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The Flat Twin ABM Radar: Not as Capable as Previously Believed

A Technical Intelligence Report

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SW 91-10069
October 1991

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The Flat Twin ABM Radar: Not as Capable as Previously Believed

A Technical Intelligence Report

This paper was prepared by Office of Scientific and Weapons Research, with contributions from OSWR

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The Flat Twin ABM Radar: Not as Capable as Previously Believed

Summary

Information available as of 1 August 1991 was used in this report.

New analysis of the Soviet Flat Twin ballistic missile defense radar shows that it is not as capable as previously believed. [redacted]

[redacted] Our analysis [redacted] indicates severe constraints imposed on the Flat Twin by its antenna. This strengthens our belief that a widespread, fast-paced Soviet ABM deployment using the Flat Twin is unlikely because of the number of radars required, as well as the extreme difficulty of modifying the Flat Twin to make it perform effectively.

Our analysis of the Flat Twin's antenna indicates that the Flat Twin is much less capable in off-boresight scanning for track and search than we had previously estimated. [redacted] indicate that the Flat Twin has a maximum scanning capability of about ±15 degrees in azimuth and elevation for tracking. [redacted] also indicates that the Flat Twin can search less than ±10 degrees. This reassessed search capability is considerably less than the earlier estimate of ±45 degrees

Because of the Flat Twin's scanning limitations, a widespread ABM system using the Flat Twin would require an overwhelming number of radars. A system deployed at Moscow and 40 of the most important areas in the Soviet Union would require about 500 to 570 Flat Twin radars. These numbers are about 30 percent higher than our previous assessment. Although the Soviets would require fewer Flat Twin radars to defend their 125 high-priority deployment sites under the START treaty, the number required is still considerable. Under the START treaty limit of about 4,900 US ballistic missile warheads—the level to be achieved by 1996—our modeling indicates that a Soviet defense would require about 510 to 600 Flat Twin radars. Under a potential future START treaty permitting about 2,450 US ballistic missile warheads, we calculate that the number of Flat Twin radars required for defense would be reduced to about 380 to 450.

Given the Flat Twin's limitations as a widespread ABM system, we believe that the Soviets would use a new type of ABM radar. We would expect a new radar to have a greatly improved scan angle, a better multiple-target-tracking capability, and greater detection range. Thus, a significant reduction in the number of radars required in a widespread ABM system would result. [redacted]

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Introduction

The Soviets have used the Flat Twin engagement radar in diverse ways throughout its history. The Flat Twin radar was initially an integral part of an ABM program called the ABM-X-3, which we believe was under development for nationwide deployment before the signing of the ABM Treaty in 1972. Despite the demise of that program, the Flat Twin has continued to support weapons systems' developments at both Kamchatka and Saryshagan [redacted]

Because the Flat Twin is transportable and had been associated with an ABM system intended to be widely deployed, we considered the possibility of the Soviets breaking out of the ABM Treaty with a fast-paced, nationwide ABM system based on the Flat Twin radar and the Gazelle interceptor. We explored the limitations of the Flat Twin radar and the advantages to the Soviets of developing a new ABM radar for a widespread ballistic missile defense

Role of the Flat Twin in Soviet R&D

We believe that the role of the Flat Twin radar in the Soviet ABM program has changed [redacted] The Flat Twin radar was designed in the 1960s and was almost certainly intended to be widely deployed as part of the ABM-X-3 system. Before the signing of the ABM Treaty in 1972, the Soviets had begun preparations for ABM testing. [redacted]

What the Soviets intended to gain from ABM-X-3 testing after signing the ABM Treaty is less clear. However, the demise of the ABM-X-3 system occurred by the late 1970s with the abandonment of the [redacted] interceptor program. We believe that Flat Twin testing conducted after 1972 probably stemmed from a requirement to continue to investigate a rapidly deployable system as a hedge against a breakdown of the treaty [redacted]

[redacted]

[redacted]

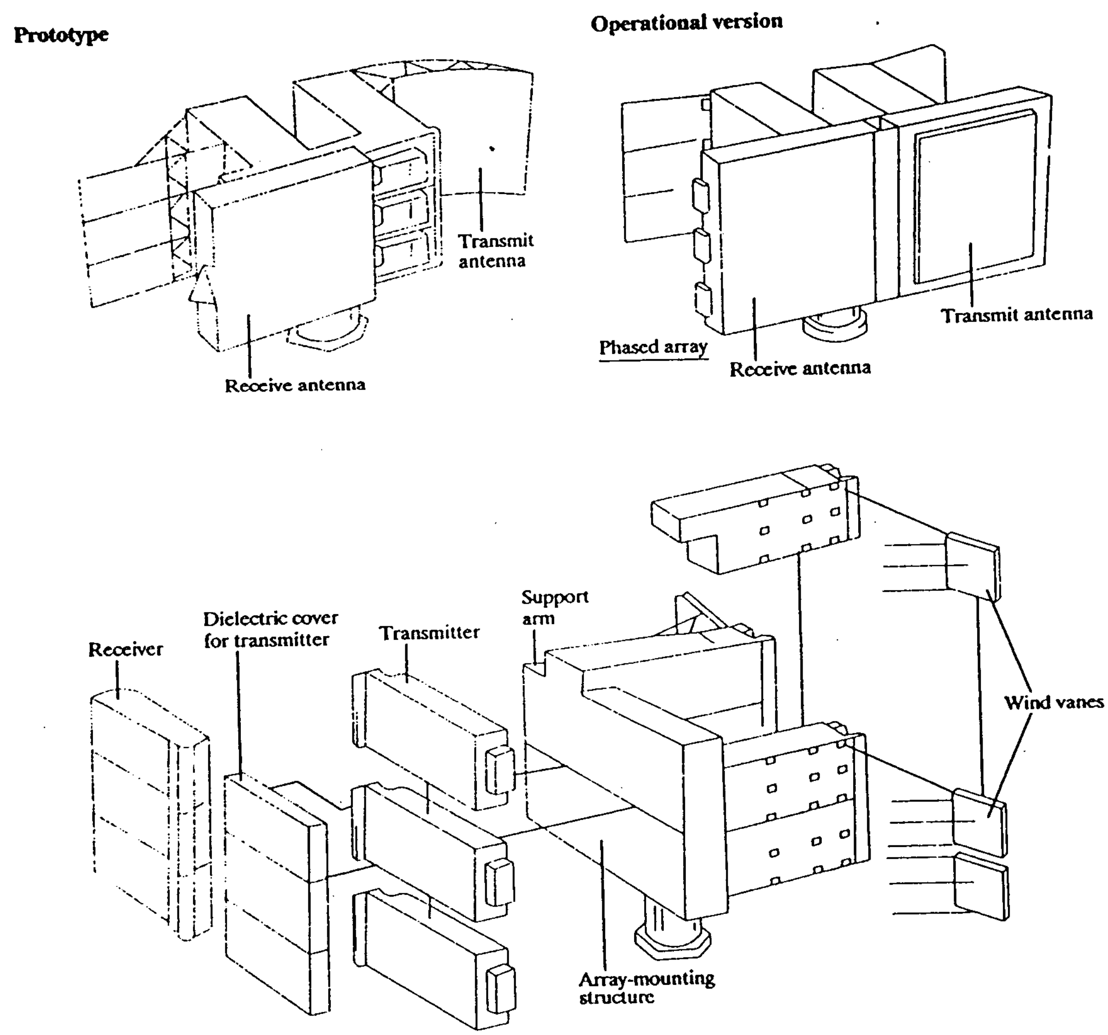
Flat Twin Radar Characteristics

Flat Twin is a transportable, multifunction, phased-array radar [redacted] in two versions, [redacted] are similar in size and general appearance. The prototype, [redacted] has a hybrid antenna system that uses a conventional, line-fed, reflector-type transmit antenna and a phased-array receive antenna. The operational Flat Twin radars, [redacted], have both transmit and receive phased-array antenna systems indicating an improved transmitter capability from the prototype (see figure 2). [redacted] the prototype and operational Flat Twins do not differ significantly in performance.

Analysis of all-source data indicates that the Flat Twin radar consists of an electronically steered, phased-array antenna mounted on a pedestal that allows mechanical steering in both azimuth and elevation. Once mechanically directed, the Flat Twin

Figure 2
Flat Twin Radar

[redacted] *the modular design of the Flat Twin makes it transportable.*



electronically scans in a limited search area for multiple targets using handover data from long-range surveillance assets.

This electronic scanning feature gives the radar the capability to cover a spatial sector more quickly than could mechanical scanning alone. Theoretically, a Flat Twin–equipped missile battery could engage targets arriving from any direction, although not simultaneously.

Flat Twin consists of a number of modules that can be transported by truck, rail, or aircraft. For example, the Flat Twin's size and mass are such that a single disassembled radar antenna can be carried by an An-124 Condor, a large Soviet aircraft similar to the US C-5A Galaxy. The Flat Twin radar is supported by 20 electronics vans providing power, cooling, and computer support.

We believe that the relocation time, excluding radar checkout, could be reduced to fewer than four months.

Scan Limitation of the Flat Twin Design

the Flat Twin is much less capable in off-boresight scanning than our previous estimates indicated

the Flat Twin has a maximum scanning capability of about ±15 degrees from the antenna's boresight in azimuth and elevation for tracking.

indicates that the Flat Twin can search less than ±10 degrees.[2] This reassessed search capability is considerably less than the earlier estimate of ±45 degrees, which was based on our presumed requirements for an operationally deployed Flat Twin. For example, the ±10-degree Flat Twin search area represents only 3 percent of the previously assessed ±45-degree search area (see figure 3).

The reduced number of phase shifters in the Flat Twin results in the decrease in its scanning capability from a theoretical maximum of ±60 degrees to about ±15 degrees. (The scan angle of an antenna decreases as the number of phase shifters is reduced.)

the Flat Twin antenna's face comprises 692 subarrays of about 16 different sizes arranged in a pseudorandom pattern (see figure 4) and a core array, which is probably for beacon tracking of ABM interceptors (see appendix). The total area of the antenna would allow a maximum of 17,000 phase shifters (elements) if spaced one-half wavelength apart. However, the volume of space available behind the face, in addition to one hole per subarray for coaxial wiring, suggests only one phase shifter per subarray.[3] This reduced number of phase shifters—692—is a 96-percent reduction of the theoretical maximum. The reduced number of phase shifters also minimizes the production cost of the radar.

[2] The differences in scan angle result from a requirement to have a higher signal-to-noise ratio for the search process. After a target is acquired, the radar can track targets at a lower signal-to-noise ratio, permitting scans up to ±15 degrees.

[3] Our analysis indicates that the elements within each subarray are all phased uniformly and that only phases of the individual subarrays—rather than each element—are changed to steer the beam. In the late 1960s, when the Flat Twin was being designed, indicated that the Soviets were having difficulties producing phase shifters.

Figure 3
Flat Twin Search Area

An array with a scan angle of ±10 degrees can scan only 3 percent of the area that can be scanned by a radar with a scan angle of ±45 degrees. We believe that the Flat Twin has an electronic scan capability of ±10 degrees.

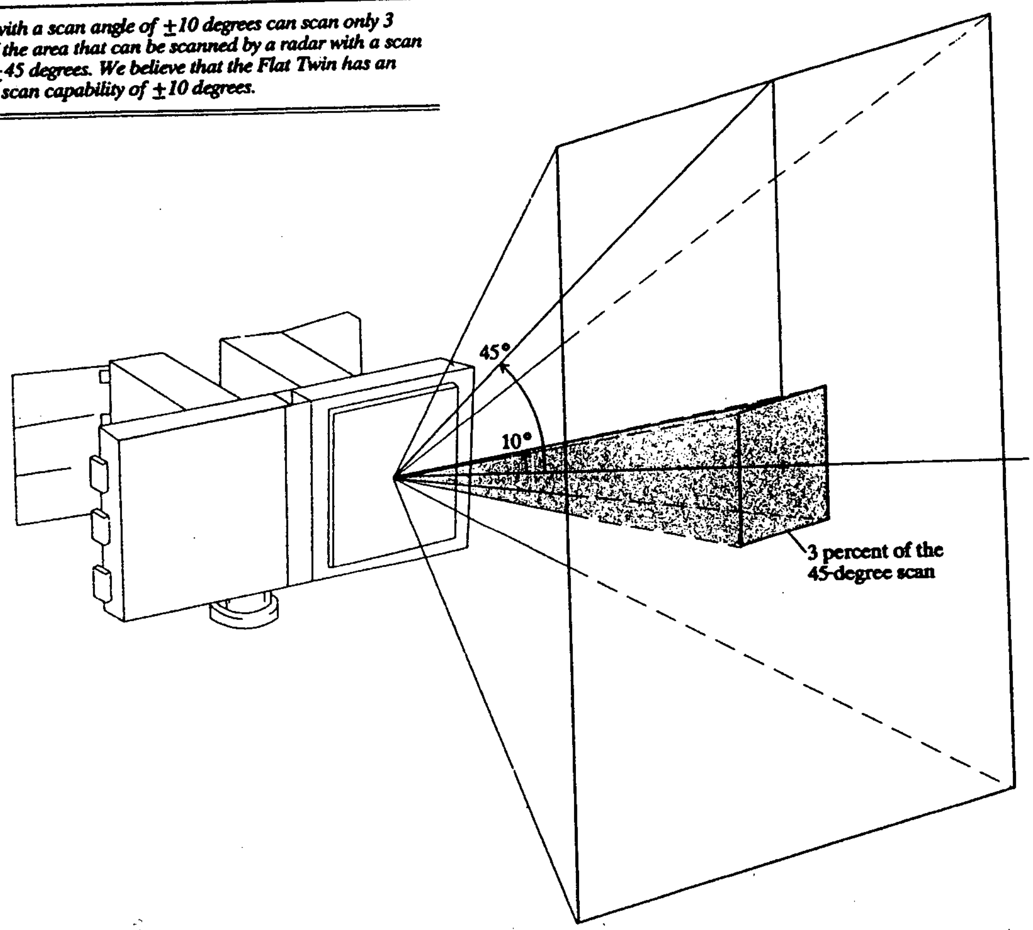
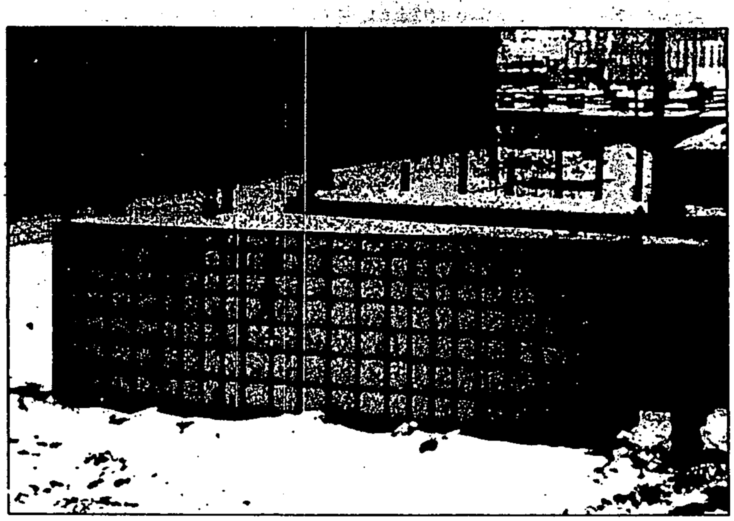


Figure 4
Flat Twin Bottom Module

The Flat Twin antenna's face contains 692 subarrays distributed in three modules. Each hole is assumed to be associated with a subarray.



We believe that the Flat Twin's scanning capability is limited by the occurrence of secondary antenna pattern maxima (grating lobes) when steered off-boresight. US research on a phased-array antenna with a 96-percent reduction in phase shifters shows that such a radar would have a scan angle of ±10 degrees with side lobes more than 30 decibels (dB) below the main beam and a grating lobe more than 25 dB below the main beam (see figure 5).[4] This research agrees with previously published Soviet papers using similar parameters. Grating lobes degrade the antenna pattern and the desired overall system performance. By using random-sized subarrays, several grating lobes appear at different angles, reducing the effect on the antenna pattern. The maximum grating lobes calculated for the Flat Twin antenna are at least 20 dB down when the antenna is steered 10 degrees off-boresight

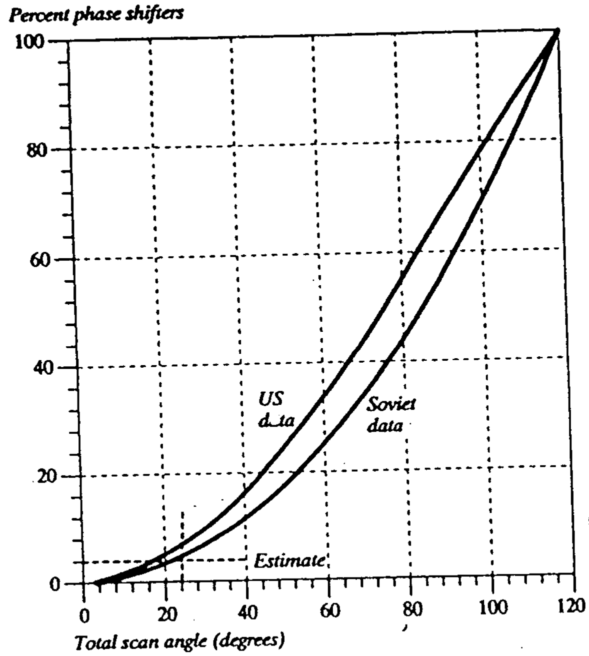
Can the Flat Twin Be Modified?

We believe that the effort involved in redesigning the Flat Twin to achieve a significant increase in off-boresight scanning capability probably would be tantamount to designing a new phased-array radar. Because of Flat Twin's unique antenna subarray design, any modification in the number of phase shifters to increase the off-boresight scanning capability would be difficult to achieve because of physical

[4] In an antenna radiation pattern, the lesser lobes of progressively decreasing amplitude on either side of the main lobe are the side lobes.

Figure 5
Tradeoffs of Scan Angle for Fewer Phase Shifters

The Flat Twin design incorporates a 96-percent reduction in phase shifters, which gives it a total scan angle of about 20 to 24 degrees, or an off-boresight scan angle of 10 to 12 degrees.



constraints on the mechanical support structure. Our analysis indicates that subdividing the subarrays to increase the number of phase shifters would also change the pseudorandom pattern of the subarrays. A new subarray layout would require significant changes in the radar's electronics. It would also require computers more capable than those associated with the Flat Twin

Effects of Flat Twin's Limited Performance

Defendable Region Limitations

We calculated the regions that can be defended by a Flat Twin/Gazelle ABM system using various scan angles. A defendable region is the area on the ground that can be defended by one ABM unit. Determined from a simple, one-on-one timeline analysis, these defendable regions represent the most optimistic extent of coverage and do not reflect degradations caused by multiple targets, nuclear bursts, or other effects

As the Flat Twin's off-boresight scanning capability is reduced, the defendable region of a Flat Twin/Gazelle system significantly decreases. Our modeling indicates that a Flat Twin with a 10-degree off-boresight search capability could defend only about 600 square kilometers, which is about 8 percent of the area defendable by a ±45-degree radar against a US Minuteman III RV [redacted]. Similar changes in defendable regions also occur against other US RVs when the scan angle is varied [redacted].

We believe this scanning limitation of the Flat Twin indicates that the radar cannot engage widely spaced RVs [redacted], the limited radar scan severely constrains the size of the coverage of the reentry complex. For example, our analysis shows that the ±15-degree tracking limit imposes a maximum crossrange distance between two simultaneously arriving RVs of between 20 and 30 km. A ±45-degree limit, however, would allow the Flat Twin to engage multiple RVs within an 80-km crossrange. The crossrange limitation would require the Soviets to deploy additional Flat Twin radars in a large region such as Moscow or Leningrad (now St. Petersburg) [redacted]

Number of Flat Twin Radars Required To Support a Widespread ABM Defense

Requirements Under Current US Strategic Force Levels. We have examined the effect that the reduced off-boresight scanning capability of the Flat Twin would have on Soviet deployment of a widespread ABM defense system. For a selected set of 125 high-priority deployment areas, the defense would require some 780 to 940 Flat Twin radars. For deployment at Moscow and 40 of the most important areas, about 500 to 570 Flat Twin radars would be required. The number of Flat Twin radars required in this analysis assumes handover data from the LPARs. Without handover data, we calculate that more than twice as many Flat Twin radars would be required to defend these sites.

The reduced off-boresight scanning capability of the Flat Twin increases Flat Twin deployment estimates by about 30 percent (see figure 9). In a previous analysis,[5] we determined that defense of a selected set of 125 high-priority deployment areas would require some 600 to 720 Flat Twin radars to defend against an attack by US missile forces. The previous analysis also indicated that deployment at Moscow and only 40 of the most important deployment areas would require 380 to 450 Flat Twins. These calculations assumed that the Flat Twin radar would have a 45-degree off-boresight capability.

Requirements Under START. The Soviets would require fewer Flat Twin radars to defend their 125 high-priority deployment sites under the START treaty. Under the START treaty limit of about 4,900 US ballistic missile warheads—the level to be

The Deployment Analysis

Recent studies [a] *have allowed us to estimate the number of components that would be required to deploy a widespread ABM defense system using the Flat Twin and the Gazelle. Likely deployment areas were identified and roughly prioritized*

Most of the areas selected contain a high number of military or industrial facilities that would be important to Soviet war-fighting capabilities. Some areas with low target density were selected if they contained one or more targets of critical importance to Soviet offensive or defensive capabilities

We postulated representative US missile attacks to determine the number and type of RVs that the Soviets might anticipate in a given area. We then estimated in detail the number and optimum arrangement of radars and interceptors that would be required to handle the specific threat to each area.

The numerical ranges in our estimates of required numbers of radars reflect variations in the assumptions made about the attack scenario and componen performance. In all cases, we assumed a 95-percent "radar confidence level." Radar confidence is the probability that one or more RVs will not leak through the defense because a site has too few radars. Sensitivity analyses showed a 95-percent level to be a reasonable compromise between deployment requirements and expected leakage

Our analysis is intended only to provide a snapshot of an early stage in the Soviet planning process for a territorial defense. In planning an actual deployment, the Soviets would have to anticipate any offensive response, most of which would have the effect of increasing the number of components required. Moreover, the Soviets would be aware that a widespread ABM defense system in violation of the ABM Treaty would be viewed as an open-ended commitment to steadily increase the number of ABM components as long as the United States deployed additional offenses to defeat them

achieved by 1996—

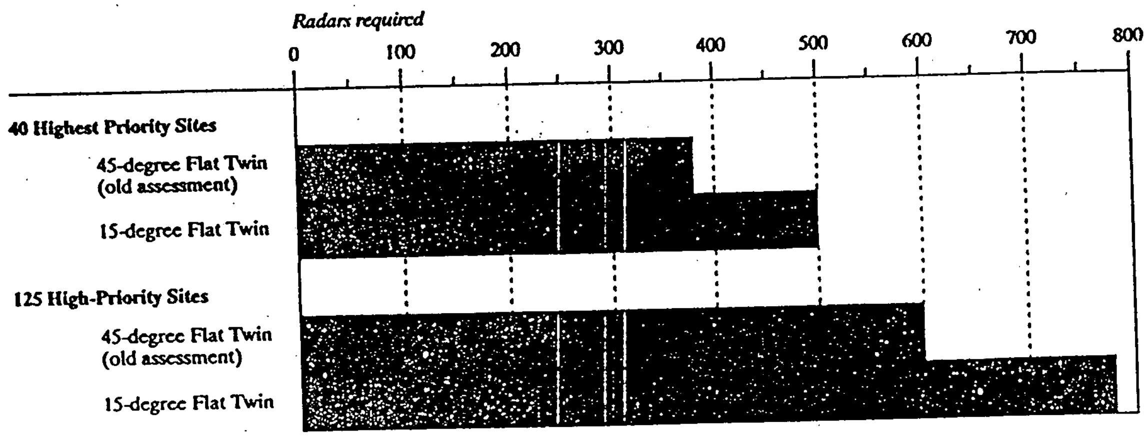
indicates that a Soviet defense would require about 510 to 600 Flat Twin radars. Under a potential future START treaty permitting about 2,450 US ballistic missile warheads, we calculate that the number of Flat Twin radars required for defense would be reduced to about 380 to 450 radar

Implications: A New ABM Radar on the Horizon?

If the Soviets became committed to developing a widespread ABM defense system, we believe that they have two viable options. Most likely, a new radar would be specifically designed to replace the Flat Twin. However, a radar similar to the Horse Leg radar, the engagement radar prototype for the ABM-4 system's Pill Box battle management radar, could be developed

We believe that a replacement for the Flat Twin radar would perform significantly better than the Flat Twin because of the evolution of technology since the Flat Twin's inception in the 1960s. The new radar would have a greatly improved scan angle, a better multiple-target-tracking capability, and greater detection range. Such a radar could be designed to be

Figure 9
Flat Twin Deployment Estimates [a]



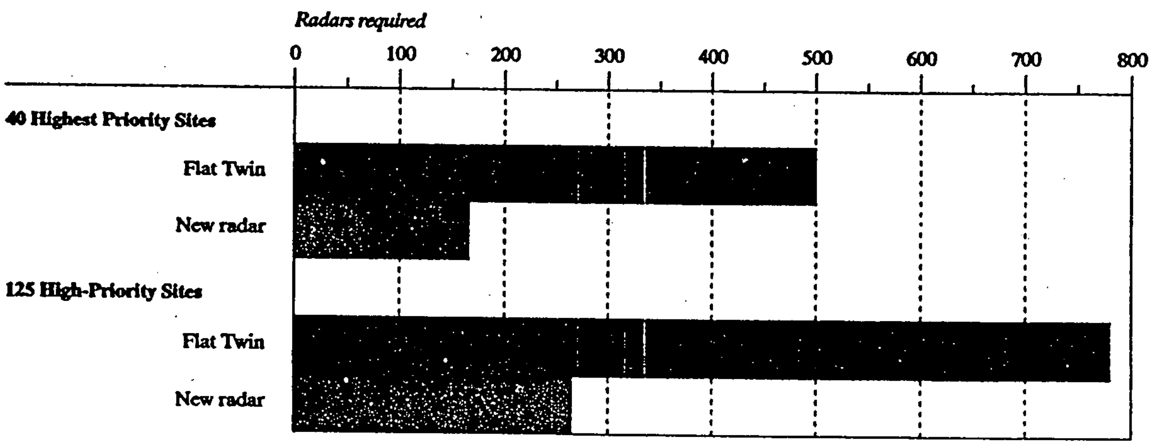
[a] Assumes handover from LPARs.

mobile, allowing deployment within a day, rather than transportable like the Flat Twin, which has demonstrated a six-week assembly time. We believe that the Soviets could develop and field a new radar at Kamchatka or Saryshagan within three to five years after they make a decision to build it.

A new mobile radar would be more appropriate than the Flat Twin for a widespread ABM defense system. The mobility alone of a new system would increase its survivability [redacted] Soviet radar requirements indicates that a new radar could reduce the required number of radars by as much as 60 percent (see figure 10). This reduction in the required number of radars could increase the attractiveness of a nationwide ABM defense system to the Soviets. We believe that the Soviets are not likely to have such a radar and a new endoatmospheric missile available for deployment—even if such a combination is now in development—until after the year 2000 at the earliest.

The Soviets could also accrue significant technical advantages by deploying a Horse Leg–type radar at Kamchatka. A Horse Leg radar would provide an additional ABM test and training site for the ABM-4 system. It would not, however, provide the Soviets the ability to field a quickly deployed, widespread ABM system. Each Horse Leg and Pill Box radar will take years to construct and would be detected long before they became operational. The Horse Leg and the Pill Box are systems that the Soviets would be more likely

Figure 10
Impact of a New Radar on Soviet ABM Radar Requirements for a Widespread ABM Defense System



to choose if, for example, they decided to openly field ABMs in response to US defensive deployments under a modified ABM Treaty, rather than covertly prepare for a fast-paced, nationwide breakout of the ABM Treaty

If the Soviets choose to improve their ability to be ready to deploy a widespread ABM defense system, they would quite possibly develop a new interceptor as well as a new radar Even if testing started soon and progressed at a more rapid pace than observed in Soviet ABM programs over the past 15 years, these interceptors would not be ready for deployment until after the year 2000. But we do not know if the interceptors under development are intended for the upgraded Moscow ABM system or are part of a program to investigate a more rapidly deployable option. If they are, in part, intended for an option for a more rapidly deployable ABM system, it is highly likely that the Soviets are also developing radars suitable for rapid deployment

Appendix

Flat Twin Core Array

Figure 12