Soviet Reactions to Stealth

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Special National Intelligence Estimate

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SOVIET REACTIONS TO STEALTH

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THIS ESTIMATE IS ISSUED BY THE DIRECTOR OF CENTRAL INTELLIGENCE.

THE NATIONAL FOREIGN INTELLIGENCE BOARD CONCURS.

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The Central Intelligence Agency, the Defense Intelligence Agency, the National Security Agency, and the intelligence organizations of the Department of State.

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SCOPE NOTE

In recent years, the United States has developed a variety of design techniques that will reduce the energy reflected by or radiated from aerodynamic vehicles and thereby decrease the likelihood of detection by enemy radar, infrared, and other sensors. The United States has also made significant strides toward the development of advanced technologies for the same purpose. This combination of innovative design and use of advanced technologies is known collectively as Stealth.

The well-publicized US Stealth development effort surely has generated concern among Soviet military planners about defense against low signature and Stealth vehicles. In addition to the need for increasing the depth of its defenses by fielding more defensive weapons of existing types, the USSR will have to consider research and development programs to improve the ability of those defenses to detect, track, and destroy Stealth vehicles. The degree of success that the Soviets achieve in these endeavors is certain to influence US military programs, strategy, and tactics.

We also anticipate that the Soviets will develop systems of their own that incorporate signature-reduction designs and technologies. The US R&D community must know as far in advance as possible the means by which the Soviets will reduce system detectability and the degree of their success. This will be necessary to aid in the development of US countermeasures and to augment the US Stealth program because Soviet approaches may differ considerably from those under consideration for US systems.

This Special National Intelligence Estimate is an effort to assess at the national level the Soviet capability and intention to respond to the US challenge. It presents our evaluation both of the defensive methods and technologies we believe the Soviets will employ to counter the US deployment of Stealth systems and of their technical capabilities to develop indigenous offensive low-signature and Stealth vehicles. The SNIE is restricted to discussing only aerodynamic and ballistic missile systems over a 10-year period. It also identifies collection and analytic gaps that must be filled in order for the Community to provide broader, more detailed studies in the future.
DEFINITIONS

Signature: The characteristic spectrum of radiated energy from the object. The source of energy may be the object itself, an incidental source whose energy is reradiated from the object, or a specific source whose energy is reradiated from the object. (Respective examples are infrared energy from an engine, visual energy from an object in sunlight, and transmitted radar energy returning to a radar receiver.)

Low Signature (Low- Observable Technology): Characteristic of any existing system—such as an aircraft, cruise missile, reentry vehicle, or spacecraft—that has been modified to reduce its signature. Such vehicles can become less detectable to enemy sensors within the limits imposed by the original design. Signature reduction for selected aspect angles or for all radiated or reradiated energy probably cannot be achieved for these systems.

Stealth (Very-Low- Observable Technology): The sum of innovative design techniques and advanced technologies as expressed in a future aerodynamic, missile, or space system developed to minimize external signatures. Such systems will achieve very low signature levels through special design to include careful shaping, by infrared and electronic emission suppression, and by the application of advanced coatings and materials. Signature reduction for any aspect angle can be achieved in this type of design.

Radar Cross Section (RCS): A quantitative measurement of an object's visibility to a radar as determined by the radar energy reflected by the object. The RCS of a vehicle is determined by its shape and construction material, the angle at which the vehicle is viewed, and the frequency and polarization of the viewing radar. RCS is usually expressed in terms of square meters.

Infrared Radiation (IR): Emitted or reflected heat energy in the near visible light frequencies. The total IR signature of a vehicle is the sum of its emissions, reflections, and engine exhaust. IR signature is customarily measured in units of watts per steradian as a function of wavelength.
KEY JUDGMENTS

Soviet Counter-Stealth

The Soviets are well aware of US plans to develop Stealth aerodynamic vehicles, nevertheless, we judge that their air defenses will remain vulnerable to penetration by Stealth aerodynamic systems for at least the next decade. This judgment is based on a number of factors that include:

- The limitations of existing Soviet sensors and information-processing systems, which were designed for use against high-signature vehicles
- The massive and capital-intensive nature of Soviet air defenses, which necessitates incremental modification rather than wholesale replacement
- The Soviets' lack of sophisticated measurement ranges, which inhibits their development of counters to the threat posed by Stealth
- The length of the Soviet R&D cycle, which almost certainly will delay the introduction of totally new defensive systems until after 1995

In the near term, the Soviets almost certainly will place a higher priority on developing defenses against US Stealth vehicles than on developing offensive Stealth systems of their own. Indeed, the Soviets already have made certain incremental modifications to currently available defensive systems in reaction to the US deployment of cruise missiles—which naturally have the low radar cross section, low infrared signature, and low electronic emission characteristics typical of a Stealth vehicle.

The critical factor in determining the degree of success that Soviet air defenses will enjoy against low-signature and Stealth targets is the availability of adequate and timely warning information. Therefore, we expect the Soviets' near-term responses to include:

Upgrading the sensors and signal processors in current systems.
Increasing the depth of their defenses by extending ground-based and naval radar and fighter coverage offshore using Mainstay AWACS aircraft, aerial refueling, and a new generation of more capable interceptor aircraft.
- Further pairing of dissimilar types of radars to fill altitude and range detection gaps.
- Increasing the numbers of selected detection and defensive systems.
- Adding mobile surface-to-air missiles (SAMs) to the inventory to complicate penetration planning.
- Increasing decentralized decisionmaking to counter overloading of their existing command and control system.
- Additional networking of early warning, ground controlled-intercept, and SAM radars.

In the longer term, the Soviets are likely to seek technological solutions to the deficiencies in their air defenses that will persist despite the near-term improvements. We believe these will include developing:
- High-power, low-frequency conventional radars incorporating new signal processors and electronic counter-countermeasures (ECCM).
- Multistatic radars.
- Laser radars.
- Acoustic detection systems.
- Improved infrared search and track sets (IRST).
- Long-range air-to-air and surface-to-air missiles with multi-mode terminal seekers.
- Fully automated command and control systems connected by digital data links.

**Soviet Stealth Developments**

The Soviets have an excellent theoretical knowledge of electromagnetics and traditional signature reduction technologies. However, achieving Stealth is dependent on the integration of shaping and other signature-reducing technologies into a weapon system.

We doubt that Soviet designers have as yet decided on an overall conceptual approach to any Stealth design. Therefore, while the Soviets probably will begin within five years to modify existing designs to reduce their external signatures, the length of the development cycle makes it unlikely that they could field an unmanned Stealth vehicle before 1995 or a manned Stealth platform before 2000. To prolong the
service life of existing aerodynamic systems—and to control the risks associated with Stealth development. Their initial attempt to produce a Stealth vehicle is likely to be an air-to-surface missile, followed by manned systems such as reconnaissance aircraft or tactical bombers, which depend on defense avoidance for survival.

The Soviets have shown an interest in signature reducing technologies with broad application to a variety of aerodynamic vehicles and have acquired related technical information, materials, and manufacturing equipment from a variety of foreign sources. We periodically acquire information from articles in technical journals or from technical intelligence sources that leads us to believe that independent research efforts are continuing in:

- Radar cross-section theory
- Radar-absorbing materials
- Automated flight controls
- Infrared signature reduction
- Electronics emission reduction

The Soviets have three outdoor radar cross section ranges, the most prominent of which are at Kalinin and Voronezh. These facilities will contribute to both counter-Stealth and offensive Stealth developments but represent a level of technology several years behind that of the United States.

Moscow has applied signature-reduction and enhancement techniques to ballistic missile reentry vehicles since the late 1960s. The objective of this program might be to deploy a mix of reentry vehicles, decoys, and other penetration aids that offer a variety of radar signatures in a single payload in order to complicate targeting for antiballistic missile defenses.
Figure 1
Design Considerations for Stealth Aircraft
DISCUSSION

The Stealth Concept

1. The objective of the US aerodynamic Stealth program is to achieve and maintain a high-confidence capability to penetrate the recently improved Soviet defenses, which rely on radar, infrared, and visual sensors to provide target acquisition, identification, and tracking data to controllers of intercept aircraft, surface-to-air missiles, and antiaircraft artillery. If attacking vehicles—aircraft, tank crews, and ballistic missiles—were not acquired by Soviet sensors or if acquisition were delayed beyond the reaction time of their defensive network, the attacking force would be able to penetrate to its target without suffering an unacceptable rate of attrition. Existing vehicles modified to reduce their radar cross section (RCS), infrared (IR) signatures, and electronic emissions will degrade the capability of most current Soviet defensive systems and render some other elements but other factors must be considered in order to penetrate future Soviet defenses. Among these future considerations are active, curtain, and reflected light.

2. Developing a Stealth vehicle requires that all of these factors be considered from design inception. Shaping to reduce radar cross section is the most critical factor in designing a Stealth vehicle; reducing infrared emissions from the vehicle's propulsion system without degrading performance is also a major design challenge. Because a vehicle's electronic emissions can be tracked by SIGINT systems, passive electronic subsystems or those designed to have a low probability of intercept must also be developed. Figure 1 illustrates some of the desirable features of a Stealth vehicle.

The Counter-Stealth Potential of Current and Near-Term Soviet Systems

3. The Soviets are well aware that the United States has planned to improve its capability to penetrate Soviet air defenses by developing aerodynamic vehicles with reduced external signatures, although they appear to consider the impending introduction of Stealth technologies as just the latest of a number of technical and tactical changes that have forced the Soviets to react over the past 15 years. Moscow perceives the United States to have a significant lead in the applicable technologies and probably has committed substantial resources to research efforts devoted to counter the US systems.

4. Over the last 20 years, the Soviets have spent roughly as much on developing and deploying strategic defense in depth as they have their offensive forces. They have established an air defense system using a layered concept that compensates for the shortcomings of the individual elements, but this approach has resulted in an air defense network so massive and widely dispersed that we believe their next-term response to any new threat will be limited to system improvement by incremental modification. The modifications already begun by the Soviets in response to the US deployment of the cruise missile—a system that inherently has a low radar cross section and low IR signatures—constitute their initial response to Stealth employment. In the longer term, we expect Moscow to develop new technologies and operational concepts that better match the increased penetration threat of US follow-on systems, but for the next five to 10 years the Soviets will be forced to rely on defensive systems already in place or expected to enter their inventory soon.

Early Warning Radar Systems

5. The critical factor in determining the degree of success that Soviet air defenses will enjoy against low-signature and Stealth targets is the availability of adequate sensors and signal processing. The existing Soviet early warning radar network is based on an extensive network of ground-based acquisition radars. The Soviets have several thousand early warning radars of some 15 types in service by 1980. Although some of these have an excellent theoretical capability to detect small targets under controlled conditions, detection ranges would be severely degraded by low-level penetrating tactics, background clutter, and other operational considerations.

6. In the near term, we expect the Soviets to deploy combinations of these systems in order to maximize their detection capabilities. VHF radars such as the Tall King C radar, also used as the acquisition radar for the SA 3 surface-to-air missile and for ground-controlled intercept, have some capability to detect
A great deal of attention in the United States is devoted to expanding its aviation capabilities in order to overcome the air defenses of the Warsaw Pact countries. In response to this threat, the United States is conducting weapon development under the "Stealth" program, which is attempting to develop aircraft that would substantially reduce the detectability of aircraft through air defense sensors using the techniques of radar location or heat-seeking.

The "Stealth" aircraft development program is being conducted by a number of large US aerospace firms. A contract for $3 billion dollars for designing the future strategic ATW bomber was awarded to the Northrop Corporation. The Lockheed Company, using the experience gained in designing the SR-71 and A-11 aircraft, is also producing stealth reconnaissance aircraft which have received the designation ORGCS. Their construction is being financed by the project for designing the future ATV fighter aircraft. The Boeing, Grumman, and Northrop companies are also participating in this work. In fiscal year 1987 alone, the United States spent nearly $1 billion dollars on this development work.

According to American military experts, the procurement and deployment of "Stealth" aircraft will greatly reduce the accuracy of defense systems, because of a sharp decrease in the distance at which they can be detected and a simultaneous increase in the effectiveness of anti-aircraft guided missiles, because of the decrease in the EIR and an increase in the scattering area when using missiles. Shortcomings of such aircraft include the need to decrease in aerodynamic characteristics, a relatively small combat load because of the presumed absence of external loads as well as a limitation in using conventional system for operation, navigation and communication.

Although accorded to the "Stealth" program, industries believe that at the experimental stage, the United States is using it for a demonstrator to determine future uses for "Stealth" technology in designing new types of combat fighters, reconnaissance aircraft, and various unmanned systems and weapon systems. The main attention of the American administration, however, is directed toward the development of strategic bomber aircraft.

In accordance with the regulations present in the United States Air Force, serial production is being planned for the ATW bombers in 1988-1990, immediately following the completion of the planned production of 500 Rockwell B-1B bombers. The ATW aircraft will be immediately used in the context of B-1H production. Thus, the B-1H bomber fulfills two functions. It is an intermediate strategic aircraft for defense, which can defend itself from defenses of a probable enemy, and it serves as a demonstrator in the event of failure of the Stealth concept.

If the ATW bomber is developed successfully, it can be deployed in 1991. In that case, some 100 of these aircraft will be accomplishing missions of penetrating and defending against defenses of the B-1H bombers, which would then be used only as carriers for guided missiles to be released outside the air defense zone of the enemy.

The Moscow Journal of Anti-Aircraft Defenses, March 1987

In addition to ground-based early warning assets, the Soviets are deploying their new II-76 Mainstay AWACS aircraft (see Figure 3), which will be used to improve their offshore early warning capability. The radar on this aircraft has a fail-safe capability against low signature targets and a poor capability against Stealth targets at high or low altitudes, over land or over water. The Mainstay's detection, tracking, and surveillance and control capabilities will be an excellent asset to interceptors and SAM batteries facing conventional and, to a lesser degree, low-intensity threats. Target track data will be relayed from Mainstay to ground, naval, and airborne defensive systems through data links, thereby alleviating some of the operational problems imposed by low-intensity and Stealth targets. We expect 25 to 30 Mainstay aircraft to be in the Soviet inventory by 1990.

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Radar Capabilities Against Low Radar Cross Section Targets

The radar cross section of a target depends on many factors, including the radar cross section of the target and the distance of the target from the radar. The relationship between these factors is described by the radar cross section equation:

\[ \sigma = \frac{4\pi D^2}{R^2} \]

where \( \sigma \) is the radar cross section, \( D \) is the diameter of the target, and \( R \) is the range to the target.

For low radar cross section targets, the radar cross section decreases as the frequency increases beyond a certain value. At low frequencies, the radar cross section increases as the frequency approaches the size of some part of the target, such as its overall length or width. This relationship is referred to as the target's resolution. At very low frequencies, the radar cross section decreases to zero.

The radar cross section is also affected by the size and shape of the target. Smaller targets or those with a smaller cross section will be more difficult to detect. The radar cross section can be reduced by painting the target with materials that absorb or scatter the radar waves, or by using stealth technology to minimize the target's radar signature.
Fighter Aircraft Systems

9. We do not expect the overall force level of Soviet interceptors to change appreciably through 1990, but the incorporation of aircraft now entering production or in the final stages of flight test will dramatically improve Soviet air defenses. By 1990, about 40 percent of the Soviet fighter inventory will consist of MiG-29 Fulcrum, SU-27 Flanker, and MiG-25 Foxbat aircraft equipped with pulsed-Doppler radars with digital data processing systems capable of conducting lock-on/lock-off attacks—a capability essential for defending against cruise missiles and low-altitude aircraft but possessed by only a small percentage of the current Soviet fighter inventory.

10. All these aircraft—the heart of Soviet air defense systems for at least the next decade—are equipped with improved radars, fire-control systems, and air-to-air missiles.

11. In a lock-on mode or bad weather, this tracking capability would be severely degraded. Nevertheless, IFF sets provide an aid to radar attack by permitting the operator to positively track a target or to attack a target in an ECM environment if some other sensor provides range data. If the Soviets perceive that US developments in reducing radar cross section cannot be combined by radar improvements alone, they may turn increasingly to infrared or other passive sensors for detection, tracking, and missile guidance.

12. In addition to defending against penetrating fighter and bomber aircraft, the Soviets are threatened with infrared launchers of cruise missiles. We note
that production of new tankers and AWACS aircraft will support the Soviets' plans to move defensive forces farther from their borders in order to intercept real or simulated enemy forces before launch. If the newest fighters also are equipped for aerial refueling, the Soviets could extend their defensive perimeter far enough offshore to provide the pre-emptive strike capability we believe they are seeking.

12. Those targets that successfully penetrate the offshore barrier will be more difficult to intercept over land even though the Soviets have extensive land-based defenses. Low-altitude penetration tactics have already reduced track time and imposed clutter problems on Soviet radar and infrared systems, reduced signature systems will further increase the stress on their defenses. Almost half of the Soviet interceptors will have some capability to attack low signature targets, including cruise missiles, in the next 15 years but probably will have little capability against Stealth vehicles before 1995. Moreover, the effectiveness of individual air defense systems will be determined in large part by the evolution of Soviet air defense doctrine, their future command and control structure, and their technological response to the increased threat.

Surface-to-Air Missile Systems

13. By 1990 the Soviets will have at least 14 surface-to-air missile (SAM) systems in the field and may have begun deploying ground-based laser defenses. As in the case of Soviet early warning radars, some SAM systems could threaten low-signature and Stealth vehicles under certain conditions, but operational factors would reduce their effectiveness under wartime conditions.

14. The SA-1, the USSR's largest range SAM, has a limited ability to attack low signature targets, especially those operated at low altitudes. Nevertheless, because of the Soviet's significant investment in this system and its deployment in Eastern Europe, we anticipate that Moscow will improve the acquisition and tracking radars currently associated with the SA-1.

15. The SA-10 (see figure 5), the Soviet Union's most modern strategic SAM, is the first designed to defend against low altitude aircraft and air-to-surface missiles. The SA-10 will be fielded in two versions: the transportable version, the SA-10A, is now being deployed; the mobile version, the SA-X-10B, is still in development.

16. The SA-X-12, in development since 1979, is the Soviets' latest tactical radar-guided SAM. Its design—which incorporates two versions of an intercept/sensor—allows the system to attack both high- and low-altitude targets ranging from cruise missiles to tactical ballistic missiles. Its ability to track low radar cross section targets could be improved by modifying its acquisition and engagement radars to include better clutter rejection in the former and lower mounting for the latter.

17. The Soviets have fielded large numbers of infrared SAM systems designed and developed in the 1970s and 1980s, but are highly modular, easy to control, and relatively cheap to build. However, present Soviet technology in this area will not pose a significant threat to US low signature or Stealth vehicles in the near term, because even the newest Soviet
Figure 5
Components of the SA-10 SAM System

Low-Altitude Acquisition Radar
(Long Range)

Engagement Radar (High Lift)

Long Range Acquisition Radar and Vans
(High Lift)

New SA-10 Mobility
Engagement Radar

Launcher

New Self-Propelled SA-10 TEL
IR SAMs show only marginal capabilities to attack cruise missiles. Substantial improvements in infrared sensing technology will have to be achieved before these weapons will be capable of attacking US Stealth vehicles.

Antiaircraft Artillery Systems
18. The ZSU-23-4 is the current Soviet mobile radar-directed antiaircraft gun system. It is capable of tracking targets with a radar cross section of 0.01 square meter or larger. The following on ZSU-X system could be improved by adding an acquisition radar, improving clutter rejection, eliminating multipath tracking errors, and upgrading its fire-control computer. Because its range would be limited to about 5 kilometers, its usefulness against low-signature and Stealth vehicles is limited to point defense of high-value targets. We expect to see significant numbers of the ZSU-X fielded during the early 1990s.

Command, Control, and Communications Systems
19. The existing Soviet air defense systems face great difficulty in tracking conventional aircraft flying at low altitude. Under some conditions, its highly centralized structure can inhibit the rapid flow of information and firing decisions necessary to engage and defeat fast-moving targets. The Soviets recognize that low-signature and Stealth targets would severely stress their network and are implementing procedural changes as stopgap measures until better systems are available in the 1990s. Decisionmaking is being forced to lower echelons to permit more rapid response to targets. Individual pilots, flight leaders, and SAM battery commanders are being taught to recognize an overload of the command and control system, and are being encouraged to engage targets on their own initiative, using local sensor and computational resources, without awaiting approval and target assignment from their superiors.

20. While Soviet commanders are encouraging the development of autonomous command capabilities to overcome some of the deficiencies in their command and control system, they simultaneously are reinforcing the role of centralized command and control by networking together early warning, ground control-intercept, and surface-to-air missile radars. The resulting networks capitalize on differences in sensor frequency, output power, and location to present a more complete picture of the threat situation, particularly with respect to low-altitude penetration and low-signature vehicles such as cruise missiles. This sort of information is essential to the orchestration of Soviet air defenses in response to the longer term Stealth threat, but sensor netting may produce overloading of the command and control system. Until technical improvements in data handling and integration are implemented, information from the netted detection systems may contribute to the effectiveness of local air defense nodes but would provide only a marginal improvement in the ability of Soviet commanders to manage the overall air battle.

21. Technological improvements will be necessary to correct the hardware limitations apparent in the Soviet air defense network. Existing Soviet command and control systems are based on a one-on-one concept—one single interceptor or SAM on a single target. The new generation of interceptors now being deployed and the SA-10 system are capable of simultaneously engaging multiple targets. As a result, the laser ground-controlled intercept system and the Vektor-2 SAM command and control system are being replaced by more capable systems.

22. New air-to-air, air-to-ground, and ground-to-air data links are already providing better situational information that will allow the Soviets to task full advantage of their new defensive systems. The present objective appears to be one of providing decisionmakers in the cockpit or at the SAM battery level with enough situational information to make correct engagement decisions. This radical departure from historic Soviet practice is necessitated not only by the decreased reaction time available to ground controllers but also by the belief that extensive electronic countermeasures may degrade command and control, or that integral command, control, and communications nodes may be put out of action. Centralized decisionmaking is ideal, but in the above cases it also should be sufficiently flexible to allow engagement decisions to be made at a level appropriate to the situation. The Soviets will retain centralized decisionmaking whenever possible.

23. The Mainstay AWACS will enhance the Soviet air defense command and control system by downlinking tracks of targets not visible to ground sensors to ground stations via digital data links. Target information collected by the Mainstay's radar and IRF (identification friend or foe) system probably includes identification, position, altitude, velocity, and number of targets in a group. We believe the Mainstay can manage up to 12 simultaneously surface-controlled
intercepts, and control of some intercepts would be accomplished via air-to-air data links monitored by controllers aboard the Mainstay. The command, control, and communications capabilities apparent in the Mainstay system essentially resulted from the Soviet perception of the threat posed by low-altitude interceptors. Although the Mainstay has a marginal detection capability, it will serve as an interim Soviet command, control, and communications response to the Stealth threat.

**Future Soviet Technical Responses**

**Early Warning Radar Systems**

24. We are aware that the Soviets are developing higher-powered, early warning and intercept radars with the better resolutions necessary to cope with the low-signature and Stealth detection and tracking problem. Soviet radar designers are likely to incorporate VHF and UHF frequencies, increased pulse repetition frequencies, and improved signal processing in their next generation of radars—possibly by developing a pulsed Doppler processor. They may also develop spread-spectrum radars in order to make effective jamming more difficult, however, these would not necessarily have improved capabilities against Stealth vehicles. These newer radars will continue to have built-in electronic counter-countermeasures (ECCM) based on such techniques as side-lobe suppression, waveform diversity, and cross-polarization cancellation.

**Fighter Aircraft Systems**

29. Articles in Soviet technical journals have discussed laboratory level optical processing of radar signals, an indication of the Soviet's interest in developing electro-optical adjuncts for airborne detection and tracking of low-signature and Stealth vehicles. Optical processing—an attractive alternative to the high-quality digital technology on which US systems depend—would increase the speed at which radar data could be processed and would allow the detection of smaller near noise-level returns by providing greater resolution power and clutter rejection. The Soviets have also demonstrated technology in operational laser transmitters, which would lead to the development of
laser radar systems for the detection and tracking of targets. However, we have no evidence of such developments at this time.

Surface-to-Air Missile Systems

30. Much of the detection and tracking technology developed for future interceptor aircraft could apply to ground-based SAM systems. Soviet experience in developing IRSTs for aircraft could lead to an advanced ground-based IRST capable of supporting cruise missile engagement by newer and future SAM systems. Such a system would require advanced infrared detector and signal-processing technology.

31. Over the years, the Soviets have continued to upgrade the capabilities of their radar-directed SAMs to meet the evolving threat to their defenses.

Command, Control, and Communications Systems

32. As the US deploys and perfects the penetration techniques of vehicles that have progressively lower signatures, we expect the Soviets to continue upgrading their acquisition and tracking radar networks by improving the data-handling capabilities of their command and control systems in order to provide the automated redundant links necessary to handle fast-moving events throughout the Soviet air defense system if the Soviets are to cope with the very short reaction times imposed by Stealth targets, they must automate many if not all of the manual operations that inhibit their current air defense system. Automating the system will require development of suitable system architecture, algorithms, and software—areas in which the Soviets must lag Western computer technology. The Soviets are likely to concentrate their resources in this area because of the potential for a high payoff against low signature and Stealth vehicles.

Ballistic Missile Defenses

33. The Soviets probably believe that application of Stealth technology to US ballistic missile reentry vehicles is farther off. Their current ABM and ballistic missile early warning systems are based primarily on radar, and their launch-detection satellites use IR sensors. The Soviets are actively engaged in research on more advanced ballistic missile defense concepts that could include directed-energy weapons. Should these prove feasible, the Soviets would have to develop more accurate tracking means that might include optical techniques such as laser or IR tracking with advanced radar concepts to provide a potentially effective counter to Stealth ballistic missile RVs.

Other Defense Options

34. There are many options that the Soviets might take in responding to the Stealth threat that are not technology dependent. Most would be readily apparent to the Intelligence Community and offer no long-term solution to the problems faced by the Soviet air defense system. The options include:

- Increasing the use of AWACS aircraft, aerial refueling, and long-range interceptors to extend defense. Offshore barriers could be augmented by naval radars, airborne SAMs, and aircraft carriers.

- Increasing the network of radars and SAMs to offset the reductions in range and reaction time imposed by Stealth targets.

- Increasing the use of mobile SAMs to complicate penetration planning.

- Creating obstacles around SAM sites and mounting more SAM radars as towers to improve line-of-sight and reduce ground clutter.

Using acoustic tracking nets, human spotters, and visually aimed antiaircraft artillery.
Using manmade obstacles such as barrage balloons.

Prospective Soviet Stealth Developments

The Impact of the Soviet R&D Process

35. The speed at which new technologies are incorporated into Soviet offensive forces will be determined by the status of technologies in research and the complexity of the systems entering development. The technology research phase can be shortened by technology transfer if applicable Western technology can be brought to the production line. However, Soviet designers tend to select major system technologies early in development process. The impact of this approach, in terms of development timeline, is summarized in table 1.

Incorporating Stealth Vehicles into Soviet Military Planning

36. Our judgments on how Soviet military planners might reach a decision to incorporate Stealth technologies in their future forces are admittedly subjective. Nevertheless, Soviet requirements to penetrate NATO's defenses appear to be the most difficult task for their forces to the present. Thus, the Soviets probably calculate that the most immediate need for stealth technologies lies with those forces intended for peripheral strike and tactical air operations, and that stealth application to intercontinental bomber and long range cruise missile designs may safely be relegated a lower priority. In the longer term, the Soviets probably anticipate that the US Strategic Defense Initiative will provide a number of the technologies to improve early warning of an enemy bomber attack and that a US deployment of ballistic missile defenses would be accompanied by air defense modernization.

57. Peripheral Strike and Tactical Air Forces.

The aerodynamic portion—aircraft and cruise missiles—of Soviet theater forces faces an increasingly capable NATO defense. NATO air defenses, particularly those in central Europe, and the defenses over US carrier battle groups—the primary targets—of Soviet naval air units are rated highly effective by the Soviets. The Soviets have invested heavily in these forces over the last 10 years, developing SU-24 Fencer and Tu-22M Backfire bombers that were developed before signature reduction was a significant design consideration. These aircraft probably will be the backbone of the peripheral bomber forces throughout the rest of the century. The Soviets probably see a need to arm these aircraft with low-signature air-to-surface missiles by 1990, and perhaps field Stealth missiles by 1995. The latter time frame is likely to incorporate some low-signature technologies.

The Soviets tactical air force operations are conducted by air superiority and ground attack fighters, and reconnaissance aircraft. The Soviets have just completed development the MiG-29 Fulcrum and the Su-27 Flanker—designs that do not appear to incorporate signature-reduction technologies. We judge that these aircraft will be the primary fighters in the Soviet tactical air inventory for years to come and probably will be modified with some low-signature features during their operational lives. The design of a Stealth fighter using technology currently available in the Soviets probably would require sacrifices in flight performance that they are likely to consider unacceptable in an air-to-air combat aircraft where maneuverability is an important aspect of survivability. We therefore doubt the Soviets will field a Stealth fighter before the next century.

59. On the other hand, the current Soviet tactical bomber and reconnaissance force consists principally of aircraft whose mid-1960's designs offer little potential for increased range or payload, or decreased external signature. Aircraft in these categories would be less affected by the survivability in flight performance forced by current Stealth technology because their roles have traditionally depended more on presence than maneuverability to survive. For these reasons, we believe that an aircraft from one of these mission areas is likely to be the first manned system to benefit from Soviet Stealth technology.

Table 1

<table>
<thead>
<tr>
<th>Status or Technology</th>
<th>Change to Weapon System</th>
<th>Years to Initial Operational Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available now</td>
<td>Minor modification</td>
<td>5 to 7</td>
</tr>
<tr>
<td></td>
<td>Major modification</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>New system</td>
<td>10 to 15</td>
</tr>
<tr>
<td>In-progress research</td>
<td>Minor modification</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Major modification</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>New system</td>
<td>35 to 45</td>
</tr>
<tr>
<td>Research phase</td>
<td>Minor modification</td>
<td>15 to 19</td>
</tr>
</tbody>
</table>

10
44. Intercontinental Forces. The Soviets are well aware that the US ICBM effort will not be expected to continue in full at the level of 1975. This should lend some urgency to the Soviet effort to improve their ICBM forces. A number of techniques have been identified and incorporated into the new generation of intercontinental offers. A similarly reliable source recently published an article in a leading technical journal indicating that the Soviets are developing new techniques for reducing the IR signatures of their ICBM. The techniques include the addition of materials and shapes to the nose section of ICBM vehicles that will reduce their IR signature in an effort to keep the Soviets from detecting and attacking their ICBM forces.

45. The Soviets are expected to continue to develop new techniques for reducing the IR signature of their ICBM. These techniques include the addition of materials and shapes to the nose section of ICBM vehicles that will reduce their IR signature in an effort to keep the Soviets from detecting and attacking their ICBM forces.

[Research Facilities]

46. A prerequisite to developing Stealth aircraft is the ability to measure very small changes in aircraft geometry as well as changes in the environment. The aircraft manufacturer must be able to detect and measure small changes in the environment. This can be done by using a high-speed measurement system that can be used to measure small changes in the environment. The system must be able to detect and measure small changes in the environment. This can be done by using a high-speed measurement system that can be used to measure small changes in the environment.

47. The Soviets are capable of constructing a compact and lightweight radar detection system that can be used to detect small changes in the environment. This can be done by using a high-speed measurement system that can be used to measure small changes in the environment.

[Acquiring and Using Stealth Technology]

42. Soviet scientists have shown an interest in reducing the IR signature of aircraft. They have investigated the use of materials and shapes to reduce the IR signature of aircraft. The materials used are designed to reduce the IR signature of aircraft in an effort to keep the Soviets from detecting and attacking their ICBM forces. The materials used are designed to reduce the IR signature of aircraft in an effort to keep the Soviets from detecting and attacking their ICBM forces.

48. We have identified three outdoor ranges in the Soviet Union capable of performing radar cross section measurements. The most active of these ranges is at Voronezh.

49. The range at Voronezh has probably been used to measure the radar cross section of several aerodynamic vehicles.
for low radar cross section measurements and, with further development, could be capable of measuring objects with even lower radar cross sections. The Yaroslavsk range is our best candidate for further development of the advanced measurement capability necessary to support both counter-Stealth sensor developments and numerous low signature and Stealth vehicle development programs.

With the advent of cruise missiles with inherently low radar cross sections, the Soviets require sophisticated radars capable of measuring the radar cross section of smaller targets. In the past, such US radars required carefully controlled, sloped surfaces extending over great lengths—often several kilometers—against which properly engineered wave reflected radar waves and unconvincing targets that, in turn, reflected the energy into carefully calibrated receiver antennas. Such large radars are known to exist. Modern radar systems have reduced the requirements for control of ground surfaces.

Aerodynamic Systems

Achieving Stealth is dependent on the integration of shaping and signature reduction technologies into a weapon system. We are aware that for years the Soviets have applied some methods and techniques of signature control—most notably radar return modification, infrared emission reduction, and low probability of intercept signals—to some of their weapon systems. By combining these methods and techniques, the Soviets could design a low signature flight vehicle; however, we have not concluded that Soviet designers have developed any conceptual approaches to Stealth vehicle in that measured development of an effective solution is only half way. They may rely on current designs, but improving US program to provide a conceptual study for their current classes.

Nevertheless, the Soviets have demonstrated a lack of a suitable design theory and have shown sufficient interest in related research areas to indicate that they are developing some signature reduction technologies. We believe that several independent researchers are continuing.

52 Articles in Soviet technical publications indicate an understanding of radar cross section reduction and airframe shaping techniques. The Soviets have conducted extensive research on radar absorbing materials and have developed a wide range of proven materials upon which their designs may draw. Although the new generation of Soviet fighters reported to contain 10 to 20 percent composite materials by weight, we have no information on the Soviet approach to the problems posed by bonding and adhesive materials required to apply composite materials successfully to airframe construction.

53 Optimum shaping for low radar cross sections could result in airframes that are structurally stable in flight. The Soviets may be conducting ground-based research in advanced aerodynamic flight controls and flow-reflective concepts at the Nevelskaya Scientific Institute of Aviation Problems.

61 In testing the radar and infrared signatures of high-performance turbine engine may well be the pacing factor in the development of any Stealth vehicle. The Soviets may be using ground-based radar to reduce the IR signature of the engines on some of their attack helicopters in reaction to the heat-seeking missile threat in Afghanistan, but external shielding of this type tends to increase the size of radar return. While they have redesigner helicopter engine exhausts, an attempt to reduce the IR signature, we are not aware of any Soviet program to reduce the infrared signatures of other types of aerodynamic vehicles.

56 The Soviets are progressing rapidly in several electronic fields associated with low-signature vehicle development. In the areas of airborne communications, the Soviets have the necessary technology to develop advanced radars. These devices communicate by means of short, high-powered bursts, that reduce the likelihood of an intercept that would give away the position of the host vehicle. Spread spectrum communications also has a high potential for application to stealth aircraft. We expect the Soviets to lead in airborne surveillance systems by 1980.

56 The Soviets have sufficient technical capability to satisfy the power generation requirements of Stealth vehicles. Laser gun equipment has been produced in the Soviet Union, and recent reports have noted the capabilities of US space-based navigation aids for non-detecting infrared, low-altitude, high-maneuvering, high-temperature. Projected improvements to the Soviet (ORASS) space-based navigation system may enable it to support Stealth operations.
57. The Soviets are also progressing rapidly in radar technologies. They have developed an electronically scanned phased-array antenna for the MiG-31 Foxhound and a phased-array processor for the 111Q5 Mainstay AWACS aircraft. They probably will investigate wideband signals and frequency agility techniques in order to reduce the emission signatures of their current airborne radars and meet the requirements of stealth vehicles. They have already fielded wideband jamming and narrow-band optical systems (laser rangefinders) in the MiG-29 Fulcrum.

58. The Soviets are testing a new generation of air-launched cruise missiles designed in the 1970s that have remarkably low external signatures that could be reduced through ingenious camouflage and use of radar absorbing materials.
Ballistic Missile Systems

68. Renewed US interest in strategic defense places a premium on early identification and very accurate tracking of ballistic missiles, reentry vehicles (RVs), and space vehicles. The Soviets may attempt to neutralize a layered defense by exploiting signature reduction techniques, many of which are equally applicable to aerodynamic, ballistic, or space vehicles. For example, the Intelligence Community has assessed the SS-18 to have a greater throw weight or range, or a combination of both, based on improvement of its propulsion system. The increased capability could be used to modify the payload vehicle to carry fewer signature-reducing vehicles and additional penetration aids and other counter-SUR devices. Over the longer term, the Soviets also might experiment with lower signature propellants and may use other techniques to achieve range and payload performance similar to that of the SS-18. They also may use other signature-reducing techniques like radar-absorbing paints and materials to reduce the vulnerability of their missiles and warheads to interceptors.

69. The Soviets probably began to apply signature-reducing techniques to ballistic missile reentry vehicles in the late 1980s.\[1\]

Intelligence Gaps

\[1\] Our calculations indicate that an absolute temperature of 1000°C or greater have melted within the RV heat shield could reduce the return signal, the maximum of the Coulomb depends on the frequency of the penetrating radio wave and the heat shield, transparency, and configuration of the contact or interface. Heat shield materials. On the basis of this activity, we conclude that the Soviets are likely using materials to modify the signature of some of their weapons systems.
Table 3
Likely Soviet Stealth Technology Efforts
ANNEX

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