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Prospects for Improvement in Soviet Low-Altitude Air Defense

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PROSPECTS FOR IMPROVEMENT IN SOVIET LOW-ALTITUDE AIR DEFENSE[1]

PREFACE

This study assesses the capability of current Soviet strategic low-altitude air defenses and prospects for their improvement within the next 10 years.

The study is focused on Soviet low-altitude air defenses because US planning calls for low-altitude penetrations of the Soviet Union and because previous estimates concluded that the Soviets' weakest defensive capabilities were against bombers flying at low altitude.

This study addresses the strengths and weaknesses of currently deployed systems against low-altitude targets, discusses the requirements for improvements in low-altitude defense, and identifies operational trends and research and development activities which may indicate which paths the Soviets have chosen for the future. Particular emphasis is placed on potential improvements which could be deployed to a significant degree within the next 10 years to improve the Soviets' capability to counter low-altitude bomber penetration of their defenses.

Readers of this study should remember that Soviet ability to defend against bombers in the 1980s will depend on a number of factors which

[1] This Interagency Intelligence Memorandum was prepared in response to a request by the National Intelligence Officer for Strategic Programs. Agencies collaborating in this report are the Central Intelligence Agency, the Defense Intelligence Agency, the National Security Agency, and the intelligence organizations of the Departments of State, the Army, the Navy, and the Air Force. The drafting responsibilities were carried out under the chairmanship [redacted] Directorate of Scientific and Technical Intelligence, Defense Intelligence Agency.

are extremely difficult to measure. For example, a US bomber strike against the Soviet Union would be accompanied by actions involving other strategic forces, US as well as Soviet. Many of these actions would affect the success of the bomber force's mission. In an all-out nuclear exchange, regardless of which side struck first, Soviet air defenses would certainly suffer degradation from US ICBMs and SLBMs. In the event of limited uses of strategic nuclear weapons it is possible that Soviet air defenses would be left largely intact.

The study deals exclusively with the missions and capabilities of the current and future Soviet air defense system in the airspace over the Soviet Union and its immediate periphery, assuming that the entire air defense system is operative. The number of bombers which would reach the Soviet Union would depend on factors not considered in this study. For discussion of these factors see NIE 11-3/8-75, "Soviet Forces for Intercontinental Conflict Through the Mid-1980s," dated 17 November 1975. Finally, future developments in US offensive forces and tactics, such as the possible introduction of advanced cruise missiles, have not been considered.

[redacted]

NOTE

This study was undertaken as part of the interagency intelligence production program to support preparation of NIE 11-3/8-75, "Soviet Forces for Intercontinental Conflict Through the Mid-1980s." While this study was not in finished form, its principal findings were available at the time NIE 11-3/8-75 was completed. The conclusions of NIE 11-3/8-75 reflect the principal findings of this paper.

CONCLUSIONS

The improvements we foresee in Soviet air defense—in air surveillance and control, interceptors, and surface-to-air missiles—have the potential for overcoming during the next 10 years most of the current technical deficiencies for defense against low-altitude bombers.[2] By 1985, if the Soviets carry out the programs we have judged as likely, they will have gone a long way toward overcoming their deficiencies, making the task of low-altitude penetration much more difficult than it is today. The actual effectiveness, however, of Soviet low-altitude air defenses against US bombers will depend heavily on the degree of air defense degradation resulting from missile strikes, electronic countermeasures, bomber penetration aids and tactics, and on the nature of US bomber force improvements. Neither we nor the Soviets would be able to predict all these factors with confidence.

Major technical deficiencies in Soviet air defenses which now limit their ability to defend against low-altitude bomber penetrations are the lack of:

—a ground-based system to provide accurate and timely air surveillance and tracking data to support ground controlled intercept operations,

—an interceptor with a look-down/shoot-down capability,

—mobile SAMs deployed with strategic air defense forces, and

—an effective airborne warning and control system for air surveillance and tracking.

There is evidence that the Soviets are working to correct the first three of these deficiencies, but we believe it is unlikely that they will be able to make major improvements in the effectiveness of their low-altitude air defenses before about 1980.

By 1985 we believe Soviet strategic air defense forces will have:

—high-speed data systems in support of ground control intercept operations;

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[2] Throughout this report the term "low altitude" is used to mean altitudes below 800 feet above terrain because US bomber forces are specifically equipped to use this altitude regime as a primary tactic. The JCS defines "very low altitudes" as less than 500 feet, "low altitudes" as between 500 and 2,000 feet. But for purposes of this Memorandum a range of 500 to 2,000 feet has not been used as the criterion for "low altitude" because the upper limits of the range would overstate Soviet low-altitude air defense capabilities in relation to US options. Also, the lower limit of 500 feet in the JCS definition does not encompass the lower range of operating altitudes of US bombers.

—significant numbers of the MIG-23 Flogger which has a limited capability to track and destroy aircraft flying below its own altitude, or an improved interceptor; and

—a new low-altitude SAM system (with a degree of mobility).

Collectively, these developments would offer the Soviets a significant potential for improvement in low-altitude air defense.

We also believe that by the early to mid-1980s the Soviets will have the technology to produce advanced look-down/shoot-down interceptors and an airborne warning and control system which would be effective over land. Given their historical and continuing emphasis on air defense, we believe they will pursue these developments. With a priority effort and depending upon the level of sophistication, such systems could be introduced in the early to mid-1980s.

The Soviets are not likely to have an effective defense against the short-range attack missile (SRAM) by 1985 and will rely on defenses to attack SRAM carriers prior to missile launch. The small radar cross sections, terrain following, long ranges, and other capabilities of prospective US low-altitude cruise missiles would confront the Soviets with additional problems in air defense.

We have considered Soviet research and development efforts on high-energy lasers and their implications for air defense. We do not believe that laser applications would have any better prospect for overcoming current deficiencies in Soviet low-altitude air defenses than the forces we have estimated as likely. Soviet research and development of lasers for air defense merit our close attention, however, for indications of unforeseen advances or breakthroughs in this rapidly moving area of weapons technology.

SUMMARY

Current Capabilities and Deficiencies of Soviet Air Defense Forces

A. Present Soviet air defenses are good against bomber attacks at medium and high altitudes over the Soviet landmass. Despite their numbers and diversity, however, it is highly unlikely that Soviet air defenses could cope with a bomber force penetrating at low altitudes, and they have no capability against the US SRAM. These conclusions are based on our identification of critical technical deficiencies in vital air defense functions. In addition, Soviet air defenses are vulnerable to bomber penetration aids and tactics, but we are unable to quantify the extent of degradation of Soviet air defenses from these causes.

B. The technical deficiencies we have identified would drastically limit the number of weapons the Soviets could apply against low-altitude bombers:

—The Soviet ground-based air surveillance and control system does not provide accurate and timely tracking data. In the most heavily defended portions of the Soviet Union, radar coverage, provided by ground-based radars, is adequate for nearly continuous tracking of low-altitude bombers. However, with few exceptions, the radar tracking data are not collected and disseminated with sufficient speed and accuracy for controllers to conduct a ground-controlled intercept (GCI). GCI controllers can conduct intercepts only within the range of their on-site radars. Consequently, given the low altitude and speed of bombers, GCI controllers are unable to direct a successful intercept during the short time available.

—The Soviets also lack an effective airborne warning and control system (AWACS) for either overwater or overland operations, which inhibits using interceptor aircraft to attack low-altitude bombers before they enter Soviet land-based radar coverage. The present Moss air surveillance aircraft have little capability to detect or track low-altitude targets or to control interceptors.

—Soviet strategic air defenses lack an interceptor with a look-down/shoot-down capability—i.e., the ability to detect, track, and engage low-altitude bombers while the interceptor is flying above the target at medium or high altitude. Such an interceptor would partially offset deficiencies in air surveillance and interceptor control.

—Soviet surface-to-air missiles have very short engagement ranges against low-altitude targets, and are vulnerable to offensive avoidance tactics. Virtually all of the SAM systems of the Strategic Air Defense Force (PVO Strany) are deployed at fixed locations.

C. In addition to the strategic air defenses, the Soviets maintain tactical air defenses as part of their Ground Forces and Frontal Aviation. Collectively, the size of the tactical air defense forces, which include mobile SAMs, antiaircraft artillery (AAA), and fighters, is comparable to that of the PVO Strany. These forces possess low-altitude capabilities which could improve the strategic defenses of the Soviet Union. The mobility of the SAMs and AAA could reduce the susceptibility of these systems to offensive avoidance tactics. The MIG-23 Flogger, the only Soviet fighter aircraft with even limited capability to detect, track, and engage targets below its flight altitude, is deployed with Frontal Aviation. Other tactical fighters are no better than those in the strategic air defenses.

D. We do not believe, however, that the Soviets see in their tactical forces a solution to their low-altitude strategic air defense problem. The availability of these tactical forces for strategic defense is quite uncertain and would depend on the circumstances of the conflict. The tactical forces are mostly deployed in areas from which they could most efficiently support theater operations, and they would have to be relocated for optimal contribution to strategic air defense operations. Although the tactical air defense forces would probably not be available should the war begin with a large European conflict, circumstances can be envisioned in which the Soviets could augment their strategic air defenses by adding the low-altitude capabilities of the tactical forces.

Improvement Programs

E. Clearly the Soviets are continuing to improve their strategic air defense system. Programs have been identified which offer the Soviets the potential for reducing the fundamental technical deficiencies discussed previously.

High-Speed Data Systems for Air Surveillance, Command, and Control

F. Since 1967, the Soviets have been deploying high-speed, computerized data systems for processing and rapidly transmitting radar tracking data to weapons units. Such systems are now widely deployed with PVO Strany's SAM forces. Deployment of similar systems to sup-

[redacted]

port GCI units began in 1972 and is continuing, although relatively few GCI units have received these systems. The value of these data systems for ground-controlled intercept is critically dependent on the timeliness and accuracy of tracking data routed to a GCI controller. To be effective for ground-controlled intercepts, these data systems would require sufficient speed and accuracy to permit GCI controllers to vector interceptors beyond the line of sight of a GCI controller's own local radar (i.e., remote vectoring) to a point where the target is within range of the interceptor's airborne intercept radar. A data system with these capabilities combined with a better interceptor such as the Flogger (see paragraph G below), would enable the Soviets to achieve a substantial improvement in their interceptor defenses. However, there is no evidence that the data systems being deployed have been used for remote vectoring. Moreover, there are differing judgments among intelligence agencies about whether the new data systems the Soviets have begun to deploy currently have the technical capabilities for use in remote vectoring of interceptors. All agencies agree, however, that sometime after 1980 when projected deployments of the new data systems and Flogger or an improved interceptor are completed, the data systems will have the accuracies needed for remote vectoring, and that the overall capability of Soviet air defenses against low-altitude bombers will be substantially improved.

Look-Down/Shoot-Down Interceptor

G. The only operational Soviet fighter with even a limited look-down/shoot-down capability is the Flogger, currently deployed with Frontal Aviation and expected to be deployed soon to PVO Strany. The Flogger's look-down/shoot-down capabilities are significantly less than those of US aircraft such as the F-15. Without support from an interceptor control element to vector the aircraft within view of the interceptor's airborne intercept radar, the Flogger could not materially improve low-altitude interceptor defense capabilities. However, the combination of the Flogger and improved air surveillance/interceptor control discussed previously offers the Soviets the potential to improve their interceptor defenses substantially.

Mobile SAM Systems

H. The first new strategic SAM system since the SA-5 is under development at Launch Complex G of the Sary Shagan Missile Test Center. We believe the system is being developed for low-altitude air defense. All the components observed are new and all are transportable, including the tower-mounted radar; however, the degree of transportability or mobility has not yet been fully assessed. The system's three

[redacted]

major components are: a tower-mounted, circularly scanning continuous-wave (CW) acquisition radar; a probable ground-mounted planar array engagement radar; and a vertical four-tube launcher. A preliminary estimate of the system's performance and configuration gives it a short-to-medium range, on the order of 20 nautical miles. A vertical launch [redacted] implies 360-degree coverage without having to traverse the launcher.

I. As an interim measure the PVO Strany could procure and deploy one of the tactical mobile missile systems now operational, such as the SA-6. But there is no evidence that the Soviets have chosen this option. If deployed in sufficient numbers—i.e., several hundred—unlocatable mobile SAMs could degrade the effectiveness of bomber avoidance tactics. [redacted]

AWACS

J. There is no evidence of a program to develop an AWACS to improve air surveillance and control. We believe that the Soviets will try to achieve this capability, but doubt that they now have the technology for an AWACS which would be effective for overland operations. If the program receives high priority, the production and deployment of an AWACS could be initiated by the early to mid-1980s, depending on whether the AWACS has an overwater or overland capability.

Other Significant Programs

K. The Soviets are pursuing other approaches for improving their air defenses, although we are uncertain about their potential impact:

—There is evidence that nuclear warheads are available to a significant portion of SA-1 and SA-2 sites and some SA-5 complexes. It is not known whether Soviet rules of engagement would permit use of nuclear-armed SAMs against low-altitude targets, particularly due to the prospects for collateral damage. If the use of nuclear warheads were permitted we would expect some increase in effective range of the SA-2 at low altitude. We have not conducted rigorous analyses of the overall impact of nuclear warheads on the effectiveness of Soviet SAM systems.

—The Soviets have under way large-scale programs involving the use of lasers for military applications. Some of these are sponsored by PVO Strany, but the specific goals and status of these efforts have not been ascertained. Estimates of the possible range of ground-based laser beam weapons indicate that only about a six-mile range could be achieved by the early 1980s. This is much less than the range of current ground-based missiles. Airborne lasers would probably be limited to a range of only two or three miles, compared to three to eight miles for current air-to-air missiles. With these limitations such weapons would not have any better prospect for overcoming current deficiencies in Soviet low-altitude air defenses than the forces we have estimated as likely. Soviet research and development of lasers for air defense merit our close attention, however, for indications of unforeseen advances or breakthroughs in this rapidly moving area of weapons technology.

Prospects For Improvement

L. We expect the Soviets to continue their efforts for an improved air defense system, but because of the time required for the production and deployment of equipment and personnel training, no material change in overall Soviet strategic air defense capabilities is expected before about 1980. By 1985, however, we expect large-scale deployments of systems now in evidence: high-speed data systems, the Flogger, and a new transportable (possibly mobile) low-altitude SAM system. Additionally, new programs employing advanced Soviet technology will probably come to fruition. We believe that by 1985 the Soviets will have introduced improvements which could reduce considerably all four of the fundamental, most-critical technical deficiencies which currently limit their capabilities against low-altitude bombers:

- —A combination of AWACS aircraft and long-range look-down/shoot-down interceptors could provide the potential for intercepting bombers along coastal penetration routes to the Soviet Union.
- —Ground-based radars, netted by high-speed data systems, could provide accurate air surveillance information to GCI controllers. These improved nettings, combined with look-down/shoot-down interceptors, could result in improved interceptor defenses over most heavily defended areas of the Soviet Union where adequate radar coverage exists. If an overland AWACS capability is achieved and added to this combination it could provide additional coverage in those areas where there are gaps in ground-based radar tracking.
- —Mobile SAMs, if not locatable, could materially reduce the capability of bombers to avoid SAMs.

We believe the Soviets will not have an effective defense against the SRAM by 1985, and will have to rely on defenses attacking the SRAM carrier prior to missile launch. The small radar cross sections, terrain following, long ranges, and other capabilities of prospective US low-altitude cruise missiles would confront the Soviets with additional problems in air defense.

M. The overall effectiveness of Soviet air defenses would depend, however, on factors such as the circumstances of the attack and the effects of electronic warfare, and on developments in US offensive forces. Also, we cannot assess the extent to which future US systems will offset the Soviet improvements which we have forecast. Neither we nor the Soviets would be able to predict all of these factors with confidence.

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DISCUSSION

I. OVERVIEW OF SOVIET STRATEGIC AIR DEFENSE

A. Size and Composition of PVO Strany[3]

1. The Soviet military is divided into five services. One of these, PVO Strany, is charged with the mission of strategic defense against bombers, missiles, and satellites. The four other services are the Strategic Rocket Forces, the Ground Forces, the Air Forces, and the Navy. Sections A and B focus on the capabilities of PVO Strany; section C deals with air defense resources organic to other forces which could, under some circumstances, play significant roles in support of strategic air defense missions.

2. PVO Strany has three arms for air defense: the air surveillance forces, the surface-to-air missile forces, and the interceptor aircraft forces. The following table shows their size.

TABLE I

PVO STRANY

Air Surveillance	about 1,000 radar sites; 90,000 men*
Surface-to-Air Missile Forces	about 1,200 SAM sites; 230,000 men*
Interceptor Forces	about 2,600 interceptor aircraft; 85,000 men*

*Manpower data do not include those PVO Strany personnel assigned to test facilities.

[3] The actual Russian words are Protivovozdushnaya Oborona Strany, which are translated as Air Defense of the Homeland. The US intelligence community usually refers to this force as PVO Strany.

B. Current Assessment of PVO Strany

3. The air defense system constitutes a formidable threat to aircraft flying at medium to high altitudes over the more heavily defended portions of the USSR. However, this air defense system would be unable to cope with a large-scale, well-coordinated bomber attack employing low-altitude tactics,[4] electronic countermeasures, decoys, and defense suppression weapons. The factors on which this assessment is based are discussed below.

4. The principal elements and individual functions of an effective air defense system are depicted in Figure 1. In addition to possessing the weapons which actually shoot down penetrators, the overall system must first find the enemy aircraft, track them, and then relay their positions to weapons controllers. All of these separate functions must be performed well if the entire system is to be effective; a breakdown or weakness in fulfilling any function can negate strengths in others. Any estimate regarding the prospects for an effective Soviet defense against low-

[4] Throughout this report the term "low altitude" is used to mean altitudes below 800 feet above terrain because US bomber forces are specifically equipped to use this altitude regime as a primary tactic. The JCS defines "very low altitudes" as less than 500 feet, "low altitudes" as between 500 and 2,000 feet. But for purposes of this Memorandum a range of 500 to 2,000 feet has not been used as the criterion for "low altitude" because the upper limits of the range would overstate Soviet low-altitude air defense capabilities in relation to US options. Also, the lower limit of 500 feet in the JCS definition does not encompass the lower range of operating altitudes of US bombers.

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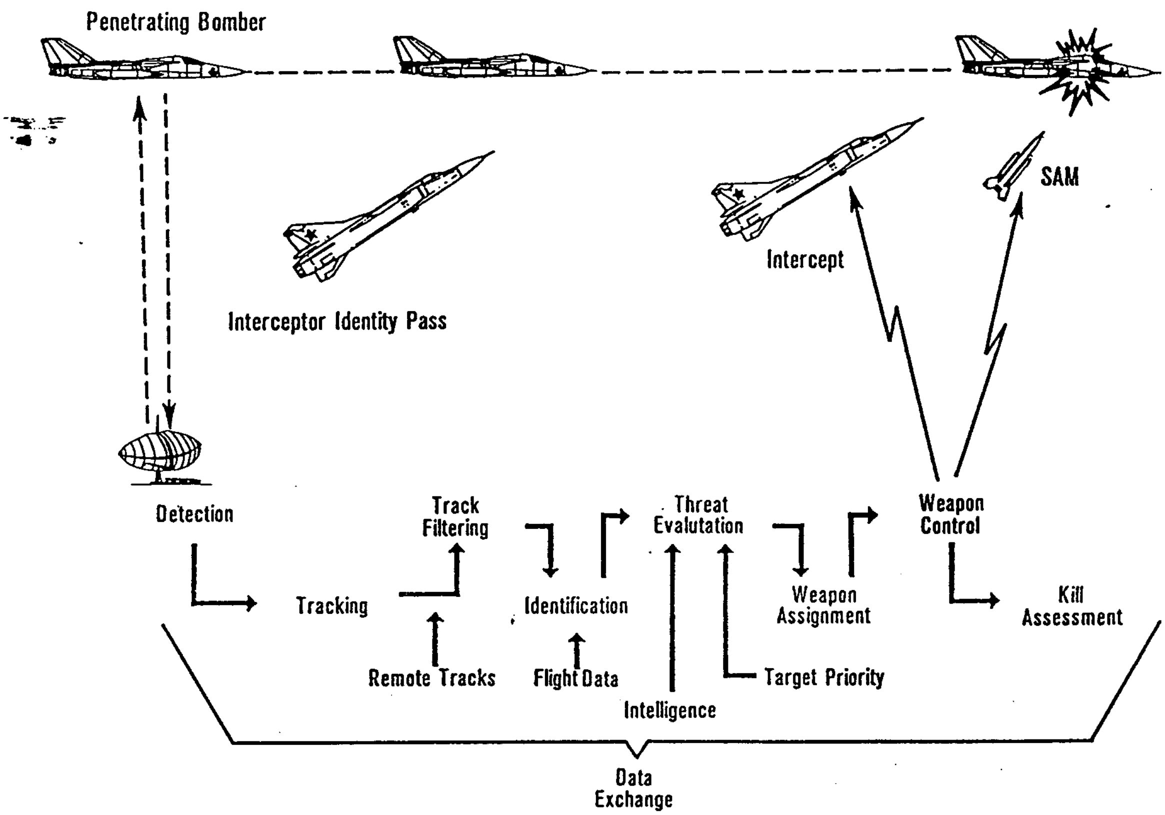
Air Defense Functions

Figure 1



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All of these separate air defense functions must be performed well if the attacking aircraft are to be engaged successfully.

altitude bombers must be an aggregate of judgments of Soviet proficiency in each of the essential air defense functions.

Interceptors

5. Although the flight profile of US bombers striking targets in the Soviet Union would vary, a typical US bomber attempting to strike selected targets in the Soviet Union would probably fly at medium to high altitudes for most of its route prior to entering defended airspace. It would then descend to a low altitude for penetration of defenses. Soviet interceptors would try to engage the bombers both before and after they reached the USSR's borders.

6. Individual interceptors operating against bombers at medium to high altitudes at distances greater than 200 nm beyond the Soviet borders would experience extreme difficulty in finding their targets because of the lack of adequate air surveillance and control in these areas. The Soviets have had airborne early warning aircraft (Moss) with limited medium- to high-altitude control capabilities for more than seven years. Relative to the amount of airspace to be defended, only a small number (nine) of these aircraft have been deployed. The Soviets are improving their capability to control and vector small numbers of interceptors with the Moss aircraft. However, the lack of an adequate airborne warning and control system is still the major factor which denies the Soviets a significant capability to intercept bombers prior to entry into Soviet land-based radar coverage.

7. Over the Soviet landmass, against bombers flying at low altitudes, the capabilities of Soviet interceptors

are very poor. Against high-speed penetrators some Soviet interceptors lack sufficient low-altitude aerodynamic performance. However, the principal deficiency is that the Soviet airborne intercept radars, used for acquiring and tracking targets, function satisfactorily at medium to high altitudes but are unable to find low-altitude targets by "looking down" below the interceptor's altitude.[5]

8. Closely related to the "look-down" problem for Soviet interceptors is the problem of destroying the target once it is located. Soviet interceptors lack a "shoot-down" capability, i.e., the capability of an interceptor at medium to high altitudes to launch an air-to-air missile that can be guided to or home on and destroy a low-flying target. Without such a shoot-down capability PVO Strany interceptors attempting to attack a bomber must fly at an altitude essentially the same as, or slightly below, that of the target.

9. The lack of an adequate means of finding low-altitude targets using equipment on board the interceptor could be offset if a control element could vector the interceptor close enough to a bomber so that the pilot could find the target. This would require highly reliable and continuous tracking of low-altitude penetrators by ground-based or airborne radars, translation of this information into commands, and transmission of these to the interceptor. The Soviets have deployed a large number of air surveillance radars in heavily populated and critical target areas, along major rivers, and in maritime areas. The site spacing of radars in these areas is such that radar coverage could be continuous and frequently redundant. Many of these radars have been equipped with moving target indicators (MTI) to allow them some capability to eliminate or reduce the effects of clutter. Nevertheless, the effectiveness of radar coverage can be degraded severely by terrain masking when aerodynamic targets penetrate at low altitudes and when these targets employ ECM and tactics to avoid detection. In addition, for tracking data to be used effectively for intercepting low-altitude targets, the radars must be netted together by advanced data transmission and processing systems. [ ]

10. For low-altitude tracking and interceptor control Soviet GCI operators rely on their own local radars which are usually limited in range to about 30 miles by line of sight. [ ] both the target and the interceptors are within an individual GCI controller's area of radar coverage for only a few minutes. This requires that control of the intercept be transferred from controller to controller at different radar sites during the course of an engagement. Even with very close coordination between several controllers and pilots, given the speeds of both the bombers and interceptors, the chances are poor that the Soviets could achieve reliable intercepts of bombers at low altitude.

Surface-to-Air Missile Forces

Low-Altitude Capabilities

11. There are four SAM systems in PVO Strany's inventory, designated SA-1, SA-2, SA-3, and SA-5, deployed at some 1,200 sites having about 9,800 launchers (there are about 11,900 missiles on launchers—some launchers accommodate more than one missile). As shown in Figure 2, these SAMs provide good coverage against targets flying at medium and high altitudes.

12. Of these SAM systems, only the SA-2 and SA-3, which are deployed at about 900 sites, are estimated to have some capability (using conventional warheads) against low-altitude targets.[6] Both were designed and tested in the late 1950s and early 1960s and each has subsequently undergone a series of modifications which appear to have improved low-altitude performance.

13. The SA-2 is primarily a medium- to high-altitude defense system. Its present minimum engagement altitude is 500 to 1,000 feet. With optical modifications that may now exist, and under optimum conditions, the SA-2 could engage targets flying as low as about 300 feet. Successful intercepts in the low-altitude regime would require near-ideal engagement conditions and ranges would be very limited.

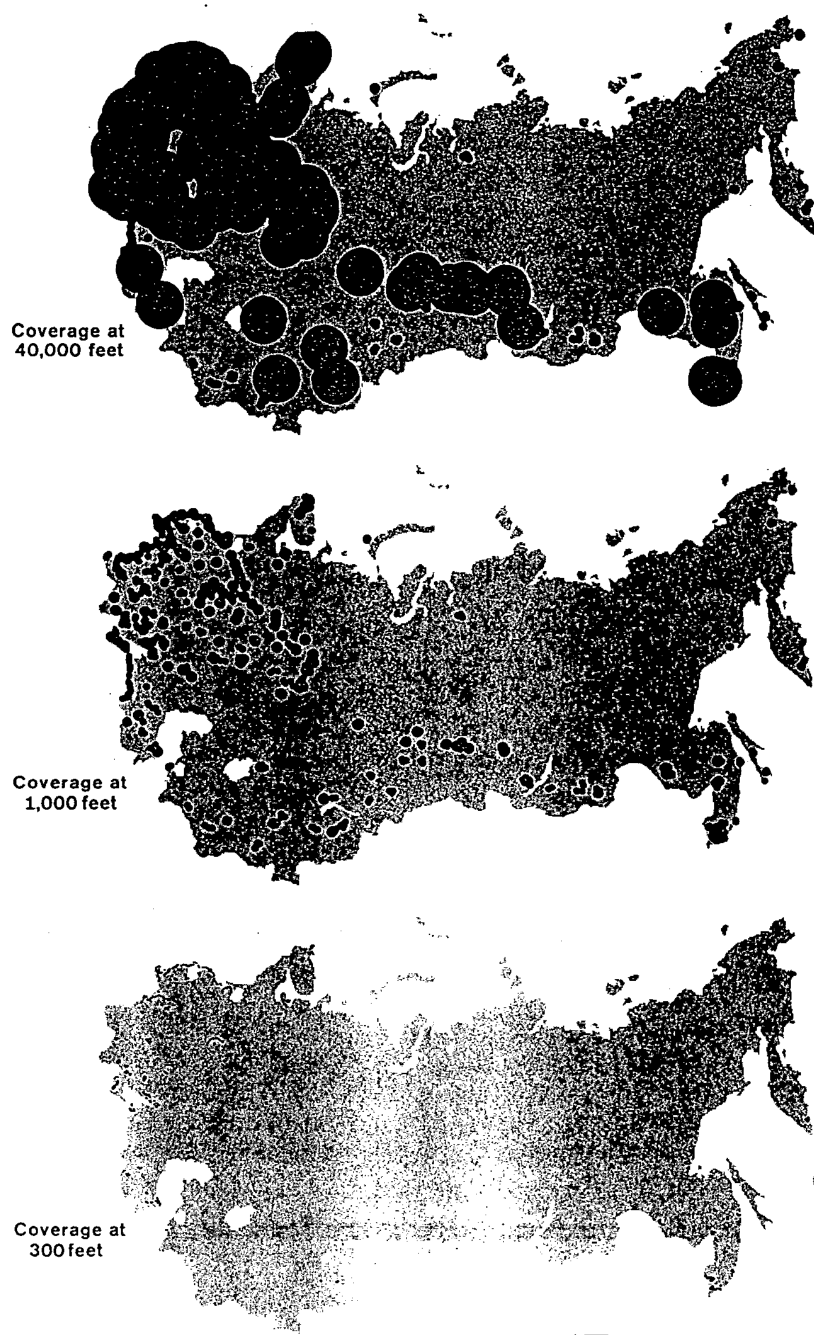
14. The SA-3, on the other hand, was designed to engage low-altitude aircraft. [ ] support es-

[5] The Flogger, currently deployed with Frontal Aviation, has demonstrated a limited capability to detect, track, and engage targets below its altitude. The capability of Flogger and its potential role in PVO Strany are discussed later in this report.

[6] The 56 SA-1 sites are all located around Moscow. Their lowest engagement altitude is currently estimated to be a few thousand feet. There are 112 operational SA-5 complexes; their low-altitude capability is about 1,000 feet using conventional warheads.

Current SAM Coverage of the USSR

Figure 2



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SAM coverage is good against aircraft flying at medium and high altitudes, but very limited against low-altitude penetrators.

timates that the low-altitude capability of the SA-3 has been improved from 300 feet to about 150 feet at 3 nm from the site under optimum conditions. These conditions include a non-maneuvering target, no ECM, no terrain masking, and adequate target acquisition data. At the maximum range of 12 nm, minimum engagement altitude is about 1,500 feet. A TV camera has been added to the SA-3 radar which aids the system in low-altitude tracking and also serves as an electronic counter-countermeasures (ECCM) aid.

15. There are two very significant features of the SA-2 and SA-3 systems that pertain to the overall problem of a large-scale bomber penetration of the Soviet Union:

—Deployed units with only a few exceptions stay at fixed sites, the locations of which are well known to US intelligence.

—Both systems have short low-altitude engagement ranges.

Taken together, these two facts permit the use of stand-off attack weapons, suppression, and avoidance tactics. Therefore, it is likely that only a small percentage of those SAMs used for barrier or area defenses would be able to engage penetrating bombers. Soviet SAMs would potentially be most effective when used for point defenses.

Nuclear Warheads for SAMS

16. There is evidence that nuclear warheads are available to a significant portion of the SA-1 and SA-2 sites, and to some SA-5 complexes. [ ] against low-altitude aircraft [ ] nuclear warheads must be considered a possibility [ ] despite the collateral damage that could occur. The increased lethal radius of a nuclear warhead could compensate for the potential fuzing problems of the SA-5 and the large miss distances inherent in SA-2 operation at low altitudes, thus increasing effective range. The use of nuclear warheads, however, would not alone negate the potential effectiveness of US forces as the fixed sites are still vulnerable to the tactics of avoidance, degradation, and destruction.

Defense Against the Short-Range Attack Missile

17. Most US strategic bombers are or will be equipped with the SRAM, which has these important features:

—It is a small high-speed missile which is extremely difficult for Soviet SAM systems to detect, track, or engage. These factors make the SRAM a weapon against which the Soviets have no defense after it has been launched from a bomber.

—Its maximum range on either a semiballistic or a low-altitude flight profile allows a low-altitude SRAM carrier to stay outside the effective kill envelope of any Soviet SAM site while launching its missile.

Because of its range advantage over Soviet SAMs at low altitude, the SRAM can be used to attack targets before the bomber can be engaged by a SAM. Additionally, when SAM avoidance may not be practical, the SRAM can be targeted against SAM defenses.

Effectiveness Against Electronic Countermeasures

18. US aircraft are equipped with a variety of systems to degrade the capabilities of Soviet radars and weapons. The Soviets regard this "electronic warfare" equipment, which includes ECM, as a definite threat to their ability to conduct air defense. In response to this threat they have developed ECCM.

19. In general, the potential effects of electronic warfare are exceedingly difficult to ascertain. Among other factors, they depend on the characteristics of both offensive and defensive equipments and many features of Soviet radars and weapons are not known. Compounding this uncertainty is the fact that ECM effectiveness is scenario-dependent. For example, it will vary with the relative difference in power output and the range between ECM emitters and victim radars. Additionally, the number of emitters, the numbers and types of radars being countered, bomber altitude, whether and how decoys are used, the manner in which ECM is used, and other important variables are all factors which must be considered in assessing ECM effectiveness. For all of these reasons, the analysis of electronic warfare interactions has not been attempted in this study.

20.

it is highly probable that US penetration aids, including ECM, will present a problem to the Soviet defenses.

Summary of PVO Strany's Capabilities

21. A summary of the preceding assessments of PVO Strany's current capabilities against low-altitude bomber attack is given in Table II.

C. Air Defenses of Other Soviet Services

22. In addition to PVO Strany, the Soviets also maintain other air defense elements within the USSR. These are the so-called "tactical" forces which are organic to the Ground Forces and Frontal Aviation. Generally, they are the best-equipped forces for low-altitude air defense in the Soviet Union today. Moreover, as shown in Table III, in terms of sheer numbers they are of comparable size to PVO Strany and could be the source of a significant number of additional resources for air defense against low-altitude bombers.

23. These forces maintain a close liaison with PVO Strany and are capable of providing needed support in several critical defensive operations. The Ground Forces' SAMs and AAA are characterized by their mobility which could be employed in a variety of useful ways to supplement PVO Strany's fixed SAM sites. Tactical SAMs and AAA could be used to fill in gaps in PVO Strany SAM coverage and supplement defenses near important point targets. The mobile SAMs and AAA could make it more difficult for US aircraft to employ the tactics of avoidance and destruction.

Similarly, Frontal Aviation's fighters could supplement PVO Strany's interceptor force, could provide replacement units for PVO Strany losses, and could provide alternate bases for PVO Strany interceptor operations. Using these forces, the overall air defense system would be more effective than that of PVO Strany alone.

24. The Soviets are strong advocates of electronic warfare as indicated by the amount of ECM and electronic warfare support measures (ESM) equipment deployed with both airborne and ground-based units of the Soviet Air Forces and Ground Forces. Those systems which could have a direct impact on penetrating aircraft are organic to the Ground Forces. Some Soviet electronic warfare equipment is designed to degrade the ability of these aircraft to attack their targets. This degradation would be attempted by electronically jamming the aircraft's bombing/navigation radar.

25. Exact numbers, deployment, and subordination of these ground-based electronic warfare assets cannot be accurately determined; however, Cheese Brick, Tub Brick, Mound Brick, King Pin, and the ECM-associated trailer radar jammers confirmed within the USSR Many of these are now located near strategically important targets such as centers of industry, major military facilities, and command centers. Almost all of the equipment is located in Ground Forces garrisons. Depending upon wartime scenarios, many of these ground army units would probably move to support theater operations along the periphery and outside the Soviet borders, while other units might remain in place or deploy within the USSR to support strategic defense of key areas. If deployed for strategic defense, the potential effectiveness of this equipment would depend upon location, terrain, Soviet command and control procedures, and bomber equipment and tactics.

26. The most important factor, however, concerning the utility of tactical air defense forces for defense of the Soviet homeland is their availability. This would depend on their location, the priority of theater operations, their organization and means of control, and the sequence and timing of events preceding a bomber attack on the USSR. All of these factors are interrelated and would critically affect the type and degree of support the tactical forces could provide to PVO Strany. The availability of tactical air defenses has been examined under four possible situations. (It is also possible that some PVO Strany assets could be used for theater air defense missions.) These are dis-

TABLE II

ASSESSMENT OF PVO STRANY'S CURRENT LOW-ALTITUDE CAPABILITIES

PVO Strany Weapon	Geographical Area Defended	Capability vs. US Bombers	Capability vs. SRAM	Principal Deficiencies
Interceptors	Beyond land-based radar coverage	Very poor	Not applicable	Some interceptors have sufficient range but the force lacks an adequate vectoring/interceptor-control capability.
Interceptors	Low-altitude Soviet airspace	Poor	None	Lack of effective "look-down" radar. Lack of "shoot-down" armament. Inadequate ground control.
Surface-to-Air Missiles	Low-altitude Soviet airspace	Limited	None	Short engagement range and generally poor performance at low altitude. Site locations are fixed. SAMs can be avoided and are vulnerable to SRAM.

Note: These assessments do not take into account any degradation of Soviet defenses from ICBM or SLBM attacks or the effects of US bomber penetration aids.

TABLE III

LOW-ALTITUDE AIR DEFENSES IN THE USSR

	PVO Strany	Ground Forces [1]	Frontal Aviation [1]
Interceptors	2,600	N.A.	1,500
Low-Altitude SAMs	576 SA-2 battalions [2] 330 SA-3 battalions [2]	12 SA-2 battalions (not deployed) 252 SA-4 batteries [3] 75 SA-6 batteries [3] 20 SA-8 batteries [3] [4] 400 SA-9 vehicles	N.A.
Antiaircraft Artillery	Negligible	Large number [3]	N.A.
Ground-based Electronic Jammers [5]	Some	Large number [3]	N.A.

[1] Availability contingent upon general purpose force requirements in theater operations.
[2] All SA-2 and SA-3 battalions are in fixed locations but can move to alternate sites.

[4] Deployment just beginning.
[5] Ground-based ECM is deployed with army air defenses

[redacted]

cussed in descending order of likelihood,

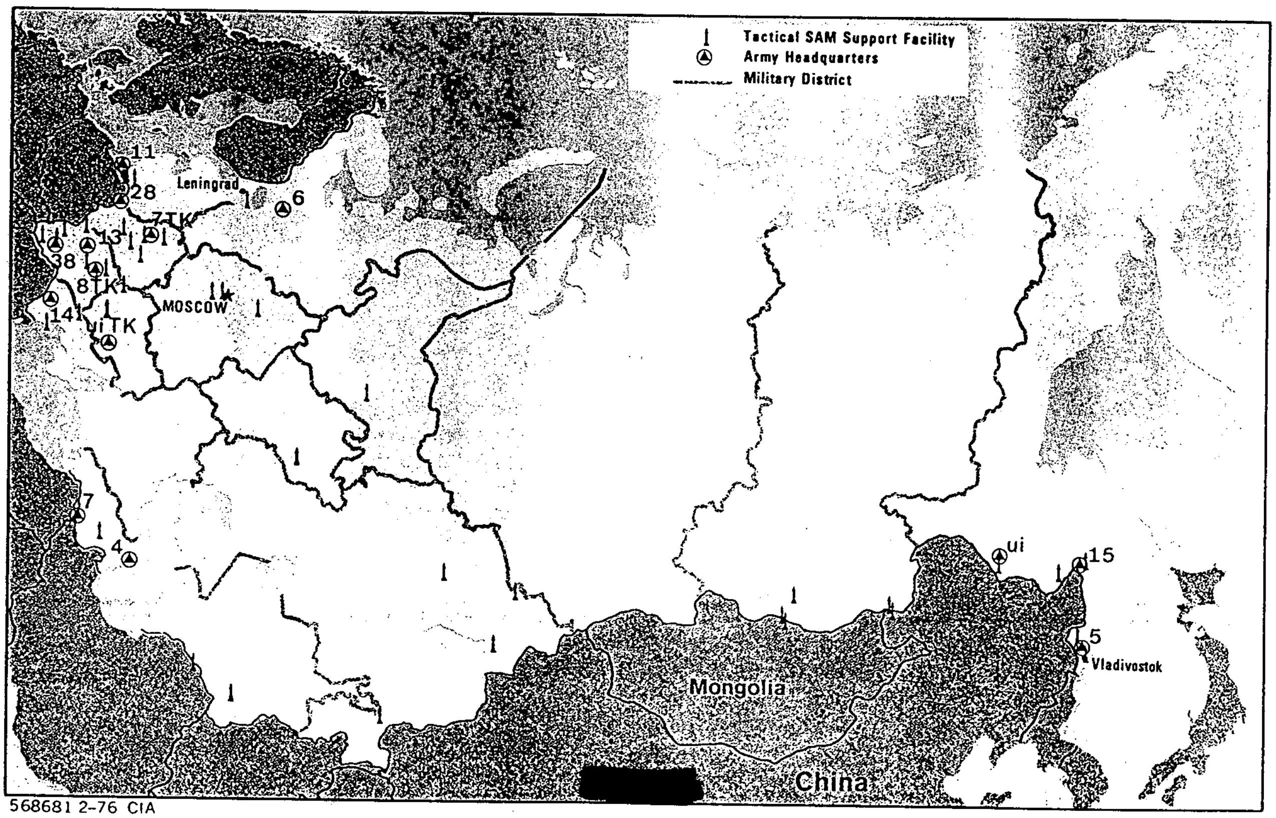
27. *Example 1—Non-Nuclear War in Europe Preceding a Bomber Attack on the USSR.* If war began with a non-nuclear conflict in Europe, large numbers of Soviet Ground Forces and Frontal Aviation elements could be moved into this theater in support of Warsaw Pact operations. At present, Soviet tactical forces are ideally situated for such a contingency. Also, most of their exercises and training are in preparation for combined arms warfare in Central Europe. Under these circumstances, it is possible that only a fraction of the tactical air defenses in the western USSR would remain in the Soviet Union, and consequently, relatively little support would be available to PVO Strany.

28. *Example 2—War Begins with a Strategic Nuclear Attack.* In this case the Ground Forces could be in essentially their present positions during a strategic bomber attack. They could provide only a point or limited area defense from their present deployment locations. Figure 3 indicates the present locations of Soviet Ground Forces. Some, such as those along the Soviet-Chinese border and in areas east of the Ural mountains, are not positioned for defense of critical strategic targets. Relatively few are very close to principal Soviet cities such as Moscow and Leningrad. Others, however, are in place for limited defense of important military and industrial targets along the western and southwestern borders of the USSR.

29. Frontal Aviation's fighters are positioned to provide support to the Ground Forces. The inherent mobility of these fighters, however, would permit considerable support to PVO Strany. At present, this support would probably have little effect on the outcome of the air battle because most current Frontal Aviation fighters are no better than PVO Strany's against low-

Location of Soviet Ground Forces

Figure 3



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Some Soviet Ground Forces are in place for limited defense of important military and industrial targets, but relatively few are very close to principal cities.

altitude bombers. At some future time when Frontal Aviation fighters do achieve an improved low-altitude engagement capability, Frontal Aviation support could be very important.

30. *Example 3—War Begins with Strategic Nuclear Attacks and the Soviets Optimize Their Strategic Defense for a Short Period.* If the Soviets were convinced that the US intended to launch a nuclear attack on the USSR, including a large bomber attack, they could resubordinate and redeploy some of their tactical air defense forces to positions more advantageous for support to PVO Strany. Even such a temporary readjustment would involve a variety of complex command, control, and coordination problems and related decisions which could be difficult for the Soviets.

31. In peacetime, tactical forces in the USSR are normally controlled by commanders of the military districts. In preparation for war, however, both ground and air elements would be assigned to fronts which would be controlled by the general staff. As a result, in the situation described in this example the use of tactical air defense assets for strategic defense would have to be done under the aegis of the general staff. The use of tactical air defense forces in this situation is probably the subject of contingency planning on both the general staff and PVO Strany levels.

32. The operational and technical problems could be solved in a number of ways. Resubordination of tactical air defense forces probably would be accomplished through some form of operational control which would allow PVO Strany to direct the tactical units without assuming administrative and logistic responsibilities. This would permit the return of the tactical units to their parent organizations with a minimum of difficulty. Technical problems might be more difficult to solve. Tactical unit command posts would have to be integrated into the PVO Strany command, control, and communications network. While we do not know precisely how tactical units would be integrated, we believe it can be accomplished.

33. *Example 4—The Soviets Maximize Their Preparations for a Strategic Nuclear Attack.* In this case the Soviets would place highest priority on the strategic air defense of the Soviet Union, and would make extensive long-term redeployments of their tactical air defense forces. [ ] It is believed to be an unlikely option. However, if it existed, it is likely that a major part of the tactical forces would be redeployed away from their current positions prior to the outbreak of hostilities.

II. LOW-ALTITUDE AIR DEFENSE: PROBLEMS, SOLUTIONS, AND SOVIET PROGRAMS

34. As noted previously, the present Soviet strategic air defenses have a number of weaknesses against low-altitude penetrators. Most of them stem from technological limitations of air defense equipment. This section reviews these technical deficiencies and their impact on air defense capabilities and describes technically achievable options to overcome them. Also identified are those options for which the Soviets have programs under way. Finally, several potential developments are discussed which appear to be highly desirable, but for which there is no evidence of Soviet activity.

A. Radars

Technical Problems and Solutions

35. Effective radars are vital to the success of air defenses because they are the prime sensors for detecting and tracking enemy aircraft. Most deployed radars can perform this function if the target aircraft are flying at medium or high altitudes; however, when the aircraft are at low altitudes, radar performance is severely degraded.

36. There are two technical reasons why it is difficult for radars to detect and track low-flying aircraft. The first is that radar beams travel essentially in straight lines so that the range at which a radar can detect a target is limited by the earth's curvature; this is the line-of-sight limitation. The second limitation is due to unwanted radar beam reflections from the earth's surface and various terrain features; these are commonly called "clutter" and "multipath" effects.

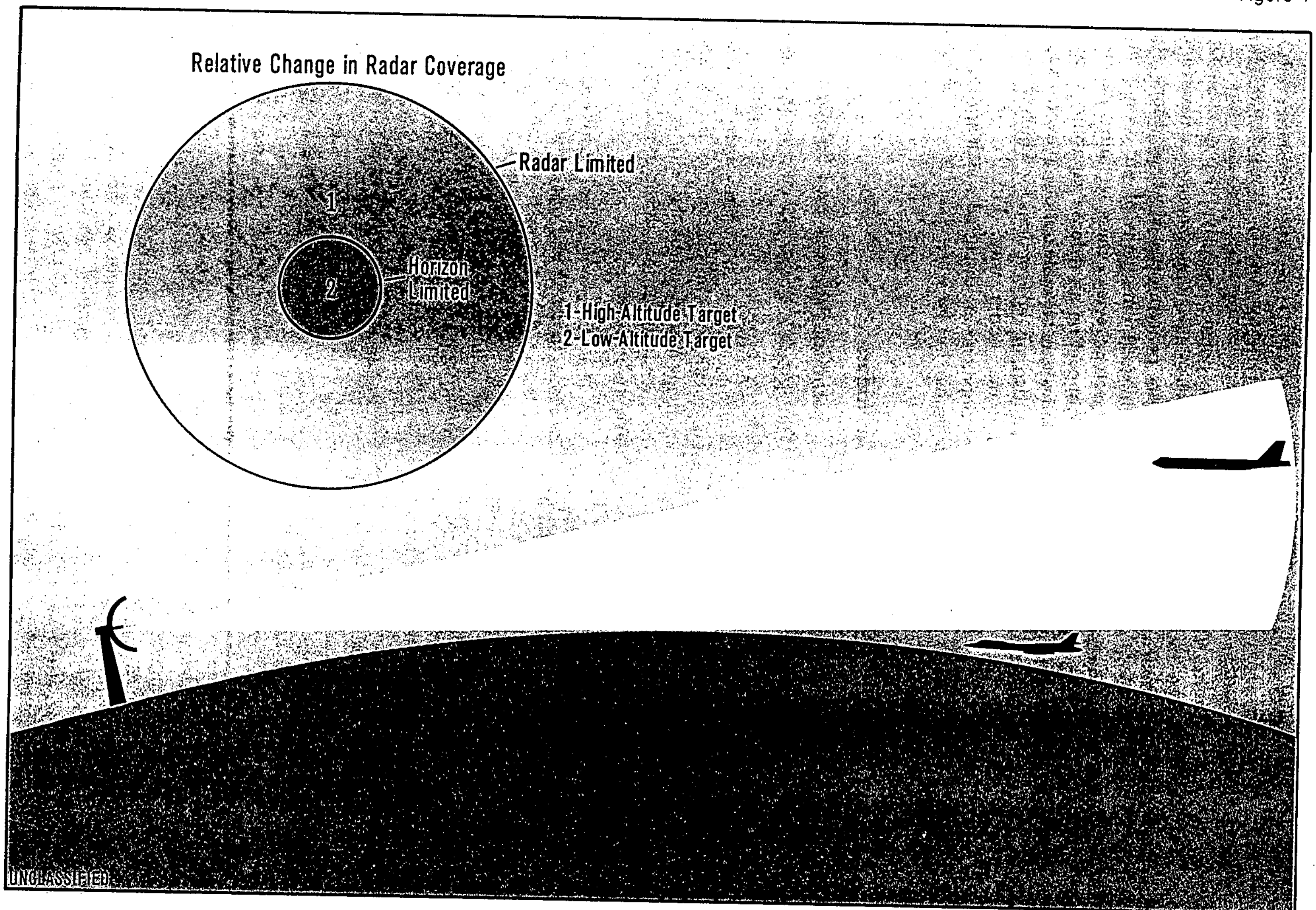
37. For ground-based radars these effects combine to limit the distance at which an aircraft flying at low altitude can be detected and tracked. Even for advanced radars, line of sight limits low-altitude target detection to 20 to 40 nautical miles from the radar site. Figure 4 illustrates the effect of the shrinking radar coverage for different target altitudes.

38. Although less affected by line-of-sight limitations, current Soviet airborne radars become severely degraded by clutter in attempts to "look down" at aircraft targets. Typical search volumes for two types of airborne radars—air surveillance and fire control—are illustrated in Figure 5.

[redacted]

Reduction of Radar Coverage for Low-Altitude Targets

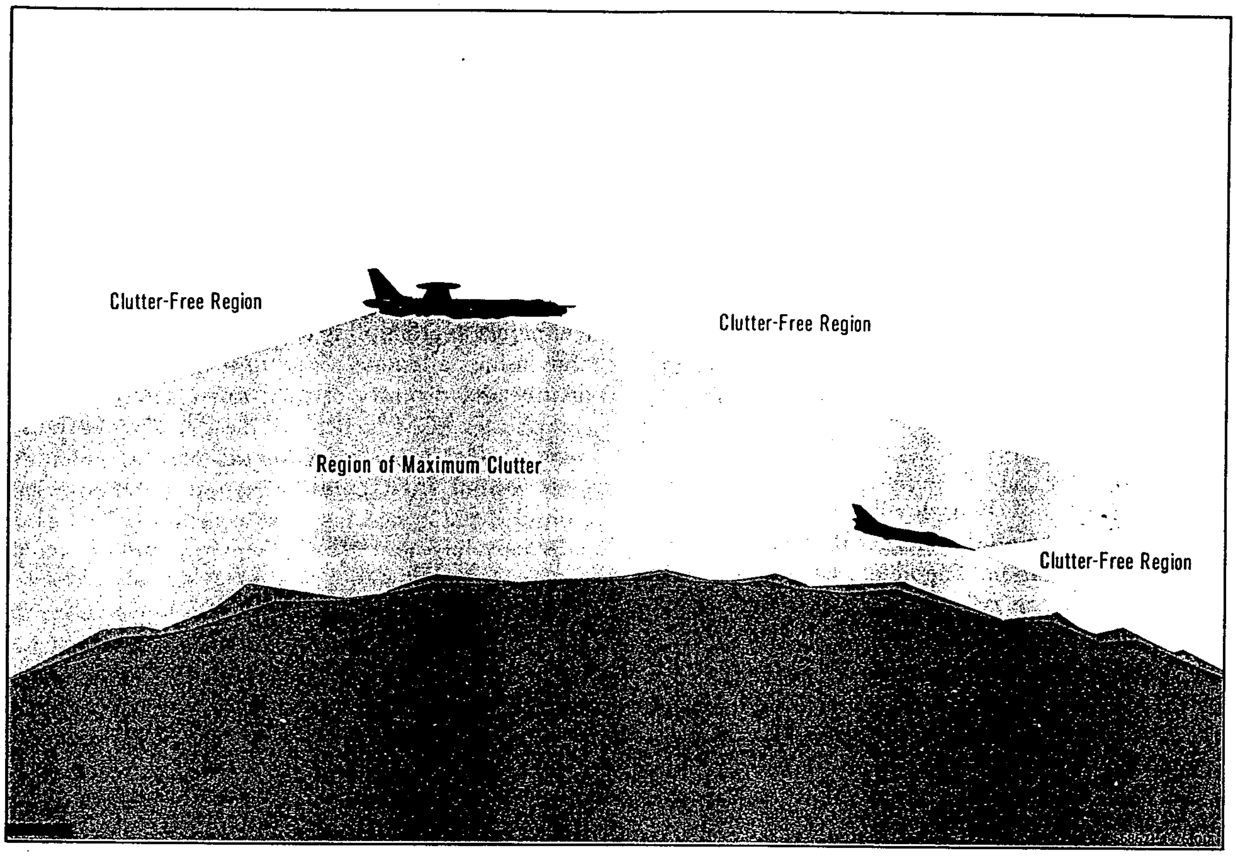
Figure 4



The curvature of the earth limits the detection range of a radar against low-altitude targets.

Search Capabilities of Airborne Radars

Figure 5



Current Soviet airborne radars become severely degraded by clutter—unwanted radar beam reflections from the earth's surface. The differences in clutter-free search regions for airborne air surveillance radars and interceptor fire-control radars are illustrated.

39. The technical problem of reducing clutter can be solved in a variety of ways. The most effective ways are associated with advanced radar technology and take advantage of the target aircraft's relative motion. Clutter reduction methods are well known to the Soviets. They possess the theoretical background to attack these problems, and have demonstrated, for many years, capabilities for engineering and production of such devices for ground-based radars. However, the problem of developing airborne radars for this purpose is compounded by size and weight constraints. Advanced electronic microcircuitry is required in order to process radar data for maximum clutter reduction on-board an aircraft platform for all-aspect target detection. Production of this microcircuitry may be the dominant factor which has precluded the Soviets' deployment of advanced airborne radars.

40. Finally, Soviet radar designers must concern themselves with the problem of overcoming the ECM employed by the penetrating bomber force. By virtue of their experiences in Vietnam, in the Middle East, and they are acutely aware of the degree to which air defense effectiveness can be degraded by offensive ECM.

Soviet Programs

41. Over the years, the Soviets have made many improvements in their deployed ground-based radars, some of which could result in better performance against low-altitude targets. They are also continuing research and development for radar improvements.

42. The only Soviet airborne radar which has demonstrated any look-down capability is that currently mounted on the Flogger B aircraft deployed with Frontal Aviation.

suggest only very short ranges, limited look-down angles, and small altitude separations as shown in Figure 6.

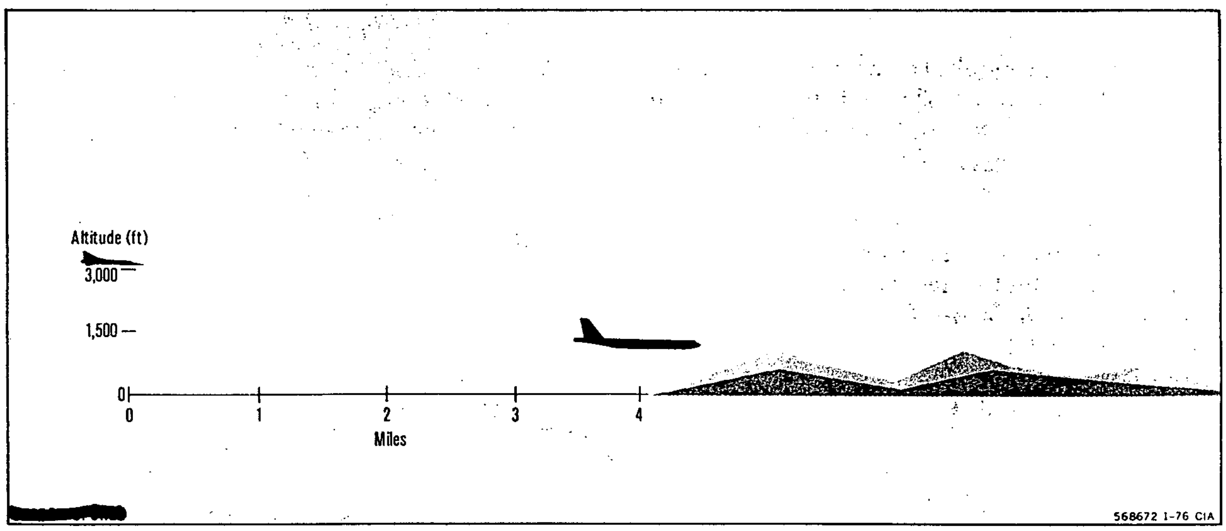
43. The Soviet state-of-the-art in look-down radar technology reflected by the capabilities of the Flogger's radar is less than that required for an advanced interceptor or AWACS with an overland look-down capability. Whether the Flogger radar uses digital processing techniques cannot be determined

44. The Soviets' ECCM capabilities have steadily grown over the years.

The density and diversity of their radar deployment also complicates ECM tactics and design.

45. Modern Soviet radars are likely to have more sophisticated ECCM features than did their predecessors.

Look-Down Range/Engagement Geometry of Flogger Figure 6



[redacted]

The Flogger B, currently deployed with Frontal Aviation, has demonstrated a limited capability to detect, track, and engage targets below its altitude. The maximum observed range at low altitude has been about 4 nm (see paragraphs 91-92).

47. The Soviets are also likely to have uncertainties about the effectiveness of their ECCM. The increased speeds of US penetrators, the use of decoys, and the use of weapons with low radar cross sections place greater demands on an air defense surveillance and tracking system and increase the advantage to the attacker from even modest, short-duration degradations of the air defenses. The Soviets also are likely to be uncertain as to whether or not they have identified all forms of US ECM. Thus, even if the Soviets maximize their efforts to reduce the vulnerability of their air defenses, they almost certainly would not be highly confident about how well the system would operate in an ECM environment. Nonetheless, Soviet radar operators are trained in an ECM environment to increase their proficiency under combat conditions.

B. Air Surveillance

Technical Problems and Solutions

48. Air surveillance combines the functions of detecting and tracking aircraft, processing radar data, and disseminating it to many users in order that they may achieve a clear picture of the position, direction of flight, and identity of all aircraft. Radar coverage over large areas can be achieved by using relatively small numbers of airborne radars or large numbers of ground-based radars, or both. Each of these two means has its own advantages as indicated in Table IV.

49. If airborne surveillance radars are to be employed, the primary problem is development of the radar itself: it must be capable of reducing or eliminating clutter effects in order to detect and track target aircraft below the radar. To date, the Soviets do not possess such a radar. If developed and deployed, a highly capable airborne radar which is vital to the air defense system would be a high-priority target for offensive penetrators.

50. Conventional radars operate on a line of sight, and are thus limited in their reach by the curvature of the earth. One technique to increase the warning time is to use an over-the-horizon detection (OHD) radar

TABLE IV

LOW-ALTITUDE AIR SURVEILLANCE OPTIONS

	Advantages
Airborne radar	Operational flexibility. Few aircraft required for large area coverage. Extends coverage beyond borders. Properly equipped can track low-altitude aircraft for relatively long periods. Survivability and quick replacement available for losses.
Ground-based radar	Easily camouflaged and can be hardened. Can use multiple means of communication (more easily netted, non-jammable land lines, redundant). Makes jamming tasks difficult through deploying multiple radar types. Can use large computers. Does not require radar advances to the degree needed by airborne look-down systems. Is not limited in terms of power availability.

[redacted]

which transmits in the same frequency range as short-wave radio broadcasts, using the ionosphere as a reflecting surface. These OHD radars have a potential to be used for aircraft detection. For example, the radar under construction at Kiev could significantly improve the Soviet ability to detect aircraft approaching from the Norwegian Sea at altitudes close to the ocean's surface. Aircraft could be detected at ranges of from 250 to 500 nm out to 1,300 to 1,900 nm. Warning time against aircraft could be extended from a few minutes to as much as several hours and with this earlier detection more efficient use could be made of airborne warning and control aircraft and long-range interceptors, if the radar is not disabled by an earlier attack. Though another OHD radar being built at Komsomol'sk would complement existing systems, it would provide no substantial advantage over existing systems in an aircraft detection role.

51. Broad area radar coverage of low-altitude targets also can be achieved by using ground-based radars. In this method, large numbers must be deployed because of the relatively short range at which low-altitude aircraft can be detected and tracked from any single radar site. Using many radars reduces the effects of loss of individual radars due to offensive ECM or physical destruction. This approach has been, and still is, pursued by the Soviets, as evidenced by the very large numbers of ground-based radars which are deployed.

52. There are technical difficulties in effectively utilizing the many inputs from such an array of ground-based radars. Track data from each radar must be collected and collated quickly and accurately in order to achieve a continuous, clear, composite picture of all aircraft in the area under surveillance. The problem of collecting, processing, and disseminating these data from a network of radars to command echelons and weapons units in a timely fashion can only be solved by a complex of computers and associated communications equipment.

Soviet Programs

53. For years the Soviets have used a manual system and [redacted] semiautomatic system for processing and disseminating radar data, and they have recently begun to deploy improved systems. [redacted]

54. An important measure of performance of these systems is the timeliness and accuracy of the air situation data that is disseminated to weapons units and command echelons. This, in turn, depends on many factors such as: the radars used and the ranges involved, the means of entering radar data into the

[redacted]

system, the equipment and techniques used for filtering and combining track data at intermediate echelons, the routing of data between nodes in the system, and the means for using track data by weapons units and command echelons. In general, the impact of these factors on timeliness and accuracy is a function of the degree of automation in the system.

55. The trend toward improving air surveillance performance

C. Surface-to-Air Missiles

Technical Problems and Solutions

58. The effect which ultimately limits the low-altitude effectiveness of SAM weapons is the relatively short range of the radars owing to line-of-site limitations. This seriously limits the time available for

the system to engage a target. In addition, the SAM systems must also overcome the degrading effects which clutter, multipath returns, and ECM have on tracking, guidance, and fuzing.

59. Since the late 1960s the Soviets have taken steps to alleviate the problem of short engagement time by introducing new radar nettings and data systems in support of SAMs.[8] Most of PVO Strany's SAMs around the USSR's periphery and in heavily defended regions now use these data systems. [redacted] indicate that the data flow in such arrangements can improve low-altitude tracking and increase the time available to a SAM site for engaging a low-altitude target.

60. Offensive jamming of various components of a SAM system can degrade its effectiveness if steps are not taken to counter the jamming. In command-guided missile systems such as the SA-2 and SA-3, [redacted] there is considerable uncertainty as to jamming effectiveness against these radars. A fuller discussion of the escalation of ECM and ECCM in SAM systems is contained in paragraphs 81-85.

61. Clutter and multipath effects can make accurate tracking and missile guidance at low altitudes difficult. This is particularly true in command-guided missile systems such as the SA-2 and the SA-3. Moving target indicator systems are used in the versions of both of these systems deployed in the Soviet Union. A moving target indicator helps to make a target more visible against a background of radar reflections from ground clutter.

62. Multipath effects are more difficult to deal with. They are produced by interference between radar signals reflected directly from a target and those from the target reflected from the ground. They cause an "image" of the target signal to appear below the elevation of the real target, distorting the real target signal. Constructive and destructive radio frequency interference between the direct and reflected signals result in the introduction of angular tracking errors into the radar's elevation tracking circuits. These tracking errors can produce large missile guidance errors and, ultimately, large miss distances.

63. Fuzing can also be a problem in these systems at low altitudes. If proximity type fuzes are used and if miss distances are large at low altitudes, fuzing ranges must be large and there is a danger that the fuze will function on ground reflections—detonating the warhead prematurely. This can be overcome through the use of warheads with greater radius of effect, command detonation, or special low-altitude proximity fuzes.

64. There are good indications that the SA-3 system was designed from the outset to compensate for problems with clutter, multipath, and fuzing. [redacted] Despite its low-altitude features, the intercept range of the SA-3 system at low altitudes is short and its performance can be severely degraded in poor low-altitude tracking conditions.

65. The SA-2 system, on the other hand, was not initially designed to cope with low-altitude targets. This capability has been added in newer models of the system. Newest versions have a moving target indicator system. However, it is unlikely that effective radar modifications to cope with multipath errors have been added.

66. In an export version of the SA-2, a binocular optical tracking system has been added. A new missile.

[8] For detailed treatments of this topic, see "Soviet SAM Data Systems," (CIA) [redacted] or "Sensitivity of the Effectiveness of Soviet Air Defense to Variations in Command and Control," (DIA) [redacted] These documents do not necessarily represent the views of all agencies participating in preparation of this IIM and are for reference only.

[redacted]

used with the system has a warhead whose fragment spray pattern is less directional than the warhead used on earlier models. To prevent fuze prefunction on ground reflections, command detonation is used. The less directional warhead helps to compensate for inaccuracies inherent in such command detonation. Using these methods, this version of the system has some effectiveness as low as 300 feet.

67. We do not understand the versions of the SA-2 deployed in the Soviet Union as well as we understand the export model. Unconfirmed reports in the past have suggested a lower altitude limit of roughly 500 to 1,000 feet for the type of systems deployed in the Soviet Union. There are indications that field modifications to systems deployed in the USSR were made in the late 1960s and early 1970s to improve performance at low altitudes. Subsequently, there

have been references to an altitude limit as low as 300 feet. We are not certain what the modifications involved, but they were stated to be improvements based on experience against low-flying targets in Vietnam. This was the same terminology used when modifications involving the installation of optical tracking devices were performed on the export version. In addition, photography of Soviet SA-2 sites in East Germany has revealed possible devices for training of optical tracking operators. Thus, although we are not able to confirm the use of optical tracking devices on similar SA-2s in the USSR, this is a good possibility.

68. At low altitudes, the SA-2 and SA-3 systems have very short effective ranges and will suffer performance degradation.

69. Some options available to the Soviets for employment of SAMs for improved low-altitude air defense against the bomber are described in Table VII. These are discussed in detail starting with paragraph 70.

TABLE VII

SAM IMPROVEMENT OPTIONS FOR LOW-ALTITUDE AIR DEFENSE

Option 1—Compensate for the range inadequacies of individual SAMs by deploying vastly increased numbers of SAM sites.

Option 2—Provide nuclear warheads for large numbers of SAM sites.

Option 3—Deploy existing mobile SAMs with PVO Strany.

Option 4—Retain SAMs to cover medium- and high-altitude penetrations, but abandon low-altitude SAM defense. Rely in the future on advanced interceptor aircraft and improved air surveillance to engage aircraft at low altitudes.

Option 5—Develop new SAM systems which have a longer range at low altitudes.

Option 6—Develop an improved SAM similar to that discussed in Option 5 with the additional requirement that it be mobile.

Option 7—Develop a SAM system capable of successful low-altitude engagements against the SRAM. This would of necessity be an advanced technology system.

Soviet Programs

70. There is no evidence that the Soviets plan to deploy vastly increased numbers of SAMs and SAM sites as postulated in Option 1 to compensate for the deficiencies in their operational systems. The Soviets probably see the problem as described in this paper, namely, one of overcoming technical limitations.

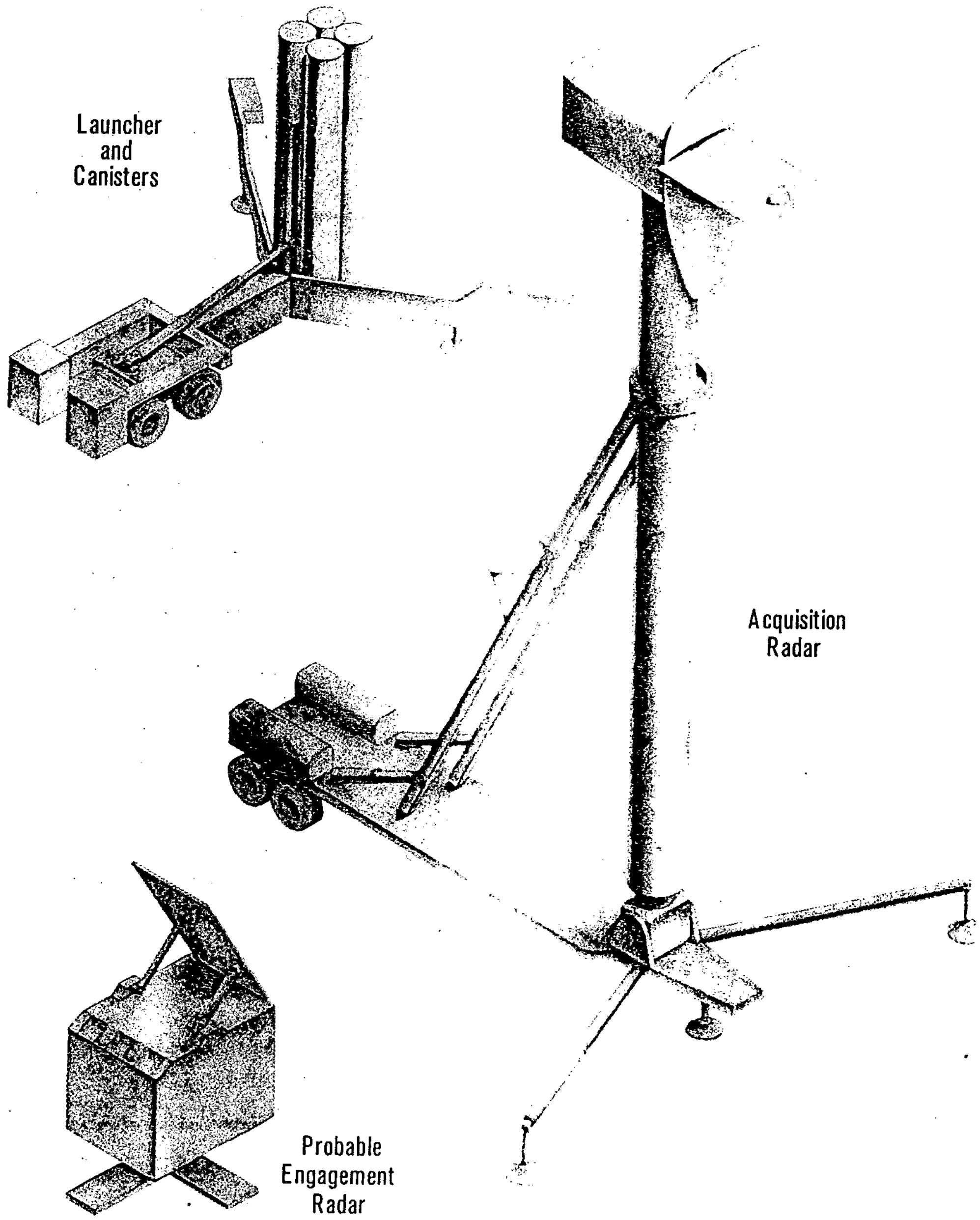
71. While there are some uncertainties about the extent of Soviet preparations, they probably plan to use nuclear warheads on some SAM systems. The effective engagement range could be increased by relaxed requirements in missile guidance tracking accuracy. Use of large numbers of nuclear-equipped SAMs would require fewer additional SAM deployments than under Option 1. We do not know whether the Soviets plan to use nuclear SAMs for low-altitude defense—as suggested by Option 2—but their use must be considered a possibility. The limited evidence is against bomber formations at higher altitudes. We believe that nuclear SAMs would give the Soviets an improved capability at low altitudes, but they would still be vulnerable to avoidance or suppression.

72. Option 3 could be implemented either by deploying mobile-SAM equipped Ground Force units in support of PVO Strany or by PVO Strany procurement of existing mobile systems. As noted earlier, the use of mobile SAMs of tactical forces to augment PVO Strany has some serious drawbacks (see paragraphs 30-32), and the Soviets probably do not foresee tactical air defenses as a major element in a successful low-altitude defense of the Soviet homeland. Nevertheless, PVO Strany could exploit the transportability of the SA-2 and the SA-3 by planning to operate them from alternate sites during a conflict, although their locations, too, are all well known. The SA-2 and SA-3 systems could be operated from unprepared sites, but this option is more difficult In any case, Soviet procurement of mobile SAMs for PVO Strany is a possibility, but we have no evidence to support this.

73. There are good indications that the Soviets have not given up on SAMs (as suggested by Option 4) for use against low-altitude penetrators. They have continually made qualitative improvements in their operational systems and have a new strategic SAM system under development.

74. As shown in Figure 8, the first new strategic SAM system since the SA-5 is under development at Launch Complex G of the Sary Shagan Missile Test Center. This site has elements which would be expected in a new low-altitude SAM system. The components observed are new and all, including a tower-mounted radar, are transportable. Hence, the system may be compatible with Options 5 and 6. Although there is some uncertainty about the degree of mobility, it is probably between that of the SA-2/SA-3 and the SA-6.

New Strategic SAM System, Complex G, Sary Shagan Missile Test Center Figure 8



[redacted]

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[redacted]

Components and missile flight tests have been observed, but it is too early for a confident assessment of the system's operational configuration and mission.

[redacted]

79. Although it is clear that a new SAM system is under development at Launch Complex G, it is too early to identify confidently its operational configuration and mission; consequently we cannot yet assess its performance. Flight testing of a missile associated with the Complex G system has been detected If the system development follows a timetable similar to other Soviet SAMs, initial operational capability could be reached before 1980.

80. The Soviets could attempt to develop a system for defense against the SRAM but we do not believe they will succeed in achieving an effective defense within the next 10 years. The development of Complex G conceivably includes such an effort, but we have no proof of this. Modifications to current systems do not appear to be for this purpose, and such modifications would be so extensive that they may not be practical. The possible anti-tactical ballistic missile (ATBM) system under development at the Soviet Ground Forces missile test center near Emba could have some capabilities against SRAMs. If the Emba system is an ATBM and was designed to cope with longer range, higher velocity missiles such as Pershing, it could have some capability against semiballistic SRAMs. It is unlikely that it would have capabilities against low-altitude SRAMs since the system's radar would need sophisticated clutter-processing equipment which is not required for ATBM use.

It is being developed for the Soviet Ground Forces, and deployment of this or any new defensive system in PVO Strany would require a massive program of production and deployment to achieve an effective SRAM defense.

81. The Soviets have been deeply concerned about the vulnerability of their SAM systems to offensive jamming. As in other areas, SAM ECCM capabilities have shown a steady growth and could now be quite substantial.

D. Interceptor Defense

Technical Problems and Solutions

86. As noted previously, the problems associated with PVO Strany interceptor capabilities depend partly on the geographical area of possible usage. Beyond Soviet borders, current interceptors are limited by poor or nonexistent interceptor control. The most feasible way to improve this situation lies in the deployment of an AWACS with a look-down capability. the Soviets' own previously-demonstrated concern for this capability and evidence that they have begun to develop radar look-down technology suggest that an AWACS is a definite possibility in the future.

87. The Soviets have, at times, employed ships for air surveillance and interceptor control, but with limited success. To improve defenses beyond Soviet borders, large numbers would have to be used and this is considered unlikely.

88. Other means of enhancing air defense operations are use of combat air patrol (CAP) and lane control tactics. CAP provides maximum intercept range in minimum engagement time. CAP is an important adjunct to normal control procedures which provides an airborne barrier across likely axes of air attack, particularly in the initial stage of the air battle when deployed at extended ranges from the territorial border. Lane control is an appropriate tactic when ground control is seriously degraded. Its purpose is to cover relatively broad areas with many interceptors operating in a semiautonomous mode. Lane control is predicated on interceptors attacking targets of opportunity. Developments in ground and airborne systems, coupled with these tactics, would improve Soviet air defense operations.

89. Within Soviet borders, achievement of a credible low-altitude interceptor defense requires a combination of two improvements: (a) a better GCI or airborne-controlled intercept capability and (b) an interceptor with a look-down/shoot-down capability. Requirements related to these two ingredients are summarized in Table VIII. Broad area air surveillance data could be available either from a look-down AWACS or from an improved, ground-based air surveillance network. These concepts are depicted in Figures 9, 10, and 11. If the Soviets use either of these concepts, its technical and operational feasibility will depend on the volume of airspace in which an interceptor can search for a target compared to the errors in the vectoring data provided by a GCI controller—the interceptor's search range must be large

TABLE VIII

REQUIREMENTS FOR IMPROVED INTERCEPTOR DEFENSE

Needed Components	Requirements
Improved Control of Interceptors	Broad area air surveillance available to GCI controller. Vectoring errors small compared to interceptor's on-board search/acquisition range.
and	
Improved Interceptor	Look-down acquisition/search range large compared to GCI errors. Shoot-down armament.

compared to the GCI tracking/vectoring errors. A qualitative comparison of these values is shown in Figure 12. Quantitative estimates are discussed in paragraph 97.

Soviet Programs

90. As noted previously, there is no evidence that the Soviets are planning to replace their present Moss aircraft with an AWACS having a look-down capability. However, there is evidence that the Soviets are beginning to deploy improved data systems with their air surveillance radars and GCI elements. The Flogger, deployed with Frontal Aviation, has a limited capability to attack targets below its own altitude.

91. The Flogger was initially deployed to Frontal Aviation in 1970. [redacted]

[redacted]

94. Although the Flogger has not yet been deployed to any operational PVO Strany combat regiments, PVO Strany pilots have been practicing with it since June 1974 at their advanced pilot training unit. [redacted] it is expected that the Flogger or a variant of this aircraft will be deployed to PVO Strany in the near future.

[redacted]

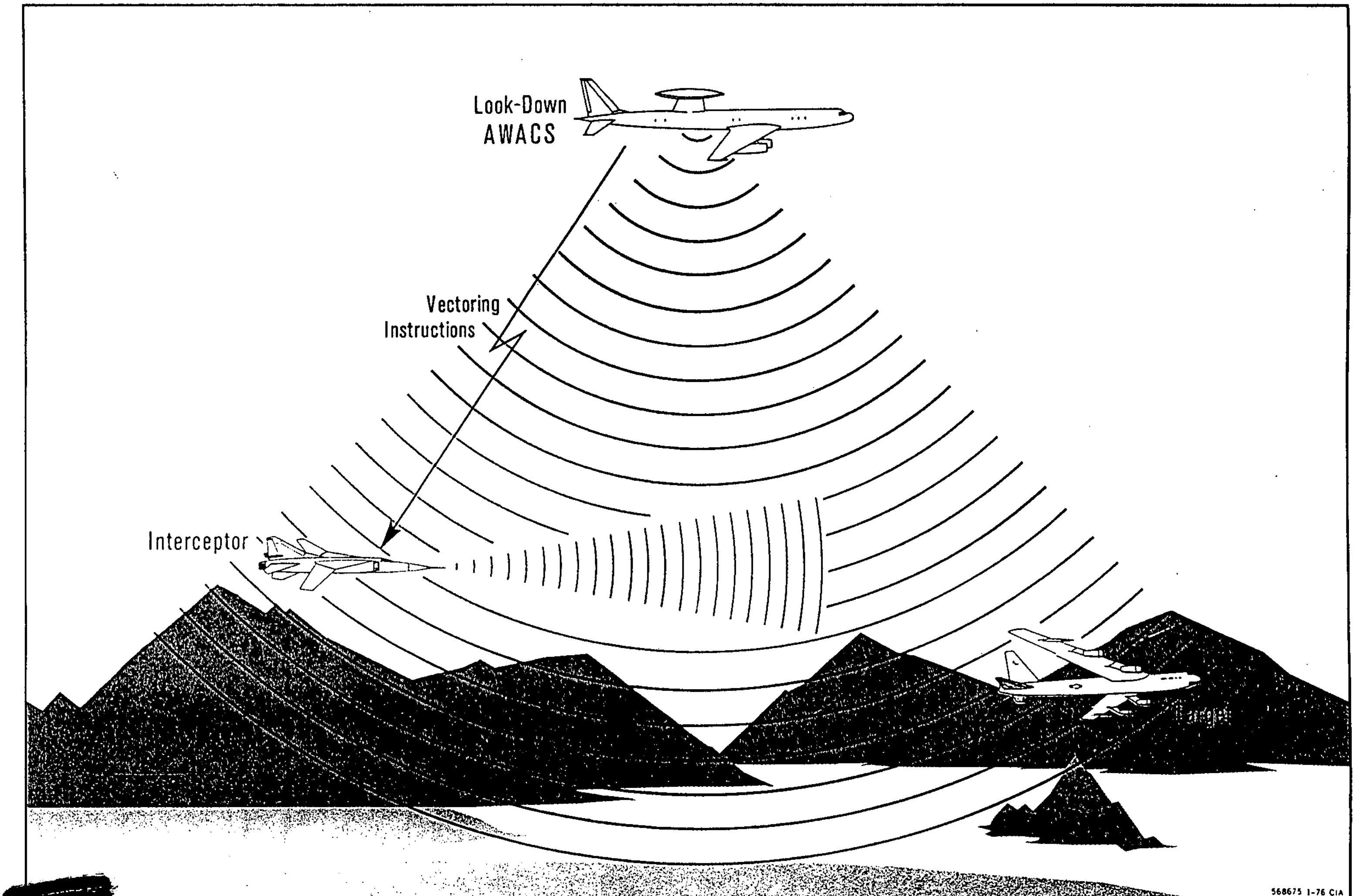
96. Control arrangements for interceptors made possible by improved data transmission systems and the netting of radars provide different degrees of improvement for low-altitude air defense. Two methods of employing the data systems and radar nettings are discussed below.

a. *Improved Battle Management and Limited GCI Support.* In this case the netting arrangements

[redacted]

Control of Interceptors from AWACS

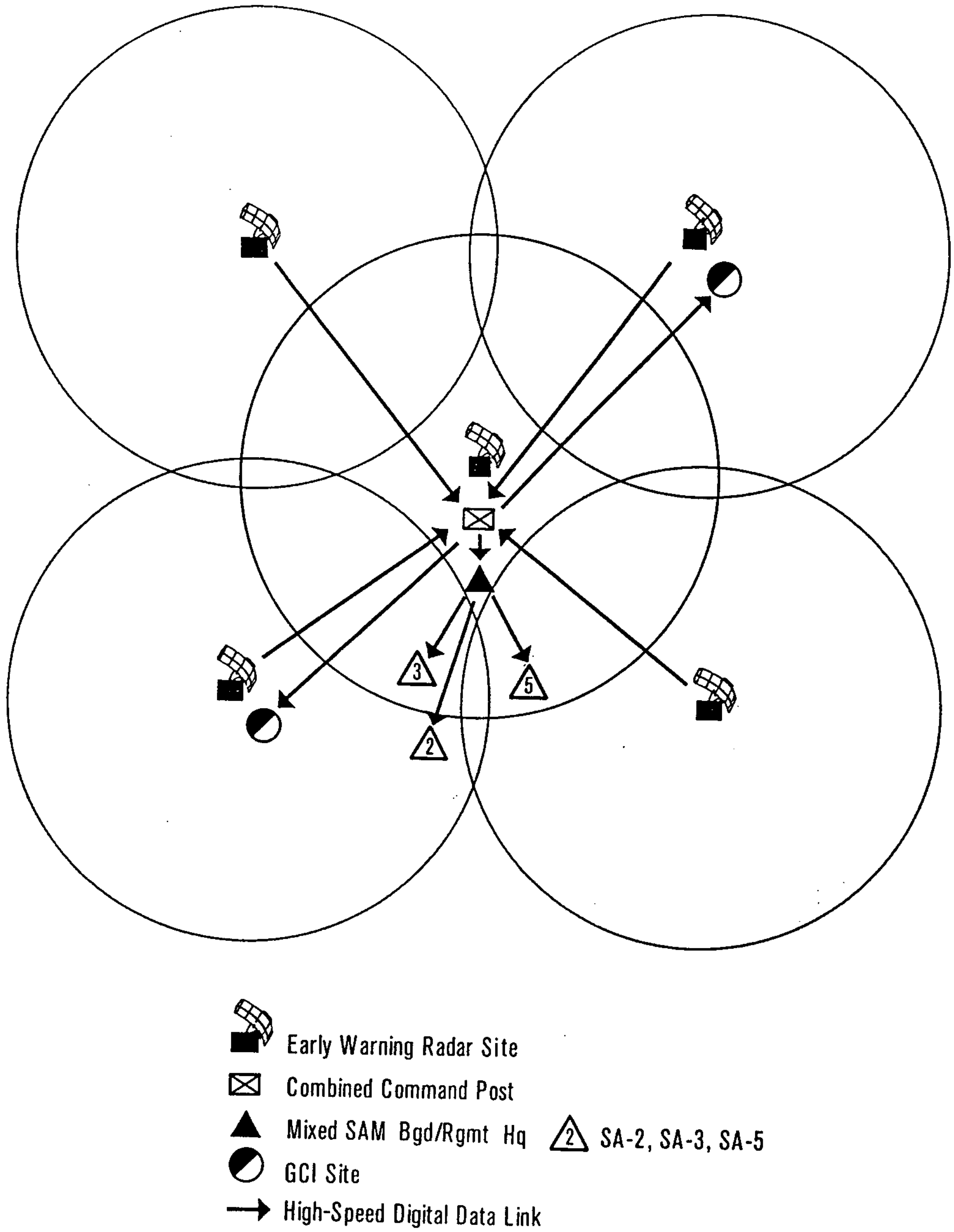
Figure 9



A look-down AWACS could track both interceptor and target aircraft as well as vector interceptors.

Radar Nettings for GCI Support

Figure 10



[redacted]

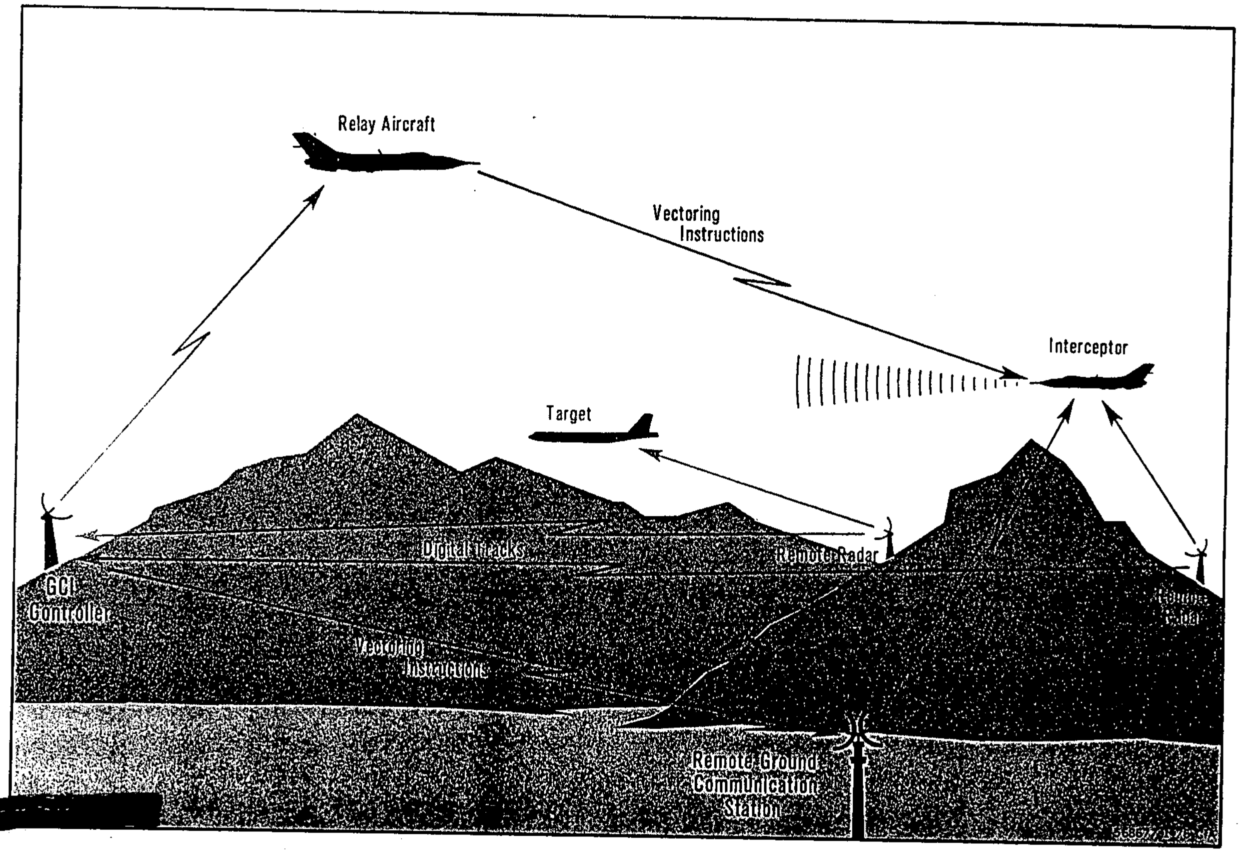
568676 1-76 CIA

The low-altitude radar coverage of a GCI site can be augmented by coverage from remote radars and high-speed digital data links. Nettings such as this have been observed in the Archangelsk Air Defense District.

[redacted]

GCI Operations Using Remote Radars

Figure 11.

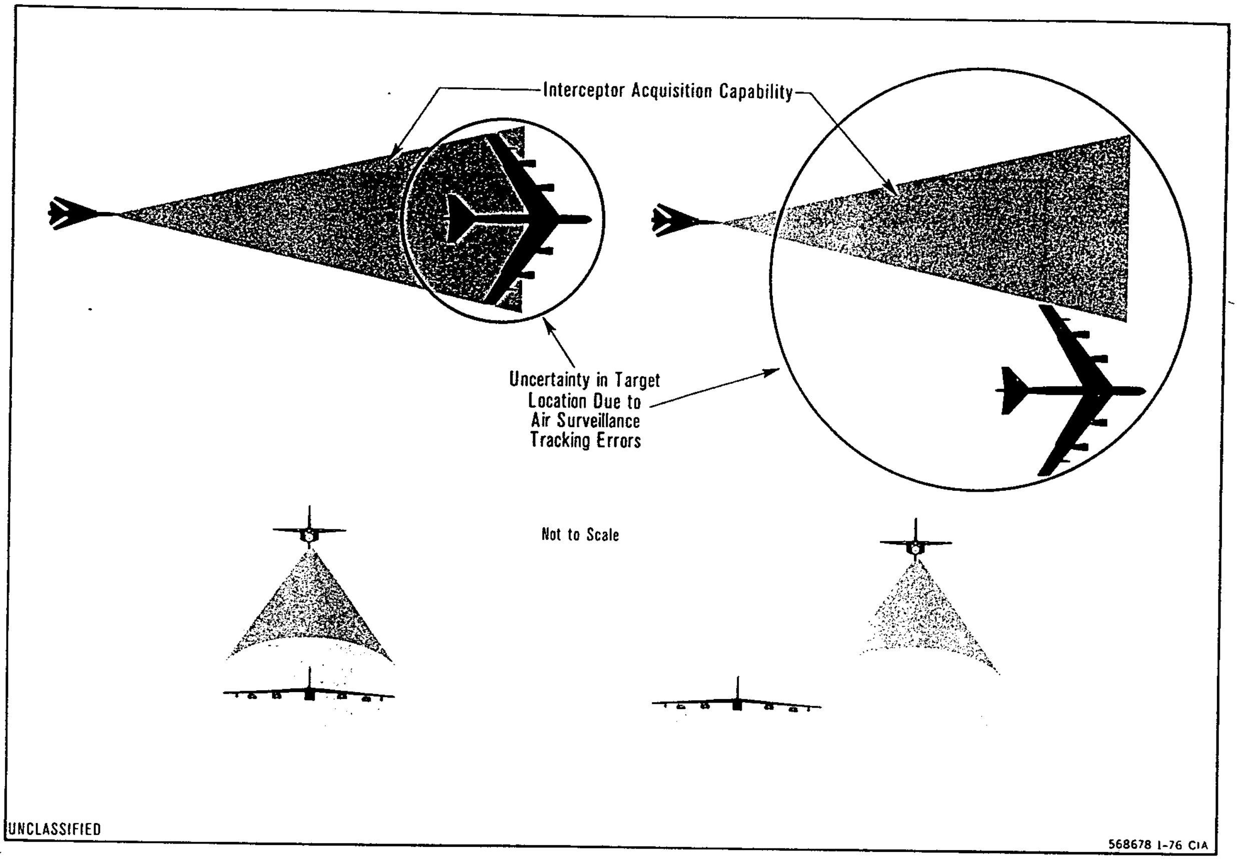


[redacted]

Using remote radar data a GCI controller could vector interceptors beyond the line of sight of his own local radar. This has been proposed as a probable future Soviet tactic.

[redacted]

Qualitative Comparison of GCI Vectoring Errors and Interceptor Search Range Capabilities **Figure 12**



For a successful intercept, GCI vectoring errors must be small compared to the search capabilities of the interceptor.

would serve two purposes. Battle managers would be presented with a clearer, more timely composite of the air situation and an improved capability to conduct mixed weapons engagements. GCI controllers would use the data to reduce some of the problems of transfer of control between different GCI controllers. Each controller, however, would rely on his own local radar for control of interceptors assigned to him. This is entirely consistent with all available data and would provide some improvement in PVO Strany capabilities. However, by relying on his own radar, a GCI controller would be capable of interceptor control over only a limited area. Many of the current problems of interceptor control would still exist.

b. *Improved Battle Management and Remote Vectoring of Interceptors.* In this case the nettings would be used for battle management improvements, but the principal gain would be to allow a GCI controller to vector interceptors beyond the line of sight of his own local radar. This is most important insofar as future air defense improvements are concerned. When combined with improved interceptors, the Soviets could have the potential for reducing many of the technical difficulties associated with low-altitude air defense over many portions of Soviet airspace in which adequate radar coverage exists. The need for frequent transfer of control between GCI controllers could be reduced or eliminated entirely. Time constraints, which currently limit the capability to conduct intercepts at low altitudes, could be substantially relaxed.

97. Because the possibility of remote vectoring of interceptors could offer the Soviets a potential means of substantial improvements in their low-altitude air defenses, its technical feasibility has been studied in some detail. Engineering models of the

[redacted]

have been constructed in order to estimate the accuracy and timeliness of the tracking data provided to GCI controllers from remote radars. These models are discussed in the Appendix.

we are reasonably confident that the calculated tracking accuracies are within the capabilities of these systems. *The Central Intelligence Agency believes that, because of uncertainties about these new systems, a confident assessment of current capabilities cannot be made. On the available evidence CIA believes that an effective remote vectoring capability is unlikely at this time.* The Flogger's look-down search and acquisition range has been compared with these estimates of the air surveillance/GCI tracking errors. This comparison, shown in Figure 13, contributes to our assessments of the effectiveness of various interceptor and air surveillance system combinations for low-altitude defense. The assessments in the following paragraphs and in Table IX reflect potential effectiveness in a benign environment.

E. Lasers for Air Defense

98. The Soviets have large-scale programs under way involving the use of lasers for military applications. Some of these are sponsored by PVO

TABLE IX

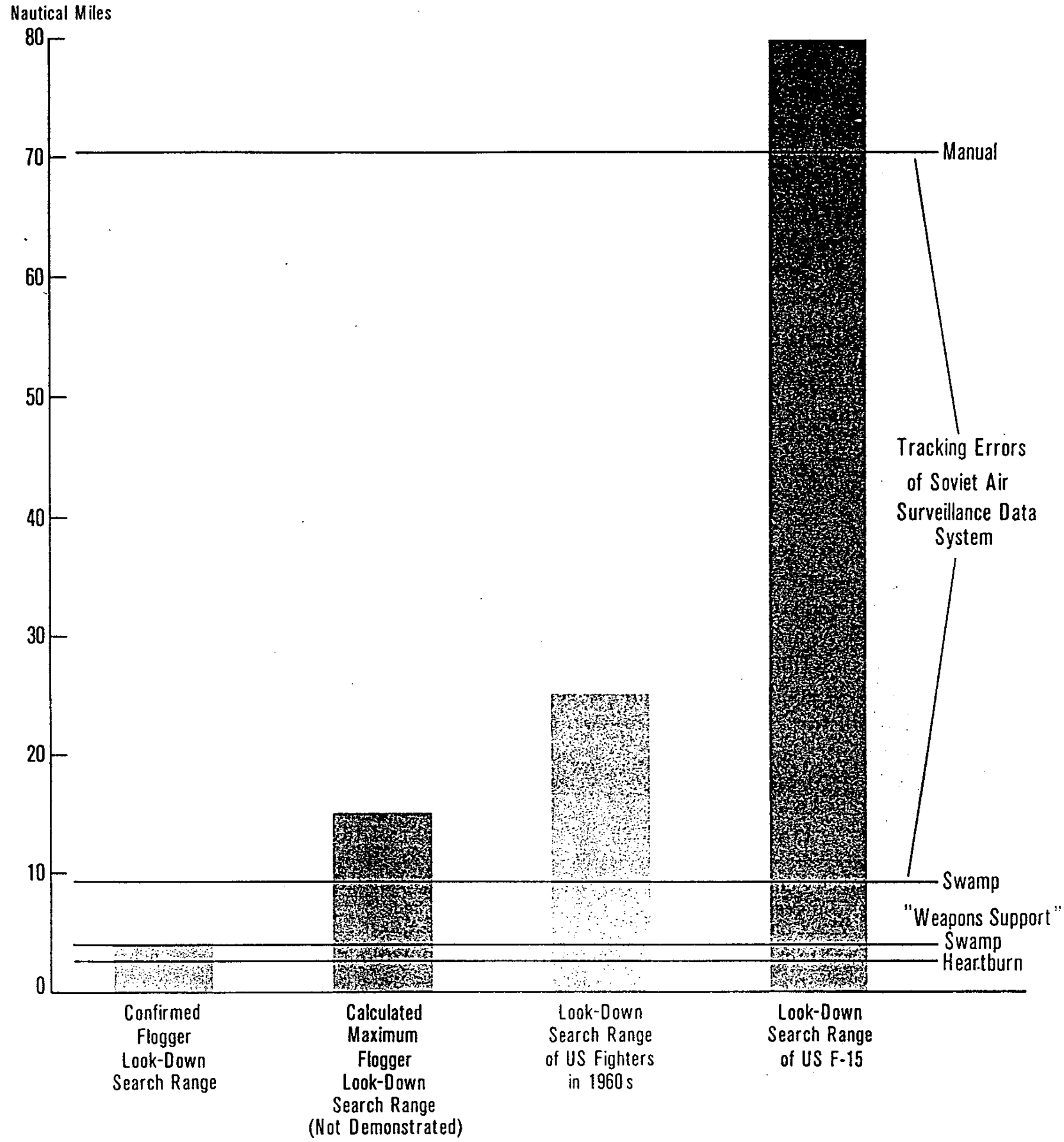
POTENTIAL INTERCEPTOR DEFENSE IMPROVEMENTS

Capability of Individual Interceptor	Capability of Interceptor GCI Control Element	Potential Effectiveness [1]
No look-down/shoot-down	No support from improved air surveillance network [2]	Very poor
No look-down/shoot-down	Remote vectoring using an improved air surveillance network	Poor
"Flogger-like," short-range, limited look-down/shoot-down	No support from improved air surveillance network	Poor
"Flogger-like," short-range, limited look-down/shoot-down	Remote vectoring using an improved air surveillance network	Fair to good
Advanced, long-range, look-down/shoot-down	No support from improved air surveillance network	Fair to good
Advanced, long-range, look-down/shoot-down	Remote vectoring using an improved air surveillance network	Very good

[1] Whether the indicated potential could be realized by the Soviets has not been assessed since the effectiveness of US ECM tactics and other penetration aids has not been included in the analysis.

Quantitative Comparison of GCI Vectoring Errors and Interceptor Search Range Capabilities

Figure 13



[redacted]

568679 1-76 CIA

These calculated values for GCI vectoring errors indicate that the Flogger or an improved look-down/shoot-down interceptor could be vectored successfully with the new air surveillance GCI data systems the Soviets are beginning to deploy.

Strany, but the specific goals and status of these efforts have not been ascertained.[10] The potential capabilities of lasers for Soviet air defense applications are:

—tracking aircraft by use of laser radars,

—laser designators for SAM guidance,

—degradation or destruction of aircraft by a laser beam weapon, and

—degradation or destruction of a SRAM by a laser beam weapon.

99. Laser radars would be technically feasible and would offer vastly increased accuracy over current Soviet radar capabilities under conditions of good visibility and weather. Laser designators could be used for SAM guidance to improve guidance accuracy and ECCM. However the lack of an all-weather capability and the lack of any apparent need for such increased accuracy suggest that the introduction of laser radars or designators would not overcome any of the major deficiencies in Soviet low-altitude air defenses.

100. Ground-based laser weapons could probably achieve a range of only six miles by the early 1980s, which is no improvement over the range of current missiles. With this limitation, such weapons would have to be used in point or vital-area defenses. Airborne lasers would probably be limited to a range of only two or three miles, compared to three to eight miles for current air-to-air missiles. Even if the Soviets could deploy laser weapons with much improved range during the next decade (there is always the potential for technological breakthroughs), these weapons would still require the extensive support of improved air surveillance and command and control systems. Deployment of these supporting systems has only begun during the past few years and is not expected to be completed until 1980-85.

F. Deployment and Operational Patterns

101. In the three air defense arms of PVO Strany (interceptors, SAMs, and air surveillance) the trend observed over a number of years has been toward more emphasis on the quality of equipment. Newer interceptors have replaced older ones on less than a one-for-one basis, resulting in smaller numbers of more-capable interceptors. The trend in SAMs has been to continue introducing modifications for improved, low-altitude performance by better target tracking, missile guidance, and fuzing. In air surveillance, the number of radars has increased slightly in recent years and there has been a continuing program of improvement. There has been a serious effort to use these radars more effectively by introducing newer data systems which can support the needs of weapons employment. Such data systems have already been widely deployed for SAM command and control. A few years ago, similar systems began to appear in support of GCI elements.

102. Even though there seems to be a clear trend toward improving the quality of equipment rather than deploying larger numbers, the overall size of Soviet air defenses is still enormous and likely to remain so. The massive size of Soviet air defense forces and the large area to be defended impacts importantly on the lead time required to effect significant changes in the capabilities of PVO Strany by introducing large numbers of new or better equipment. After completion of an R&D phase, it normally takes several years for the Soviets to produce and deploy sufficient numbers throughout their air defense forces. Additionally, PVO Strany personnel will require a period of training and practice before they achieve proficiency.

III. PROSPECTS FOR IMPROVED LOW-ALTITUDE AIR DEFENSE

103. The preceding sections have described the Soviets' problems in low-altitude air defense and have identified those technically feasible options and programs for improvements which they appear to be pursuing. These factors will be used as inputs for judgments about overall air defense improvements in the 1976-85 time frame. Before expressing these judgments, however, it is necessary to emphasize some key qualifications which affect the judgments.

A. Qualifications

104. Our judgments about future low-altitude air defenses focus on prospects for the Soviets to overcome deficiencies in their current system. In reaching our conclusions we were unable to subject to rigorous analysis several factors which, to the extent that they apply, would further degrade Soviet air defenses. [redacted]

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[10] See Interagency Intelligence Report "Soviet Capabilities to Develop Strategic Laser Systems," [redacted] and NIE 11-3/8-75, "Soviet Forces for Intercontinental Conflict Through the Mid-1980s," [redacted] Volume III, Annex C, for a detailed discussion of Soviet laser programs.

B. Judgments Regarding Individual Soviet Programs

105. In Section II it was shown that the Soviets are working on a variety of programs to alleviate deficiencies in their low-altitude air defense system. In the following paragraphs we estimate the degree of success of Soviet improvement programs during the next 10 years.

Air Surveillance

106. Evidence to date indicates that the Soviets' approach to achieving good low-altitude air surveillance has been to use their existing ground-based radars and to net them together for more efficient weapons support using improved, computerized data systems. In addition, they have modified individual radars, employed towers and mounds to enhance siting, and are continuing R&D. We believe that these approaches are likely to achieve some degree of success.

107. Netting together clusters of relatively small numbers of radars—i.e., less than 10—is within current Soviet technological capabilities and the Soviets should be able to provide adequate surveillance to weapons over the limited area covered by these radars at low altitudes. However, there is doubt whether the Soviets will have developed or acquired the computer technology to centralize control of large numbers of radars for timely and accurate low-altitude air surveillance and weapons control over very large areas.

108. It is likely that they do not yet possess the technology required for an AWACS. However, when the appropriate radar processing techniques and electronic components are available to them, we believe that they will develop look-down radars for overland air surveillance in the early 1980s. The actual production and deployment could be initiated by the mid-1980s if the program is pursued with high priority. When deployment is completed AWACS would extend air surveillance and control to the overwater approaches to the USSR and would supplement overland surveillance and control by ground-based systems.

Surface-to-Air Missiles

109. Mobile SAMs offer the Soviets potential defensive improvements, but the inherent short, low-altitude range of SAMs would require deployment in large numbers to supplement effectively PVO Strany's fixed SAM sites. The time frame for implementing such a decision would depend on the type of mobile SAM to be acquired. If PVO Strany decided to acquire an existing SAM such as the SA-6, production and full-scale deployment could be achieved by the late 1970s. In this case PVO Strany would be buying a system based on technology of the early 1960s. It is more likely that they would decide to deploy a new system such as that undergoing R&D tests at Sary Shagan (see paragraphs 74-79). This, however, would mean that operational deployment would probably not begin until the early-1980s.

110. There is evidence that nuclear warheads are located at a significant portion of SA-1 and SA-2 sites and at some SA-5 complexes. Whether use of these warheads would be permitted for engagements against low-altitude targets is unknown, but if it were, we would expect some increase in effective range. We believe that even with nuclear warheads the low-altitude effectiveness of the SA-1 is marginal. The low-altitude effectiveness of the SA-5 is unknown.

111. Finally, we believe that the Soviets will not have developed or deployed a SAM system capable of intercepting a low-altitude SRAM by 1985. Even though they possess the necessary missile technology, PVO Strany air surveillance/tracking radars would not be expected to achieve continuous tracking of a high-speed, small radar-cross-section target at low altitude. There is a better possibility that the Soviets will develop a system with some capability for intercepting semiballistic SRAMs.

Interceptors

112. The most important need of PVO Strany interceptors is a look-down/shoot-down capability against a low-altitude bomber. A fire control system resembling that in an advanced US aircraft such as the F-15 is not expected to be achieved by the Soviets before the 1980s. We do expect, however, that PVO Strany will soon begin to deploy the Flogger or a modification [redacted] capability to engage targets below its altitude is much less than that achieved by the US [redacted] A new, long-range look-down/shoot-down system could be introduced in new PVO Strany interceptors in the 1980-85 period depending on the priority of the program and the sophistication of the weapon system developed. Once developed, this system also might be retrofitted into existing interceptors such as Foxbat and Flagon, but it is more likely that the Soviets would incorporate these systems into aircraft as they are produced.

113. In any event, Soviet production rates and deployment patterns indicate that several years would be required for PVO Strany to deploy sufficient numbers—many hundreds—of such interceptors. It follows that little material improvement in PVO Strany's low-altitude interceptor capabilities is expected before 1980. During 1980-85, however, it is expected that PVO Strany's operational low-altitude interceptor capabilities will be improved markedly.

C. Prospects for Improvement

114. A summary of projected interceptor improvements, both for individual programs and combinations of programs, is given in Table X. We believe that the potential capabilities of PVO Strany's interceptor defenses will be substantially increased by appropriate combinations of two fundamental improvements: (a) an improved air surveillance system to provide target tracking data to interceptor controllers, and (b) look-down/shoot-down interceptor aircraft.

115. Combination 1 and 3 in Table X is the result of improving air surveillance by a continuation of the ongoing Soviet program to net numbers of ground-based radars together, using high-speed data systems, in order to provide accurate and timely tracking data to GCI controllers from remote radars. When combined with interceptors such as the currently-available Flogger (3a or 3b) or one incorporating advanced technology (3c), Soviet interceptor defenses will be potentially better over heavily defended portions of the USSR where low-altitude radar coverage exists. However, this combination will not alleviate existing deficiencies where ground-based radars do not provide coverage—i.e., along overwater approaches to the USSR or over many areas of Soviet airspace for which low-altitude radar coverage is discontinuous.

116. When an AWACS is added to this combination (1 and 2 and 3 in Table X), the Soviets will be able to engage penetrators prior to their entry into the USSR. An AWACS will also be capable of supplementing ground-based radar coverage over areas in which low-altitude coverage is discontinuous.

117. Projections of future SAM improvements are given in Table XI. We are still uncertain about the low-altitude range capabilities of the nuclear-equipped SAM systems. Mobile SAMs offer the Soviets potential defensive improvements, but the inherent short, low-altitude range of SAMs would require deployment in large numbers to supplement effectively PVO Strany's fixed SAM sites. Deployment of the magnitude required to place principal reliance on SAMs for low-altitude defense would be expensive, even for the Soviets, and there is no evidence that a decision for such large-scale deployment has been made.

118. We believe that it is unlikely that the Soviets will have significantly better low-altitude air defenses before about 1980. In subsequent years, however, we foresee in Soviet air defenses—in air surveillance and control, in interceptors, and in surface-to-air missiles—the potential for overcoming most of the current technical deficiencies for defense against low-altitude bombers. By 1985, if the Soviets carry out the programs we have judged as likely, they will have gone a long way toward overcoming their deficiencies against today's low-altitude threat, thus making the task of low-altitude penetration considerably more difficult. However, the overall effectiveness of Soviet air defenses would depend heavily on the circumstances of the attack, on the degradation of air defenses resulting from ballistic missile strikes, on the effects of electronic warfare, and on developments in US offensive forces—factors which we are unable to measure. We believe the Soviets will not have an effective defense against the SRAM by 1985, and will have to rely on attacking the SRAM carrier prior to missile launch. Furthermore, the Soviets probably anticipate that developments in US forces will have

the potential of seriously reducing the effectiveness of their air defense improvements.

119. We have considered the possibility of air defense applications of directed-energy technologies—i.e., lasers and other beam weapons. We do not believe feasible applications of these technologies during the next decade would have as good a prospect for overcoming Soviet deficiencies in low-altitude air defenses than the improvements we have estimated as likely. However, we must be alert to the potential for breakthroughs resulting from the intense Soviet R&D effort in directed energy.

TABLE X

FORECAST OF PVO STRANY INTERCEPTOR DEFENSE, 1976–85

Projected Improvements	Estimated Deployment in PVO Strany By: 1980	Estimated Deployment in PVO Strany By: 1985	Comments
1. Improved ground-based air surveillance network using new data systems to support GCI	Limited	Approaching completion	Deployment, which began in 1972, is continuing. Even if completed there will be lack of radar coverage beyond 200 miles from Soviet coastline and over many portions of USSR.
2. Development of overland AWACS	None	Possibly some deployment	Development will depend on Soviets' achievement of required radar processing technology and the priority of the program.
3. Deployment of look-down/shoot-down interceptor			
a. Flogger or equivalent	Limited	Large number	Flogger, which has only limited look-down/shoot-down capability, is currently deployed with Frontal Aviation, and PVO Strany pilots have been practicing with it for more than a year at an advanced training school.
or			
b. Flogger [ ] capability of two to three times [ ] look-down search range	Limited	Probably large number	[ ] some modification to the present radar may be necessary to achieve it.
or			
c. Five to ten times look-down search range of Flogger (advanced technology required)	None	Probably some deployment	[ ]
Combinations of Improvements			
1 & 3a or 3b	Limited	Approaching completion*	Degree of deployment will depend on which interceptor PVO Strany deploys, i.e., 3a or 3b or 3c. Any of these options will improve potential air defense capabilities when large-scale deployments are achieved.
1 & 3c	None*	Probably some deployment	
1 & 2 & 3a or 3b or 3c	None*	Possibly some deployment	Soviets have not [ ] capability for AWACS. This combination provides potential for excellent air defense capabilities.

* Estimate based on the lesser of deployments cited for individual contributions to combination.

TABLE XI

FORECAST OF PVO STRANY SAM IMPROVEMENTS, 1976–85

	Estimated Deployment in PVO Strany By			
Projected Improvements	1980	1985	Comments	Potential Effect
1. Nuclear SAMs	75% of requirement	Complete as required	Available to a significant portion of the SA-1 and SA-2 sites, and to some SA-5 complexes. Still not ascertained whether nuclear-equipped systems are intended for low-altitude engagements.	For the SA-2, could result in some defense improvement if low-altitude range exceeds 10 nm. Estimates of low-altitude maximum range of SA-2 vary between 7 and 20 nm.
2. SA-6 system or modification	Possibly high level	Complete	Large numbers would be required. No evidence of PVO Strany plans for such an acquisition.	Would make the task of low-altitude penetration considerably more difficult.
3. New system now being tested at Sary Shagan	Probably very few	Nearly complete	PVO Strany interest is established, but status/results of R&D tests are not known. Large numbers would be required.	Would make the task of low-altitude penetration considerably more difficult if used in a mobile role.

[redacted]

APPENDIX

NEW SOVIET AIR SURVEILLANCE DATA SYSTEMS

[redacted]

~~Top Secret~~

[redacted]

~~Top Secret~~