D. Intelligence Gaps and Limitations

The Soviet Collection Program

109. Our understanding of the various mechanisms used by the Soviets and their Warsaw Pact allies to acquire Western space-related technology is adequate for determining the overall level of threat posed to Western sources. [redacted] Our information is less comprehensive, but still sufficient, for assessing those collection mechanisms that have been the most productive for the Soviets since the mid-1970s. [redacted]

110. [redacted]

111. [redacted]

Soviet Needs

112. In assessing future developments, whether technologies or systems, there are obviously factors for which we cannot account. Even if we could define completely the Soviet status in each of the technologies addressed in this Estimate, we would still face some serious uncertainties when attempting to predict future Soviet military developments. In many cases, the Soviets are as uncertain as we are about the outcome of their research. Future developments will depend upon the success or failure of various research projects, decisions yet to be made, intentions that may change, leadership changes, and reactions to future US weapon military and military-related space systems. [redacted]

113. [redacted]

[redacted]

[redacted]

Table 2
Application and Benefits of Critical Western Space Technology to Soviet Military-Related Space Systems

Space System	Critical Technologies	Likelihood of Flight Test	Estimated Date of First Flight Test	Soviet Benefits
Soviet technologies now available				
Modular space station	K Large structures K Propulsion K Guidance and navigation	High	1985-87	Demonstrate and develop technological capability for long-term, continuous manned space operations including surveillance, experimentation, and manufacturing
Space transportation	K Propulsion Aerodynamics Cryogenic fuel storage and handling K Materials Thermal protection system K Computing K Guidance and navigation (for space tug) K Large structures Remote manipulator Power extension system K Power sources Power extension system	High	1986-88	Heavy-lift launch capability, on orbit construction and repair
Spaceplane	K Propulsion Aerodynamics K Materials Thermal protection system K Guidance and navigation	High	1985-87	Improved cross-range maneuvering capability, shorter response time for manned missions
Spacecraft-to-spacecraft data relay	25X1 [redacted] K Attitude control Tracking	High	1986-89	Improved communications coverage, reliability, and survivability
Protok digital data transmission	25X1 [redacted]			
Hybrid military communications	K Signal processing 25X1 [redacted]	High	1985-87	Improved real-time military communications and survivability of communications
GLONASS navigation	25X1 [redacted]		1982	Improved navigation accuracies for airborne and sea-based users
Electro-optical reconnaissance	K Sensors 25X1 [redacted]		1982	Near-real-time reconnaissance

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

Table 2 (continued)
Application and Benefits of Critical Western Space Technology to Soviet Military-Related Space Systems

Space System	Critical Technologies	Likelihood of Flight Test	Estimated Date of First Flight Test	Soviet Benefits
Soviet technologies now available				
Geosynchronous launch detection	K Sensors 25X1 [redacted] K Signal processing 25X1 [redacted] K Attitude control 25X1 [redacted]	High	1984-86	Wide-area continuous surveillance capability
Developmental ASAT (with fragmentation warhead)	K Sensors Thermal infrared or submillimeter wave K Signal processing Target/background discrimination		1976	Improved ASAT system
Radiofrequency ASAT spacecraft or jamming spacecraft	K Power sources K Signal processing K Microelectronics K Directed energy 25X1 [redacted]	Low	Late 1980s	Multiple target capability: non-coorbital engagement
Soviet technologies not yet available				
Megawatt-class laser ASAT	P Directed energy 25X1 [redacted] P Power sources P Propulsion (multimegawatt class) 25X1 [redacted]	Moderate Low to moderate (Multimegawatt class)	Late 1980s to early 1990s Mid-1990s	Multiple target capability: noncoorbital engagement
Submarine (laser) communications	25X1 [redacted]			
25X1 [redacted]				
Advanced electro-optical reconnaissance	P Sensors Electro-optical arrays M Command and control Data relay (100 megabits per second) M Signal processing A/D conversion Digital processing M Attitude control K Microelectronic	Moderate	Early 1990s	General reconnaissance Indications and warning with worldwide visible and infrared real-time coverage through satellite relay

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P: Pacing—cannot start without.
M: Major—expect to have when needed.

Table 2 (continued)
Application and Benefits of Critical Western Space Technology to Soviet Military-Related Space Systems

Space System	Critical Technologies	Likelihood of Flight Test	Estimated Date of First Flight Test	Soviet Benefits
Soviet technologies not yet available				
Radar (imaging) reconnaissance	[redacted] M Sensors Synthetic aperture radar [redacted] K Microelectronics	Moderate to high	Mid-to-late 1990s	Real-time monitoring; 24-hour, all-weather reconnaissance for targeting flexibility
Aircraft detection	P Sensors [redacted] M Large structures Antenna [redacted] K Attitude control	Moderate	Mid-to-late 1990s	Detect bombers, cruise missile carriers, tankers, transport-sized targets
Large space station	P Large structures M Attitude control K Life support K Power sources Nuclear power system for manned spacecraft	High	1990-92	Continuously manned operations; sustained surveillance, experimentation, and manufacturing
Soviet technology availability in the 1980s doubtful				
Particle-beam ASAT	P Directed energy Ion source Accelerator Beam focusing and stripping Pointing and tracking M Power sources M Sensors Beam sensing for target acquisition Damage assessment [redacted]	Low	Mid-to-late 1990s	Multiple target capability: non-coorbital engagement

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

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~~Top Secret~~ [redacted]

Table 2 (continued)
Application and Benefits of Critical Western Space Technology to Soviet Military-Related Space Systems

Space System	Critical Technologies	Likelihood of Flight Test	Estimated Date of First Flight Test	Soviet Benefits
Soviet technology availability in the 1980s doubtful				
Laser ballistic missile defense	P Directed energy Laser source Thermally stable, adaptive, large segmented optics Pointing and tracking K Power sources [redacted] P Computing Battle management P Sensors Acquisition and damage assessment	Low to moderate	Late 1990s to early 2000s	Boost phase to midcourse RV defense: hard kill at 1,000 kilometers
Particle-beam ballistic missile defense	P Directed energy Beam source Accelerator Beam focusing and stripping Pointing and tracking P Power sources [redacted] P Computing Battle management P Sensors Beam sensing for target acquisition Damage assessment	Low	2000 ?	Advanced boost-phase ballistic missile defense
Limited area submarine wake detection	P Sensors SAR P Signal processing [redacted]	Low to moderate	Mid-to-late 1990s	High search rate; detection of surface manifestations of submarine wakes

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

[redacted]

[redacted]

Table 3
Developmental and Prospective Soviet Military-Related Space Systems and Critical Technologies

Critical Technologies		Military Systems
[redacted]	K	Aircraft detection
		[redacted]
	K	GLONASS navigation
	K	Particle beam ASAT
	K	Limited area submarine wake detection
	P	Laser ballistic missile defense
	K	Electro-optical reconnaissance
	P	Particle beam ballistic missile defense
	K	Advanced electro-optical reconnaissance
	P	Radar (imaging) reconnaissance
		[redacted]
	K	Hybrid military communications
	K	Geosynchronous launch detection
	M	Megawatt-class laser ASAT
		[redacted]
Sensors	K	Developmental fragmentation-warhead ASAT
	K	Geosynchronous launch detection
	P	Laser ballistic missile defense
	P	Aircraft detection
	P	Particle beam ballistic missile defense
	P	Limited area submarine wake detection
	K	Electro-optical reconnaissance
	M	Advanced electro-optical reconnaissance
	M	Radar (imaging) reconnaissance
	M	Neutral particle beam ASAT
[redacted]		[redacted]
	K	Hybrid military communications
	P	Limited area submarine wake detection
	P	Radar (imaging) reconnaissance
	K	Geosynchronous launch detection
	M	Aircraft detection
	K	Electro-optical reconnaissance
	K	Developmental fragmentation-warhead ASAT
	K	Radiofrequency spacecraft damage or jamming
	M	Advanced electro-optical reconnaissance
Power sources	K	Space transportation system
	P	Megawatt-class laser ASAT
Power sources	K	Radiofrequency spacecraft damage or jamming
	M	Particle beam ASAT
	K	Large space station
	K	Laser ballistic missile defense
	P	Particle beam ballistic missile defense
Attitude control	M	Large space station
	K	Aircraft detection
	K	Geosynchronous launch detection
		[redacted]
	M	Advanced electro-optical reconnaissance
Directed energy	P	Particle beam ASAT
	P	Laser ballistic missile defense
	P	Megawatt-class laser ASAT
	P	Particle beam ballistic missile defense
	K	Radiofrequency ASAT spacecraft or jamming spacecraft
Large structures	K	Space transportation system
	K	Modular space station
	M	Aircraft detection
		[redacted]
	P	Large space station
Propulsion	K	Modular space station
	P	Multi-megawatt-class laser ASAT
	K	Space transportation system
	K	Spaceplane
Guidance and navigation	K	Modular space station
	K	Space transportation system
	K	Spaceplane
		[redacted]
Computing	K	Space transportation system
	P	Laser ballistic missile defense
	P	Particle beam ballistic missile defense
Materials	K	Space transportation system
	K	Spaceplane
		[redacted]
Microelectronics	K	Radiofrequency spacecraft damage or jamming
	K	Advanced electro-optical reconnaissance
	K	Radar (imaging) reconnaissance
Life support	K	Large space station

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

[redacted]

Table 4
Applications and Benefits of Critical Western Space Technology to Soviet Nonspace Military Systems

Military System	Critical Technologies	Likelihood of Occurrence	Estimated Initial Operational Capability	Soviet Benefits
Attack helicopter	P Sensors K Materials	Medium	1993-97	Survivability; firepower; agility; all-weather operations; indirect armor and mobile target attack
Fire-and-forget heliborne antitank missile	[redacted] M Sensors [redacted] M Microelectronics LSI Packaging	Medium	1993-97	Increased probability of kill and decreased launch platform vulnerability
Mobile high-energy laser	P Directed energy Pointing and tracking K Power sources	Medium	1995-2000	Improved battlefield air defense
Airborne laser	K Directed energy Optics Packing	Medium	1995-2000	Improved battlefield air defense long-range intercept; self-defense; strategic air defense
[redacted]				
Long-range air-to-air missile	P Sensors M Computing K Propulsion	Low	1992-97	Attack at long range; supersonic speed; multiple simultaneous combat engagements
RAM M high-altitude reconnaissance aircraft	K Sensors K Signal processing	High	Before 1988-90	Near-real-time battlefield technical reconnaissance
[redacted]				
Moored passive acoustic system follow-on	K Signal processing K Computing Command, control, and communications and fiber optics	High	1988-90	Long-range detection on approaches to major bases; improved defense of some SSBN operating areas
Parametric sonar	K Signal processing K Computing	Low	1988-90	[redacted] fire control; communications and bottom sounding; short-pulse narrow beam with small aperture
New low-frequency hull-mounted sonar	K Signal processing	Medium	1990-93	Long-range detection by convergence zone and bottom-bounce techniques
Towed array	K Signal processing K Sensors	Medium	1990-95	Reduced reliance on active sonar; improved passive detection

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

Table 4 (continued)
Applications and Benefits of Critical Western Space Technology to Soviet Nonspace Military Systems

Military System	Critical Technologies	Likelihood of Occurrence	Estimated Initial Operational Capability	Soviet Benefits
Airborne submarine wake detector (limited area)	P Signal processing P Sensors	Low to medium	1990-97	High-search-rate detection of surface manifestations of submarine wakes
Follow-on high-energy laser	K Directed energy Pointing and tracking	Medium	1995-2000	Shipborne self-defense
Advanced mobile and airborne command and control	M Microelectronics	High	1990-95	Centralization and survivability of ICBM control; increased capacity; decreased reaction time

25X1 [redacted]

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

CIA Statute [redacted]

Table 5
Critical Technologies Required by Soviet Nonspace Military Systems

Critical Technologies		Military Systems
25X1 [redacted]		
Sensors	P	Attack helicopter
	M	Fire-and-forget heliborne antitank missile
	P	Long-range air-to-air missile
	P	RAM M high-altitude reconnaissance aircraft
		25X1 [redacted]
	K	Towed array
Signal processing	P	Fire-and-forget heliborne antitank missile
	K	RAM M high-altitude reconnaissance aircraft
		25X1 [redacted]
	K	Moored passive acoustic system follow-on
	K	Parametric sonar
	K	New log-frequency hull-mounted sonar
	K	Towed array
	P	Airborne submarine wake detector (limited area)
		25X1 [redacted]
Power sources	K	Mobile high-energy laser
		25X1 [redacted]
Power sources		25X1 [redacted]
Directed energy	P	Mobile high-energy laser
	K	Airborne laser
		25X1 [redacted]
	P	Follow-on high-energy laser
		25X1 [redacted]
Propulsion	K	Long-range air-to-air missile
Computing	M	Long-range air-to-air missile
		25X1 [redacted]
	K	Moored passive acoustic system follow-on
	K	Parametric sonar
		25X1 [redacted]
Materials	K	Attack helicopter
Microelectronics	M	Fire-and-forget heliborne antitank missile
		25X1 [redacted]

K: Key—available now.
P: Pacing—cannot start without.
M: Major—expect to have when needed.

CIA Statute [redacted]

Annex A

Apparent Soviet Attempted Duplication of US Systems and Subsystems

1. This annex presents only those cases where we 25X1 25X1 [redacted] base our judgments on the similarities of Soviet space system or subsystem characteristics to those of US space systems or subsystems. CIA Statute [redacted]

25X1 [redacted]

25X1 CIA Statute [redacted]

25X1 [redacted]

4. Unlike the Soviet radar systems available in 1978, Seasat was capable of generating high-resolution radar imagery from space. The long pulse duration was required to satisfactorily illuminate the targets in the scene, the coherence and compression factors provided enhanced resolution in azimuth and range respectively, and the 25X1 [redacted] wavelength was especially useful for ocean imagery. CIA Statute [redacted]

25X1 [redacted]

25X1 CIA Statute [redacted]

25X1 [redacted]

25X1 [redacted]

Global Navigation Satellite System (GLONASS)

10. 25X1 [redacted] the Soviet GLONASS system appears to be, at least in concept, identical to the US NAVSTAR Global Positioning System (GPS). 25X1 [redacted] 25X1 [redacted] 25X1 [redacted] Information on the US GPS system has been publicly available since the mid-1970s, and we believe the Soviets could easily have used it to help design their own system. CIA Statute [redacted]

Satellite Data Relay System

11. The Soviet Satellite Data Relay System (SDRS) appears to be, at least in concept, a clone of the US Tracking and Data Relay Satellite System (TDRSS). The Soviets have launched two precursor spacecraft—one in 1982 and one in 1984. 25X1 [redacted] 25X1 [redacted] 25X1 CIA Statute [redacted]

12. The main features of the Tracking and Data Relay Satellite System are the ability to track satellites automatically and to relay data from other US satellites to a ground station in the United States. One of the prime users of the system is the manned shuttle orbiter. CIA Statute [redacted]

13. The mission of the Soviet system, as stated in filings with the International Frequency Registration Board, is to relay data from low-orbiting satellites to ground stations in the USSR. The only users specified in the filings are manned Salyut-type space stations. The Soviet satellite, like the US satellite, will be placed in a stationary Earth orbit. The common frequency bands of both systems correspond almost exactly. (s)

Annex B

25X1
[redacted]

25X1

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25X1

25X1

CIA Statute

Annex C

Key Soviet Space Systems and Their Technology Needs

Systems in Development— Technologies Now Available

Modular Manned Space Station

1. Soviet statements of intentions to build modular space complexes have been clearly borne out by testing which has taken place in the early 1980s. In June 1981 the Soviets docked Cosmos 1267 (a new Salyut-class space station module) to the Salyut-6 space station and performed dynamic testing. This was followed by the docking and manning of another Salyut-class space station module (Cosmos 1443) with Salyut-7 in 1983. We believe the Soviets currently have all of the necessary technology required to construct an operational modular space station consisting of a core vehicle (possibly Salyut-8 with multiple docking adaptors) and multiple Salyut-class space station modules. Guidance and control algorithms and procedures for such a new structure will need to be perfected. The mission of a modular space station would probably be a continuation of activities presently done on the Salyut space stations, including military research, but probably with emphasis on space-based manufacturing using dedicated space station modules. [redacted]

Space Transportation System

2. The Soviets are developing a reusable space transportation system (STS) that includes development of a new heavy-lift launch vehicle, a shuttle orbiter that is virtually identical to the US shuttle orbiter, and probably an orbit transfer vehicle (space tug). Development of the Soviet STS probably began in the mid-1970s shortly after cancellation of their SL-X-15 (TT-05) heavy-lift launch vehicle program. At least one prototype shuttle had been produced in early 1983 and was involved in captive flight-testing atop a Bison aircraft. [redacted]

3. The Soviet developmental shuttle orbiter is virtually identical to the US shuttle orbiter in both appearance and physical dimensions. The major difference is that the US design has the large main boost engines on the shuttle orbiter, while the Soviet design has them on the launch vehicle. [redacted]

4. The new Soviet heavy-lift launch vehicle, the SL-W, [redacted] The first launch of the heavy-lift vehicle (without the shuttle orbiter) could occur in 1985. [redacted]

5. Comments by the Soviets in open literature imply that they are developing a space tug that would work in concert with their shuttle orbiter to retrieve disabled spacecraft and return them to low-Earth orbit or to Earth for repair. A space tug could also be used in the assembly of space stations and solar power platforms or to increase the operational life of Soviet spacecraft. [redacted]

6. The development of an STS will radically change the way the Soviets conduct a major portion of their space operations. It will allow such operations as on-orbit repairs and spacecraft retrieval—both of which will have particular significance to the Soviets in light of the short lifetimes of their current spacecraft. [redacted]

7. Because of its similarity in shape and size to the US shuttle orbiter, we believe that the Soviet shuttle orbiter will have similar payload capabilities and perform the same type of missions as the US system. It will probably provide passenger and cargo transportation to large manned space stations and also enable delivery, recovery, refueling and repair of new families of spacecraft designed to be compatible with the Soviet shuttle orbiter. [redacted]

8. While we believe the Soviets now possess the bulk of the technology required for the STS, they will have a continuing need to improve the supporting subtechnologies. Particularly valuable will be performance data on the operation of components of the US STS. This will save the Soviets considerable time and resources and reduce risks. Such critical technologies include aerodynamics, thermal protection, and computing. Because of continuing Soviet interest in optimizing the use of their STS, they will also have a need

for a grappling arm like the Canadian arm on the US shuttle orbiter and a power extension system to allow flights longer than about a week. [redacted]

Spaceplane

9. The Soviets have in development, for probable operational deployment in the late 1980s, a reusable aerodynamic space vehicle that is about one-fifth the size of their shuttle orbiter. The vehicle will probably carry a crew of from two to four cosmonauts and a relatively small payload. [redacted]

10. We believe the spacecraft is being designed for multipurpose missions. Possible missions will include reconnaissance, satellite inspection and negation, and use as a crew transport vehicle. The Cosmos-1374-type vehicle, which we believe to be a subscale model of the spaceplane, [redacted] The purpose of this vehicle is probably to assess the flight characteristics of the vehicle design [redacted] and possibly to serve as a test bed for evaluating the performance of materials during reentry. [redacted]

11. The development of a spaceplane with the capability to perform the missions listed above would require a thorough understanding of lifting reentry body guidance and control capability, thermal protection systems for reentry, and an aerocontrol system. [redacted]

Satellite-to-Satellite Data Relay System

12. The Satellite Data Relay System (SDRS) will consist of a three-satellite network in geostationary orbit and two ground stations in the extreme eastern and western ends of the USSR. The purpose of this system is to relay data from low-orbiting satellites to the two ground stations. [redacted] The Soviets stated that one of the low-orbiting users would be manned space stations of the Salyut type. [redacted] Such a system could eliminate the need to use inefficient store-dump systems for data retrieval from these low-orbiting satellites. [redacted]

[redacted]

13. [redacted]

POTOK

14. This system will consist of a three-satellite network in geostationary orbit and two ground stations in the extreme eastern and western ends of the USSR. The purpose of this system is to relay digital data from thus far undefined peripheral Earth stations to the two ground stations. (U)

15. [redacted]

Hybrid Military COMSATS

16. These spacecraft will provide real-time multiband communications relay services to a large number of military users including airborne, naval, land-fixed, and land-mobile users. [redacted]

17. The technologies needed for these satellites—including data relay, switching, and signal processing—are not new ones and present no problems to the Soviets. This system is behind schedule. [redacted]

Global Navigational Satellite System

18. According to Soviet public statements, the Global Navigation Satellite System (GLONASS) will consist of nine to 12 spacecraft and will provide navigational service both for ships and aircraft. The resultant positional accuracies will possibly be as good as 30 meters. [redacted]

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[redacted]

19. [redacted] information on the US NAVSTAR Global Positioning System may, however, have aided the Soviets in the design of their system. [redacted]

Electro-Optical Reconnaissance System

20. The Soviet Union flight-tested its first near-real-time imaging space system in late 1982 and early 1983. The spacecraft stored image data and subsequently relayed it back to the Soviet Union through a developmental Soviet data-relay satellite in geosynchronous orbit designated as Cosmos 1366. The imaging spacecraft's sensors operated in the visible region in one spectral band, and we believe it provided a resolution of between 1.5 and 3.0 meters with associated swath widths of between 5 and 20 km, respectively. [redacted]

Geosynchronous Launch Detection System

21. We believe that the Soviets will develop a network of spacecraft in geosynchronous orbits, possibly similar to US Defense Support Program spacecraft, to provide coverage of nominal launch areas for long-range SLBMs and possibly to supplement current Soviet coverage of US ICBM launchsites. Additionally, the spacecraft could provide detection of ballistic missile launches from Europe and China redundant to and slightly earlier than that provided by ground-based radars. Current Soviet launch detection spacecraft (LDS) are in semisynchronous orbits. A geosynchronous spacecraft launched in March 1984 apparently is intended to supplement current semisynchronous LDS coverage of US ICBM fields. It is also possible that this is the first of several planned by the Soviets in the next few years to test new sensors and systems for detecting US SLBM launches. [redacted]

22. [redacted] we believe the Soviets now have the required level of technology to develop an improved LDS system. [redacted]

Developmental Orbital Fragmentation-Warhead ASAT System

23. The Soviets have had an operational fragmentation-warhead orbital antisatellite system since at least 1971 which uses a radar for target acquisition and homing. The Soviets have also been testing since 1976 a developmental orbital interceptor. [redacted]

24. The Soviets need to improve the homing sensor if they are to achieve success in their developmental ASAT program. Technologies critical to this system are either visible, infrared, millimeter- or sub-millimeter-wave sensor technology with associated target/background discrimination technology. We believe the Soviets possess the required technologies [redacted]

Space-Based Radiofrequency Spacecraft Damage or Jamming System

25. As of the mid-1970s the Soviet General Staff was considering the problem of how to employ space-based jammers to interfere with military communications and ground-based radars. Although the Soviets have the technological capability to deploy not only space-based jammers but also antisatellite radiofrequency (RF) damage weapons, we [redacted] consider the likelihood of the Soviets building such a spacecraft by the 1990s to be very low. [redacted]

26. If the Soviets decide to develop space-based RF weapons or jammers they would not lack any of the required technology. The Soviets could use existing launch facilities and boosters to place RF weapons or jammers at altitudes sufficient to deny US spacecraft-to-spacecraft crosslinks and uplink command and control signals or to burn out sensitive spacecraft receiver components. [redacted]

Future Systems—Required Soviet Technologies Not Yet Available

Space-Based Laser ASAT System

27. We believe the Soviet Union has a project to develop a space-based laser system which would initially have an antisatellite capability but could be improved to allow other applications. It would offer the advantage of increased lethality over ground-based laser ASAT systems, would have no weather constraint, would provide a multishot capability, and advance systems could engage targets [redacted] We believe that there is a moderate likelihood that the Soviets will test, by the early 1990s, a megawatt-class weapon system [redacted]

28. [redacted] The Soviets probably do not yet possess the technology levels required for a megawatt-class ASAT system. [redacted]

Submarine (Laser) Communications System

29. Soviet spacecraft communications research has included efforts to develop a spacecraft-to-submarine laser communications link. The research was initiated about 15 years ago and involves experimentation with blue-green lasers that can be used to communicate with submerged submarines. [redacted] A laser communications link would be able to handle extremely broadband, short-duration signals to enhance the security and survivability of submarines on patrol. [redacted] We judge there is a moderate likelihood that testing of laser communications components will take place in space in the mid-to-late 1980s, followed by a first flight test of a submarine laser communication spacecraft in the late 1980s to the early 1990s [redacted]

30. A required technology [redacted] is the pointing and tracking necessary to aim a narrow laser beam at a submarine. [redacted] The GLONASS network will be able to provide position information to the laser communications satellite. We believe the Soviets have made adequate progress in developing another required capability—modulation of the broadband laser beam. [redacted]

[redacted]

Radar Reconnaissance (Imaging) System

33. A radar-imaging reconnaissance system could augment the USSR's photoreconnaissance systems by obtaining images in all types of weather and lighting conditions. A space-based synthetic aperture radar (SAR) is the most likely means for providing this capability. The Soviets have conducted R&D flights of SARs for nonacoustic ASW research on aircraft since 1971 [redacted] The timely nature of the information obtainable with such a system will also require near-real-time satellite-to-satellite data relay to the ground station and relay of the results to appropriate users. [redacted]

Space-Based Aircraft Detection System

34. We believe the Soviets perceive a requirement to detect and locate large US aircraft, specifically bombers and cruise missile carriers, over certain critical routes. [redacted]

35. Soviet experience with space-based real-aperture radars dates back to the first RORSAT in 1971. Further development, however, of sufficiently large antennas of accurate shape and which can be rapidly scanned, such as a phased-array radar, is required to detect aircraft. A 10-meter-diameter, 2-GHz-frequency parabolic-dish antenna was tested in 1979 on Salyut-6 but it did not properly deploy. Soviet clutter suppression technology also needs to be improved significantly over that currently associated with the RORSAT. We believe that the indigenous Soviet technology required for development of a space-based radar aircraft detection system is likely to be available by the end of the 1980s. [redacted]

36. An infrared aircraft detection system would operate in the thermal IR (8 to 14 micrometers). It would require sensor elements small enough so that the aircraft occupies a significant fraction of the area of an element, and—depending on the scan technique used—a large number of detector elements (at least 1 to 10 million) to provide adequate coverage of the earth. The accuracy of spacecraft stabilization necessary for such a system would be about 3 to 10 microradians. We do not believe Soviet indigenous technology required for an IR aircraft detection system will be available until the 1990s. [redacted]

37. Spacecraft-to-spacecraft data relay is needed so that the ground station will have direct access to the spacecraft at all times. An onboard central processor will also be required to handle moving target detection, target discrimination, and signature analysis algorithms. [redacted]

Large Space Station

38. By the early 1990s the Soviets' experience with their modular space station probably will be sufficient to allow the initiation of construction of a large space station. The components of such a station would be modules, each of the Skylab class, that would be launched by the heavy-lift launch vehicle. We expect the assembly of such a station to take place over several years, with initial crew sizes ranging from 12 to 20 persons. The Soviet STS would resupply and transfer crews to the space station. The uses of such a large space station would include: maintenance, repair, and control of spacecraft in orbit; a transnuclear conflict command post pending relocation/reconstitution of terrestrial authorities; military R&D; directed-energy weapons development; scientific and industrial work in a zero-gravity environment; stocking of fuel and supplies for lunar or planetary expeditions; and the assembly of interplanetary and other spacecraft that would be free of the design constraints imposed by the requirements of vibration and aerodynamic flow during launch. [redacted]

39. Operation of the large space station for some activities will require new guidance and control techniques. The Soviets will need to study the dynamic properties of the large station, and both structural and distributed control will be needed if any large solar power arrays or other long booms are to be used. We believe the Soviets are considering the use of nuclear power sources for future manned spacecraft—possibly the large space station—to satisfy anticipated demands for power in space. New life support systems may be needed for the large station—perhaps a partially closed system using part expendable and part regener-

ative components—because this will be a new, large, and segmented structure and [redacted] potentially great resupply needs. [redacted]

Future Systems—Availability of Required Soviet Technologies in the 1980s Doubtful

Space-Based Particle-Beam ASAT System

40. Since the early 1970s, the Soviets have had a research program to explore the technical feasibility of a space-based particle-beam weapon (PBW) system. In this effort, the Soviets have developed some technically advanced components [redacted] into a complete test system. [redacted]

41. A space-based PBW ASAT system would destroy or degrade its target by directing a beam of high-energy neutral hydrogen atoms against the target. Energy from the beam would be deposited in the interior components of the target as opposed to the surface deposition (surface heating) caused by laser weapons. Prime power levels on the order of hundreds of megawatts would be needed for a thermomechanical kill of the target. If only the electronics of the target are to be upset, the prime power level required would drop drastically to the 100-kilowatt level—for similar ranges. Even for the lower prime power level, electronic upset is difficult to shield against. The technology requirements of a thermomechanical kill system, including precise pointing and tracking, are severe, and it is unlikely that the Soviets could test a prototype system earlier than the year 2000. Technology for a system intended only to upset spacecraft electronic systems could, however, be available by the late 1980s. A prototype system [redacted] tested in the mid-to-late 1990s. [redacted]

42. In general, the required technologies for a PBW ASAT include: ion sources; ion beam acceleration and focusing; beam neutralization (stripping off of the extra electron); power sources; pointing and tracking, target acquisition, and damage assessment (which would include methods of sensing the beam in order to measure where the beam is going and the sensing of gamma rays or neutrons returned from an illuminated target) [redacted] electronics for survivability [redacted]

Space-Based Laser Ballistic Missile Defense System

43. The development of a space-based laser ballistic missile defense (BMD) system would be more difficult than for a laser ASAT system. This is because greater laser energy would be required, many targets would have to be addressed in rapid succession, and the targets [redacted] and more difficult to damage [redacted]

44. Although a space-based laser BMD system may prove to be technically feasible, such a system would require significant technological advances in large-aperture mirrors and in pointing and tracking accuracy. Five- to 25-meter-diameter (depending largely on the laser's wavelength) segmented mirrors would be required which employ adaptive optics to maintain a coherent beam (to allow delivery of maximum energy on the target). In addition, orbit coverage would be needed of both ICBM and SLBM launch areas, and, since ballistic missiles are most susceptible to being tracked for only a short period after launch, a large number of spacecraft with rapid retargeting capability would be required. The system would require networking of the spacecraft and the use of a sophisticated onboard computer battle management system employing artificial intelligence in order to allow autonomous operation. In view of these requirements, which are in addition to those required for a laser ASAT system, we do not expect the Soviets to be able to test a [redacted] the late 1990s at the earliest. [redacted]

Space-Based Particle-Beam Ballistic Missile Defense System

45. The requirements on this system are a combination of the most demanding requirements of both the PBW ASAT and the laser BMD systems. A space-based PBW BMD system would be subject to the same fleet requirements as a space-based laser BMD system—large fleet sizes would be necessary for continuous coverage. The target return and damage assessment requirements would be more severe than for the laser ASAT or for a PBW ASAT—which would have only one target to assess. Beam sensing would be required for closed-loop tracking just as for the PBW ASAT. Because of these requirements, we do not believe the Soviets could test a prototype PBW BMD spacecraft by the year 2000. Major components of such a system, applicable also to a PBW ASAT [redacted] er, be tested before the year 2000. [redacted]

Space-Based Limited-Area Submarine Wake Detection System

46. The Soviets are actively studying ways [redacted] tecting submarine wakes using airborne radars [redacted]

[redacted]

47. [redacted]