-of-sight coverage. In each drawing, earth curvature has not been considered, but it would be a factor to be considered even at this limited range.

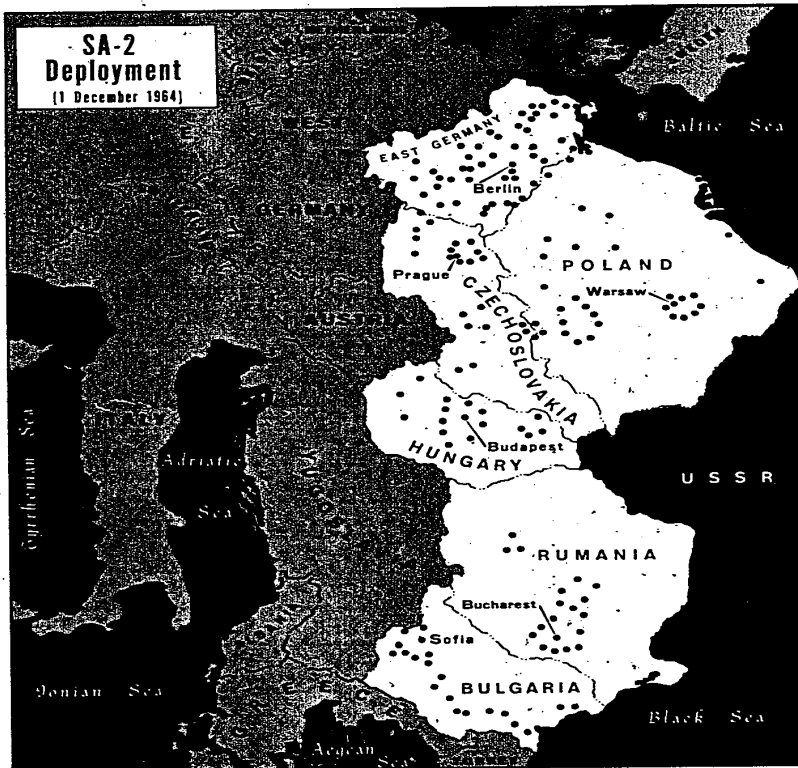
With the SA-3 system, the masking problem is considerably more acute. As a result, deployment is carefully determined, and in some cases, the associated radars for the SA-3 such as Low Blow and Flat Face, have been placed on platforms 40 to 50 feet high. This elevation is intended to clear the masking of nearby trees and surmount nearby low terrain.



TYPICAL SA-3 radar on tower. [S]

*Since radar signals travel in a straight line, a terrain feature interrupting the signals obstructs the line-of-sight. This obstruction creates a fan-shaped area behind the obstacle which is not radar covered. This is the masked area.

**SA-2
Deployment**
(1 December 1964)



Murmansk, Pechenga, Kaliningrad, Komsomolsk, and Nakhodka. The great majority of such installations are defended by SA-2's.

- Important military research and development centers. The primary centers are Kapustin Yar, Tyuratam, and Sary Shagan. The important nuclear weapons research development centers include Sarova, Dodonovka, Kasli, Kyshtym, Yuryuzan, and Nizhnaya Tura.

- Industrial complexes and installations. Foremost in this category are the large cities with their attendant industrial capability and resources such as Moscow, Leningrad, Kuybyshev, Sverdlovsk, and Baku. In addition are the large dams and hydroelectric

stations such as those at Volgograd, Kuybyshev, and Bratsk.

- Population centers. Practically all cities with populations exceeding 100,000 are within the effective defensive range of at least one SAM site. In this extensive deployment of SAM defenses, the Soviets have chosen to protect large cities with their attendant industrial capacity, important military R&D centers, skilled manpower, and over-all capability to produce weapons and other war materiel. Also, the large cities are located on the principal surface transportation links, and many are key transportation hubs. As more militarily important installations are located in or near the large cities, the defensive requirements in turn are increased.

The present SAM deployment pattern presents considerable difficulty in actually determining which targets are defended by a particular SAM or a group of SAM's. The defense coverage by SAM's overlaps, and whether a SAM site is a part of an area or point defense pattern is often open to conjecture. Within the defense range of an SA-2, installations may include ICBM or nuclear weapons storage sites near a large city which also includes a number of important industrial targets. Even with various areas of heavy overlap, there is a wide range in the quality and quantity of defense coverage provided in the USSR—ranging from poor to excellent, with from 1 to more than 80 SAM's defending a single area or center.

Role in ground forces

Little information is available concerning deployment of surface-to-air missiles with the Soviet ground forces. Each Soviet field army is believed to include three battalions (six launchers each) of SA-2's and it is estimated that four battalions of low-altitude SA-3's or some other low-altitude missile system will eventually be provided. These weapons, however, probably can be integrated into the *PVO Strany* (Air Defense Forces of the Homeland) when required.

In the Moscow 1964 May Day Parade, the Soviets exhibited for the first time the Ganef, a dual-mounted missile system on a tracked chassis. This missile is believed to be a surface-to-air weapon for deployment with field troops and, with the exception of a somewhat reduced maximum altitude, has performance characteristics roughly similar to those of the Guideline.

The Ganef has been seen only in the parades of last May and November, and the extent of its deployment can be estimated only on the basis of requirements. It does not appear likely, however, that this missile would be deployed in a fixed pattern similar to those of previous SAM's.

Deployment of the SA-2 and SA-3 systems is continuing, and it is expected they eventually will cover all significant targets in the Soviet Union. [END]