SECRET

[redacted] UNCLASSIFIED

FTD-1744E-334-78

FOREIGN TECHNOLOGY DIVISION

Do Not Destroy; Only Copy

No File copy

EXECUTIVE SUMMARY
FORECAST OF SOVIET DIRECTED ENERGY ASAT SYSTEMS 1978-1998 (U)

FOIA required

NATIONAL SECURITY INFORMATION
Unauthorized Disclosure Subject to Criminal Sanctions

[redacted]

Classified by: USAF/IN[illegible]A
Exempt From General Declassification
Schedule of Executive Order 11652
Exemption Category 2
Declassify Upon Notification by the Originator

UNCLASSIFIED

[redacted]

UNCLASSIFIED

[redacted]

EXECUTIVE SUMMARY
FORECAST OF SOVIET DIRECTED ENERGY ASAT SYSTEMS 1978-1998 (U)

Authors: [redacted]

EXP B6

FTD-1744E-334-78

DATE OF PUBLICATION
15 December 1978

Information Cutoff Date
1 March 1978

NATIONAL SECURITY INFORMATION
Unauthorized Disclosure Subject to Criminal Sanctions

This product was prepared by the Foreign Technology Division, Air Force Systems Command. It has been reviewed and approved by the ACS/Intelligence, Hq USAF but does not necessarily represent an approved Department of Defense position and is not to be considered a Department of Defense Intelligence Product.

[redacted]

Classified By: USAF/INA
Exempt From General Declassification
Schedule of Executive Order 11652
Exemption Category 2
Declassify Upon Notification by the Originator

(Reverse Blank)

[redacted]

(This page is Unclassified)

UNCLASSIFIED

PREFACE

(U) The Executive Summary presents an overview of the forecasted Soviet capability to develop directed energy (DE) antisatellite (ASAT) systems. Ground-based, airborne, and space-based lasers, and particle beam ASAT systems are considered. Intelligence analysts, specializing in each of the subsystem technologies examined, worked on a team effort to assess these capabilities. The organization of this summary parallels that of the all-source study "Forecast of Soviet Directed Energy ASAT Systems 1978-1998 (U)." Detailed information on any of the subjects presented here as well as additional intelligence information may be found in the all-source study.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Cont)

LIST OF TABLES

CONCLUSIONS (U)

(U) ~~(S)~~ The Soviets have demonstrated a well funded directed energy (DE) program and it is probable that ASAT applications will be among the earliest missions considered. The use of DE weapons against US military satellites would prevent these satellites from performing their mission.

(U) ~~(S)~~ The Soviets are working in all the major technologies necessary for development of ground-based, airborne, and space-based laser ASAT systems, and space-based neutral particle beam ASAT systems

[redacted]

EXP 31

(U) ~~(S)~~ Initial studies indicate the Soviets could place a prototype* neutral particle beam ASAT in space during 1988-1998. Existing launch systems could boost the ASAT into several hundred kilometer orbits, but the maneuvering capability would be limited. The system would possess the potential to destroy electronics, optics, and hydrazine tanks of satellites at ranges of several thousand kilometers; however, the actual effective range would be limited by the tracking system to 300-500 km. With the limitations of low orbiting altitude and minimum maneuverability a neutral beam system would not be competitive with the projected space-based laser ASAT.

*(U) Prototype—a weaponized device with full design range and firing characteristics that requires a limited amount of further development before IOC.

[redacted]

~~SECRET~~

Fig. 1 Forecasted Soviet Laser ASAT Prototypes (U)

GXP B1

SECTION I INTRODUCTION (U)

(S) [redacted]

(U) The forecasted Soviet capability to develop a DE ASAT system was based on technologies that would not require scientific and engineering breakthroughs* (high-risk technologies). The DE ASAT prototype systems presented represent a best judgement forecast of the Soviet capabilities to 1998. A confidence level has been assigned to the forecast of each technology and system capability presented. The confidence level is based upon the quantity and quality of available intelligence information and upon the accuracy of long-term trend projections.

(U) ~~(S)~~ The types of DE ASAT systems considered (Figure 2) do not represent all possibilities, [redacted] on Soviet technological efforts. Other possible DE ASAT systems, such as a ground-based microwave system, were not examined.

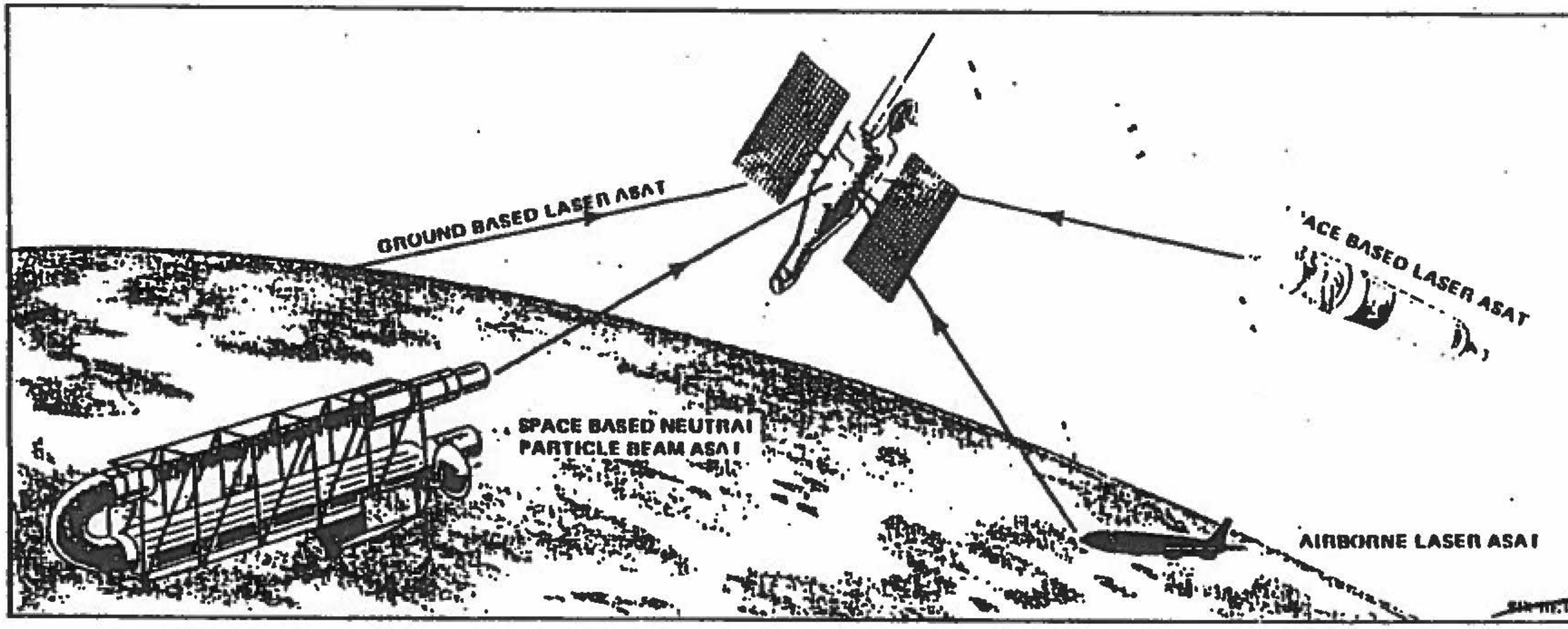


Fig. 2 Directed Energy ASAT System Concepts (U)

*(U) Scientific/engineering breakthroughs - major advances in scientific and engineering areas that require the development of scientific/engineering concepts and techniques not presently known.

SECTION II SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

(U) (S) The DE ASAT system prototypes discussed in this section are considered potentially deployable in the time frames shown, considering the known advancing Soviet capabilities in the necessary component technologies. Consideration of all the potential laser and neutral particle beam devices and related technologies is beyond the scope of this study. However, the devices chosen for system integration provide sufficient data to establish a quantitative assessment of a likely 0-20 year Soviet DE ASAT threat.

(U) (S) The computer code used to generate the laser calculations depicted in this section is an adaptation of the Air Force's COMBO laser propagation and scaling model. The device power is that laser power existing at the laser oscillator. COMBO propagates a (Gaussian) beam through a (Cassegrain) telescope that focuses the beam in the target plane. Because of mirror imperfections and diffraction in the telescope, approximately one-quarter difference in output power is observed between the oscillator exit aperture and the telescope exit aperture. The laser radiation intensities shown represent the average power per unit area.*

1. Ground-Based Laser ASAT (U)

1.a. Discussion (U)

(U) (S) Table 1 provides the parameters of the laser device and associated technologies that are believed most probable for a ground-based laser weapon ASAT prototype system in the time frames considered. The three ground elevations chosen for basing the laser weapon ASAT system (300, 1,500, and 3,000 m) reflect the following considerations: much more attractive atmospheric propagation conditions exist as elevation increases, Soviet optical viewing sites currently exist at elevations as high as 2,000 m, and geographic areas with elevations above 3,000 m and with suitable climates exist in the Soviet Union)

TABLE I

GROUND-BASED LASER ASAT PARAMETERS (U)

TECHNOLOGY	1978-1980	1980-1983	1983-1988	198[illegible]
Site elevation (m)	300	300		
		1,500	1,500	1,500
		3,000	3,000	3,000
Device type	CO_2 EDL*	CO_2 EDL	DF-CL**	DF-CL
Wavelength (μm)	10.6	10.6	3.8	3.8
Pointing and tracking (μrad)	15	15	10	1
Optics diameter (m)	1.5	1.5	3.0	3.0
Output power (MW)	0.5	2.0	5.0	10.0
Weather/humidity	Mild/15%	Mild/15%	Mild/15%	Mil[illegible]
Confidence level	H	H, L, L	H, H	M, M

*CO_2 EDL—carbon dioxide electric discharge laser.
**DF-CL—deuterium fluoride chemical laser.

(SECRET) (U)

*(U) This is a more realistic approach than representing laser radiation intensities on target as the peak power per unit area, which is frequently used.

SECRET

UNCLASSIFIED

EXP B1

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

(S) [redacted]

1.b. Assessments (U)

[redacted]

[redacted]

2. Airborne Laser ASAT (U)

2.a. Discussion (U)

(U) (S) The parameters of the laser devices and associated technologies selected for the airborne laser ASAT prototypes are shown in Table II. These prototypes are considered to represent the Soviet capability in the time frames considered. Two existing Soviet aircraft, CAMBER A (IL-86) and CANDID (IL-76), are capable of accommodating the required weights and volumes for a 10-hour cruise time above the tropopause.

TABLE II

AIRBORNE LASER ASAT SYSTEM PROTOTYPES (U)

PROTOTYPE	DEVICE		POINTING AND TRACKING			SYSTEM	
YEARS	TYPE/MODE	POWER (MW)	JITTER (μrad)	RANGE (km)	MIRROR (dia)(m)	WEIGHT (kg)	VOLUME (m³)
1983-1986 (4-1)*	CO_2EDL/CW	0.5	10	250	0.7	9,300	20
1983-1986 (3-1)	CO_2EDL/Pulsed	0.5	10	250	0.7	9,500	20
1986-1990 (3-1)	DF-CL/CW	1.0	4.	350	1.25	6,000	20

*Confidence level of the forecast.

SECRET (C)

*(U) Damage caused to a satellite's sensors by laser radiation of the same wavelength as the sensors are designed to detect. (Details in Section IV, paragraph 1.b.)

UNCLASSIFIED

SECRET

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

(U) (S) In Figure 1, flux on target for airborne lasers in an ASAT role is plotted for 45 degree zenith angles. This figure shows that these airborne lasers can produce damage that is equivalent to that produced by ground-based lasers; however, the range of the airborne laser ASAT system is limited to a maximum of about 350 km because of infrared pointing and tracking requirements. Within this range somewhat more flux could be delivered on the target by the airborne laser if the beam was directed straight up (zenith angle of 0 degree), but the mirror sizes could not be increased enough to make a significant change in flux levels.

2.b. Assessment (U)

(U) (S) Airborne laser ASAT prototype systems [redacted] are less attractive than the space- or ground-based systems with respect to flux on target and range. An airborne laser ASAT system, however, would have the advantage of mobility over the ground-based system. This mobility would permit multiple target engagements and would bypass severe weather.

3. Space-Based Laser ASAT (U)

3.a. Discussion (U)

(U) (S) The prototypes projected for space-based laser ASAT systems are shown in Table III. The selected devices were based on a consideration of all the required technologies presented in Section III. A laser run time of 100 seconds was arbitrarily chosen to provide a multishot capability with engagement times of <100 seconds possible except for the CO_2EDL, which was electric power constrained to an engagement of 20 targets at 5-second run times. [redacted] Analysis of acquisition and pointing and tracking capabilities has shown that ranges of less than 500 km appear to be the maximum without scientific/engineering breakthroughs. The two laser devices selected for calculation reflect the probable first-generation laser weapon systems: the 10.6 μm CO_2 EDL and the 2.7 μm hydrogen flouride chemical laser (HF-CL). The Soviets appear to be further along in developing the CO_2EDL than the HF CL at this time; therefore, one can be more confident in predicting the CO_2EDL space-based laser ASAT capability. But from a weight, volume, and power requirement consideration the CL system would be the preferred development choice. The 0.5 MW HF-CL in Table III could be reduced in power to 0.4 MW with little change in damage capability and a several hundred kilogram reduction in system weight.

(U) (S) An important technology requirement for EDL systems is the power supply and power conditioning required to perform the specific missions. Consideration of a number of power devices for space-based laser devices leads to the following conclusions—space missions based on EDLs are not difficult to support from a power standpoint unless engagement numbers are high, and silver-zinc (AgZn) batteries appear to be the most likely choice the Soviets would make.

(S) [redacted]

(S) [redacted]

EXP 81

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

TABLE III

SPACE-BASED LASER ASAT SYSTEM PROTOTYPES (U)

PROTOTYPE	DEVICE		POINTING AND TRACKING			SYSTEM[2]	
YEARS	TYPE/MODE	POWER (MW)	JITTER (μm)	RANGE (km)	MIRROR (dia)(m)	WEIGHT (kg)	VOLUME (m^3)
1983-1988 (H)[1]	CO_2EDL/CW	0.5	5	350	1	9,300[3]	20
1983-1988 (H)	CO_2EDL/PULSED	0.5	5	350	1	9,500	20
1983-1988 [illegible] 1988-1998 (H)	HF-CL/CW	0.5	5	350	1	2,600[3]	15
1988-1998 [illegible]	HF-CL/CW	1.0	5	350	1	6,000[3]	20
1988-1998 (L)	HF-CL/CW	1.0	2	500	1	6,000	20

[1]Confidence level in the forecast based on consideration of combining prototype components and the confidence in the technology forecasts.
[2]Includes the weight and volume for laser device, fuel and tankage, and telescope; power supply, conditioning, fuel, and tankage if necessary; pointing and tracking system; C[3] package; and structure weight.
[3]Used in Figure 9.

~~(SECRET)~~ (U)

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

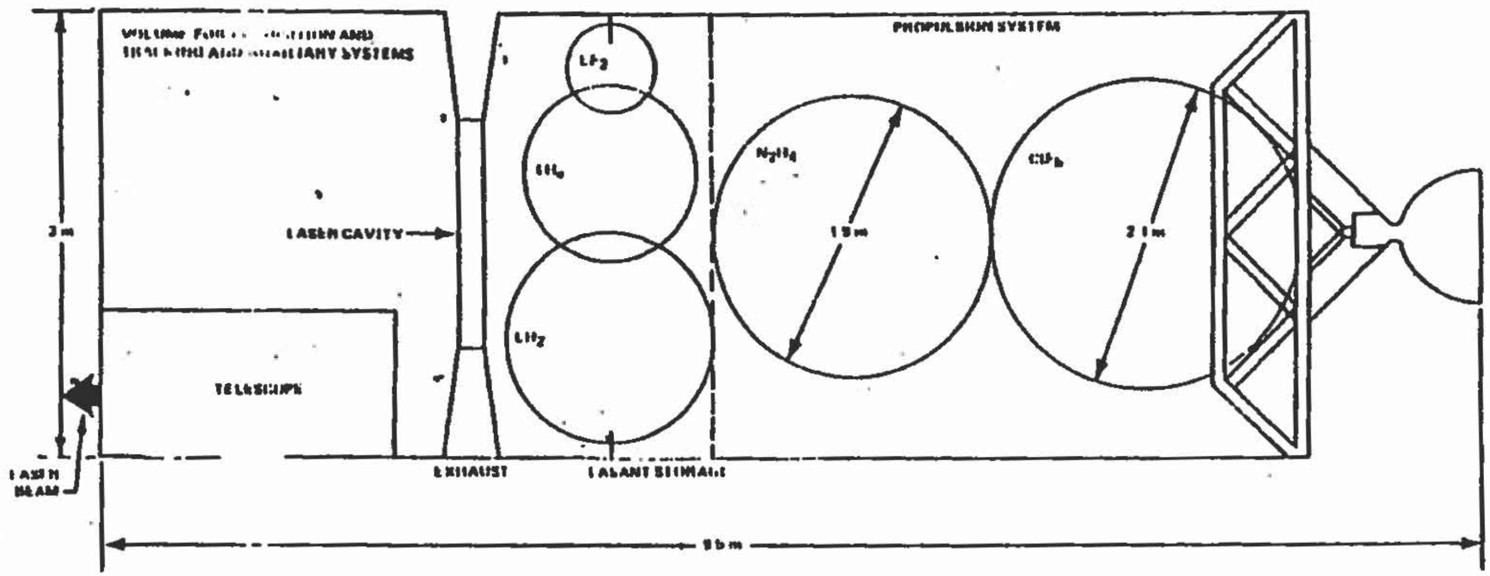
[redacted]

EX1
B1

[redacted] (U)

Fig. 3 Orbital Capabilities of Forecasted Directed Energy ASAT Prototypes (U)

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)



[redacted] (C)

Fig. 4 Hypothetical Soviet Space-Based Chemical Laser ASAT (U)

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

3.b. Assessments (U)

(1)(U) ~~(S)~~ 1978-1983—The Soviets are not likely to have a space-based high-energy laser ASAT capability.

(2)(U) ~~(S)~~ 1983-1988—The Soviets are likely to have the capability to develop a space-based CO,EDL ASAT prototype system [redacted]. The Soviets could field a space-based HF-CL ASAT prototype system [redacted]

(U) (3) ~~(S)~~ 1988-1998—The Soviets are very likely to have the capability to develop the HF-CL ASAT prototype system.

4. Space-Based Neutral Particle Beam ASAT (U)

4.a. Discussion (U)

(U) ~~(S)~~ The only type of particle beam weapon (PBW) that could be used in an ASAT role is a neutral beam weapon operating in space. Charged particle beams may propagate in the atmosphere, but they cannot propagate over long distances in space since a charged beam would rapidly spread, thus, becoming diffused and ineffective over relatively short distances. Neutral beams in the atmosphere would rapidly become ionized and propagate for only short distances; however, in space they should propagate for very long distances with little beam spread.

(U) ~~(S-NOFORN)~~ [redacted], the Soviet's best approach to a neutral PBW would be the use of a radio frequency (RF) accelerator which accelerates a beam of either negative hydrogen ions or tritons (hydrogen isotope with two neutrons in the nucleus). These ions are then stripped of the extra electrons to produce an intense beam of neutral hydrogen or tritium atoms. In Figure 5, the major components of a hypothetical, space-based, neutral particle beam ASAT system are labeled and a probable spacecraft arrangement of the neutral PBW using an H_2-O, turbine power supply is shown. This power supply was chosen for illustration because of its light weight and ease of packaging; however, the stability problem introduced by the turbine and its exhaust was not evaluated.

(U) ~~(S)~~ The weight, volume, and length of a number of projected Soviet prototype neutral particle beam ASAT systems are presented in Table IV. Tritium is the neutral particle in all cases. The neutral particle beam device for the 1983-1988 period was based on Soviet technology capabilities that probably would be available by 1980, while the devices for the 1988-1998 period were based on the projected Soviet technological capabilities within 10 years. The choice of power supplies is governed by a number of basic design choices—firing rate, total number of shots, and the type of target kill desired. The 10-second shot for cases 1-6 and the 1-second shot for cases 7-9 provide the required amount of energy on target for an electronics kill, optics kill, or hydrazine tank destruction. In order to melt satellite components, shot times would have to be 10 times longer; and the weights and volumes for the required power supplies are considered to be prohibitive.

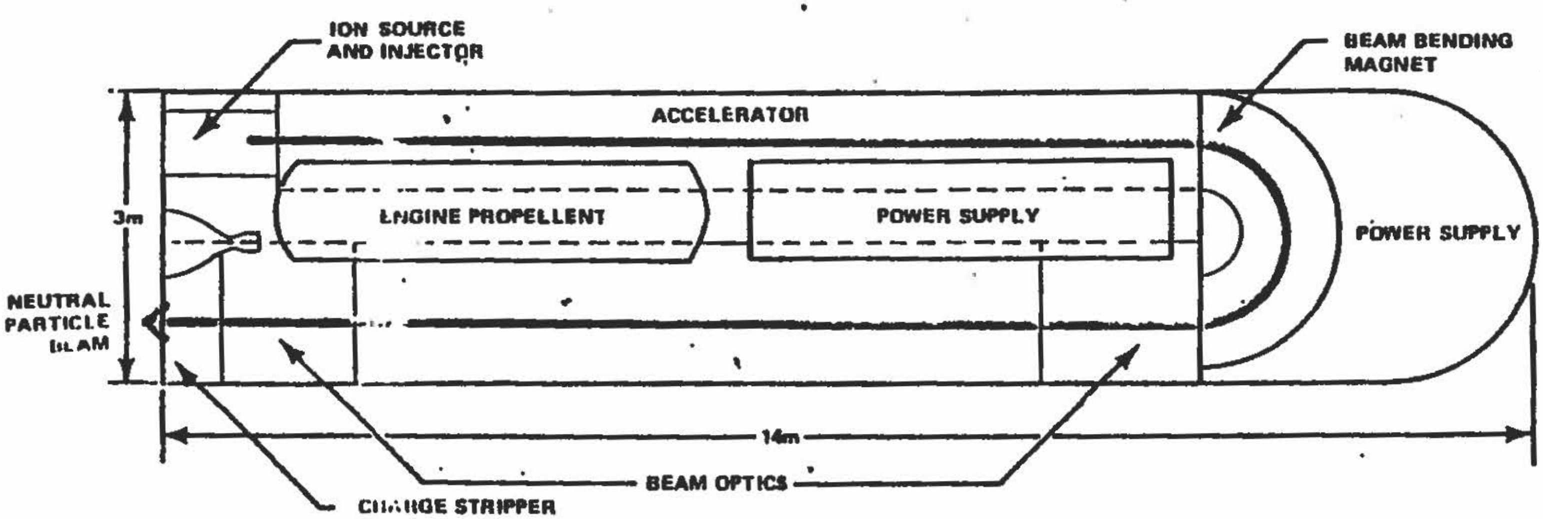
(U) ~~(S)~~ Based upon considerations of weight, volume, and power subsystem sophistication, neutral particle beam ASAT missions would be difficult to support from a power standpoint. No particular power subsystem emerges as a likely choice. However, to simplify the number of total particle beam ASAT systems considered, the three power systems shown in Table IV were chosen.

(U) ~~(S)~~ The confidence in the system forecasts shown in Table IV is low because of—[redacted] such a system is complicated and presents severe engineering difficulties; [redacted] and many power system constraints have not been addressed such as vibration, thermal effects, and nuclear shielding requirements. Therefore, this neutral particle beam ASAT analysis must be considered only a preliminary assessment.

(U) ~~(S)~~ Figure 3 reflects the capability of the largest current Soviet launch system, the SL-13. The neutral particle beam ASAT systems considered in 1983-1988 have an 18-m length and it is doubtful that they could be launched into orbit by the SL-13 since it has only accommodated an estimated 14-m-long payload. By 1988-1998 the Soviets may have a 12-m-long prototype and cases 4, 5, and 6 could be placed into low orbit, but only by the SL-13. No capability exists to place such payloads into 12-hour or synchronous orbits with existing Soviet launch vehicles.

EXP B1

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)



[redacted] (U)

Fig. 8 Hypothetical Soviet Space-Based Neutral Particle Beam ASAT (U)

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

TABLE IV

SPACE-BASED NEUTRAL PARTICLE BEAM ASAT SYSTEM PROTOTYPES (U)

PROTOTYPE CASE	PROTOTYPE YEARS	ION SOURCE (A)	ACCELERATOR VOLTAGE (MeV)	POWER SYSTEM (output power-MW)	NUMBER OF SHOTS	LIFETIME* (days)	LENGTH (m)	WEIGHT (kg)	VOLUME (m³)
1	1983-1988 (L)**	0.1	80	H_2-O_2 turbine (10.6)	20-10 sec shots	30	18	15,000	60
2	1983-1988 (L)	0.1	80	Ag-Zn primary (15.6)	20-10 sec shots	30	18	[illegible]	40
3	1983-1988 (L)	0.1	80	Reactor, flywheel (15.6)	10 sec/8 hr	365	18	[illegible]	40
4	1988-1998 (L-M)	0.1	80	H_2-O_2 turbine (10.6)	20-10 sec shots	30	12	[illegible]	50
5	1988-1998 (L-M)	0.1	80	Ag-Zn primary (15.6)	20-10 sec shots	30	12	[illegible]	30
6	1988-1998 (L-M)	0.1	80	Reactor, flywheel (15.6)	10 sec/8 hr	365	12	9,000	30
7	1988-1998 (L)	1.0	80	H_2-O_2 turbine (100)	20-1 sec shots	30	12	40,000	90
8	1988-1998 (L)	1.0	80	Ag-Zn primary (100)	20-1 sec shots	30	12	[illegible]	70
9	1988-1998 (L)	1.0	80	Reactor, flywheel (100)	1 sec/8 hr	365	12	[illegible]	50

NOTE:

System weight and volume include the neutral particle beam device; cooling subsystem, including coolant and tankage; power supply, conditioning, and fuel and tankage. The remaining necessary subsystems would amount to only an additional several hundred kilograms in weight and approximately 1 m³ in volume.

*Lifetime controlled by the auxiliary power system: batteries for all systems except reactors that include auxiliary power in primary power system.

**Confidence level of the forecast.

~~(SECRET)~~ (U)

SOVIET DIRECTED ENERGY ASAT SYSTEM CAPABILITY (U)

(U) A number of factors could change the Soviet deployment capability:

(1) The accelerator structure could be stowed in a folded position, and deployed once the payload is in orbit. This would present difficult engineering problems, but such a concept has been discussed in the US.

(2) The propulsion and ASAT could be launched separately and then docked.

(3) The possible Soviet deployment of the SL-X vehicle during 1978-1998 could allow the placement of all systems in Table IV into low and 12 hour orbits and the lighter systems into synchronous orbit. It is not known whether the Soviets would use a vehicle of this kind, comparable to SATURN V, for such a mission.

(4) During 1988-1998, the Soviets could have a reusable space system which could be used to launch neutral particle beam ASAT systems into space in sections with assembly done on-station.

(5) If the Soviets could achieve a scientific/engineering breakthrough in pointing and tracking, then a neutral particle beam ASAT system would be able to attack most targets in low-Earth orbit with only changes in attitude. The neutral beam weapons considered are capable of satellite negation to ranges of 6,000-10,000 km. As yet there is no known way to acquire targets or identify the location of the neutral beam at these long ranges.

4.b. Assessments (U)

(U) The following assessments are based upon an initial investigation of the Soviet capability to develop a neutral particle beam ASAT system:

(1) The Soviets are not likely to have the capability to develop a prototype system during the 1983-1988 period.

(2) The Soviets could have the capability, during 1988-1998 period, to develop a prototype system that could be placed in low-Earth orbit. Such a system could destroy electronics, optics, and hydrazine tanks of target satellites at 300-500 km

(3) An SL-X launch vehicle or component docking is required for the Soviets to deploy neutral particle beam ASAT systems as discussed in this study to 12-hour or synchronous orbits.

SECTION III

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

(U) (S) The subsystems of the DE ASAT weapons considered in this study are shown in Figure 6 [redacted]. The DE devices, the acquisition pointing and tracking subsystems, and the orbit determination capability are considered in more detail.

[redacted]

1. Laser Devices (U)

1.a. Background (U)

(S-NOFORN)* [redacted]

(S) [redacted]

1.b. Forecast (U)

(S-NOFORN) [redacted]

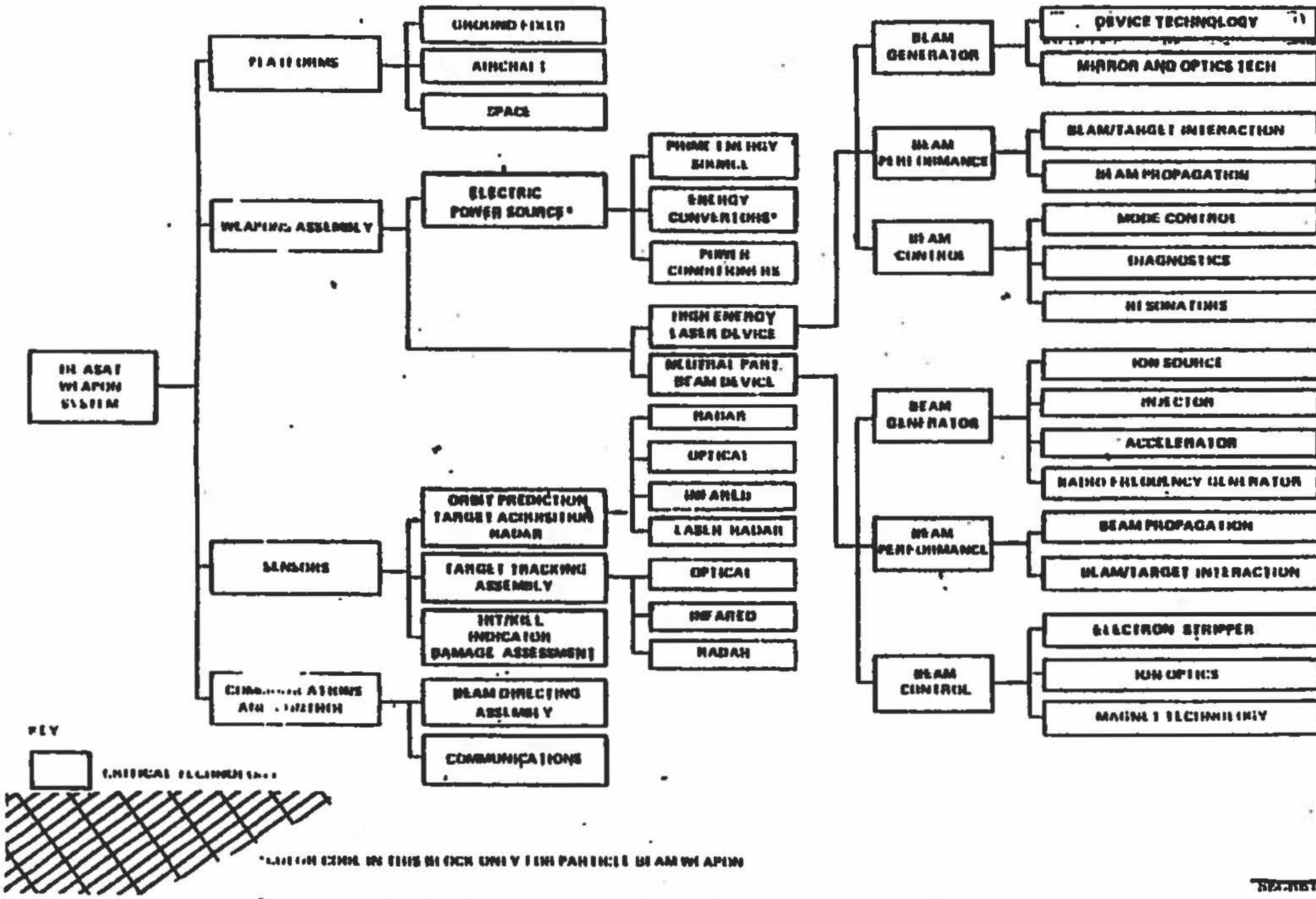
*(U) Critical Technologies--Technologies that require scientific and technical advances in order to meet the DE ASAT system performance requirements.

**(S) [redacted]

EXP B1

[redacted] UNCLASSIFIED

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)



SECRET (U)

Fig. 8 Directed Energy ASAT System Technology Tree (U)

EXP B1

[redacted] UNCLASSIFIED

[redacted]

EXP
B1

Fig. 7 Soviet Directed Energy ASAT Capability in Subsystems and Systems (U) [redacted]

[redacted]

UNCLASSIFIED

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

TABLE V

SOVIET HEL DEVICE CAPABILITY ESTIMATES* (U)

[redacted]

(SECRET)

EXP B1

UNCLASSIFIED

[redacted]

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

2. Neutral Particle Beam Weapon Technologies (U)

2.a. Background (U)

~~(S)~~ [redacted]

~~(S-NOFORN)~~ [redacted]

(U) ~~(S-NOFORN)~~ Statements by R. I. Soloukhin, when acting as Director of INP, Novosibirsk, have established that the Soviets have at least considered the use of a neutral PBW, presumably for space-based systems. [redacted]

Soloukhin explained that the project had been proposed (apparently about 1969) to leaders at the highest technical levels of the Soviet Union by G. I. Budker, Director of INP, but had not been approved. The weapon concept was described as involving the production of electrically neutral beams, such as is done in an ion engine in which ions are produced in an ion accelerator and then neutralized by adding electrons.

2.b. Forecast (U)

~~(S-NOFORN)~~ [redacted]

TABLE VI

NEUTRAL PBW TECHNOLOGY FORECAST (U)

TECHNOLOGY	PRESENT USSR	1980-1983	1983-1988	1988-1998
Ion source (A)	0.1	1 (H)*	10 (L)	100 (L)
RF accelerator (MV/m)	4-5	8 (H)	10 (H)	12 (L)
RF power tube (MW)	1-10	10 (H)	20 (H)	50 (M)
CW pulsed	100	120 (H)	200 (H)	500 (L)

*Confidence Level

~~(SECRET)~~ (U)

EXP B1

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

3. Acquisition and Pointing and Tracking Systems (U)

3.a. Acquisition (U)

(U) ~~(S)~~ Fundamental to any DE weapon system is the initial acquisition of the target and its subsequent handover to the weapon's beam directing system. This technique/procedure generally entails at least two handover sequences: (1) initial volume search for target detection and acquisition with a radar, or a coarse optical or infrared (IR) coarse tracker, with handover to a fine optical or IR fine tracker; and (2) the slaving of the weapon's beam directing system to the fine tracker.

(U) ~~(S)~~ The Soviets have the capability to develop the radar and optical systems necessary for the acquisition and handover sequences of a ground-based laser ASAT system. This is not true for an airborne or space-based DE ASAT system. Present Soviet airborne and space radars do not have adequate acquisition ranges. Millimeter wave radar or microwave radars with monopulse have possibilities in overcoming these limitations; however, the weight, volume, and power requirements certainly would exceed those of an IR system. For an airborne laser ASAT, a Soviet IR sensor has been identified which could possibly handle the pointing and tracking requirements. However, the range of this IR system would be no greater than 350 km in 1988-1998. This same Soviet IR sensor does show promise as a space-based DE ASAT acquisition and pointing and tracking system.

3.b. Infrared Tracking

(U) ~~(U)~~ The Soviets have been particularly discreet in releasing information concerning their device technology. Generally, the data have been limited to scientific papers dealing with methods of producing various IR detectors; but recently, the Soviets published their first paper on an IR imaging array system. This device uses a 50-element linear array of InSb (3-6 μm) for medical and quality control applications. The device, as described in the article, would not be directly suitable for use with a laser weapon. However, enough data were available to synthesize a tracker using the same detector array (Table VII).

TABLE VII

INFRARED TRACKER TECHNOLOGY FORECAST (U)

	1978-1980	1980-1983	1983-1988	1988-1998
Resolution (μrad)	180	60	30	15
Acquisition range* (km)	135	250	350	500
Resolution using predictive track estimation** (μrad)	30	10	5	2
Confidence	H	H	M	L

*For the space-based system.
**The Soviets currently use similar rate-aided tracking techniques in their radar systems.

(U)

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

3.c. HEL Optical Mounts and Stabilization Control Systems (U)

(U) The optical mount and stabilization system points the optical line of sight (LOS) in a given direction and stabilizes the LOS against base motions and disturbance torques. This stabilization is critical in achieving high-beam energy on target.

(U) To stabilize the LOS, the beam transmitting optics are mounted in a set of gimbals affording at least 2 degrees of freedom. A set of position transducers, probably gyro sensors, must be mounted to the gimbals. The sensor signals drive the gimbal actuators, thus, stabilizing the beam against mechanical disturbances to the optical mount. (The forecasted Soviet mirror diameter and accuracy capability for the following optical mounts can be found in Figure 7).

3.c.(1) Ground-Based Mount (U)

(U) (S) At the present time, there is no specific technical information concerning Soviet development of gimbal systems and stabilization systems for laser weapons. However, by examining existing optical systems, assessments have been made of the Soviet capability for developing ground-based laser ASAT stabilization systems and optical apertures over the next 20 years.

3.c.(2) Air-Based Mount (U)

(U) (S) Weight and volume constraints and the necessity of canceling out relatively large disturbances are the driving design requirements for an air-based HEL weapon stabilization system and optical mount. Other difficult engineering problems include the necessity for a large HEL window or open port and the limitation of the maximum diameter of the aperture to less than ~1.5 m. [redacted] Soviet literature shows that the Soviets presently have the production capability to build conventional gyroscopes capable of drift rates on the order of 0.01 degree/hour. Such drift rates would require a closed-loop control system to constrain the pointing error to a tolerable level.

3.c.(3) Spaced-Based Mount (U)

(U) (S) Weight and volume constraints are again the critical design requirements for a space-based laser ASAT. Unfortunately there are no specific data on Soviet design approaches, so an assessment of Soviet capability must be derived from postulated subsystems. The approach taken in designing a space-based optical mount in this effort is to utilize the spacecraft as the coarse-track "gimbal" and provide only a fine track gimbal for the optical system. [redacted]. Calculations show that such a system with a precise gimbal actuator of 0.01 μm displacement sensitivity can have a pointing accuracy near 0.02 μrad, which means the pointing accuracy would be determined by the tracking accuracy.

4. Orbit Determination (U)

4.a. Radar (U)

4.a.(1) Detection (U)

(U) (S) The satellite altitudes, for which radar detection was considered, fall into the four following bands: (a) near-Earth orbits (up to 1,500 km) at 63-110-degree inclinations, (b) 20,300 km circular, (12-hour) orbits at 30 and 60 degree inclinations, (c) a highly eccentric 12-hour orbit (8,000 km by 46,000 km) at a 63 degree inclination, and (d) geosynchronous satellites (approximately [illegible],000 km) located between 40° W and 230° E longitude.

(S) [redacted]

EXP B1

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

EXP B1

[redacted]

Fig. 8 Range vs Site-Circular Orbit ~20,300 km, 30°/60° Inclination (U)

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

EX8 B1

(U) (S) Two methods that could be implemented to improve this detection range were analyzed--coherent integration, which requires longer looks at each potential target position and, therefore, longer volume search times from (up to 40 minutes) depending on satellite class; and an enhanced radar (higher power, better noise figures) also with coherent integration.

[redacted]

4.a.(2) Tracking (U)

[redacted]

4.b. Optical Systems (U)

4.b.(1) Detection (U)

(U) (S) The Soviet Union has established an optical detection tracking network throughout the USSR. However, only those few optical sites with large optics, high precision satellite tracking cameras [redacted] appear suitable for detecting and tracking geosynchronous satellites. The Soviets also have utilized equipment in astronomical observatories to track satellites and particularly deep space probes. [redacted]

4.b.(2) Tracking (U)

(C) (S) Simulations of Soviet optical tracking capability have been made using an integrated optical tracking network with 2 arc-second angular measurements, observing three classes of satellite orbits: (a) 20,300 km circular 12-hour orbits at a 63-degree inclination; (b) highly elliptical (275 x 39,350 km) 63.5-degree inclination orbit; and (c) geosynchronous orbits. The orbital observations were limited to those facilities known to have [redacted] cameras, and tracking accuracies for each orbit type were generated for 6, 12, and 24 hours of observations. With unknowns such as sensor location accuracy, timing device accuracy, and computed satellite position accuracy, it is difficult to evaluate system errors; however, the results do show that position uncertainties are generally within a few tens of meters.

4.c. Laser Ranging (U)

(U) (S) The Soviets have been performing laser ranging against satellites since the early 1970's. There are currently nine satellite tracking stations worldwide with laser ranging equipment that can operate against satellites in up to 1,500 km orbits with range accuracies

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

EXP B1

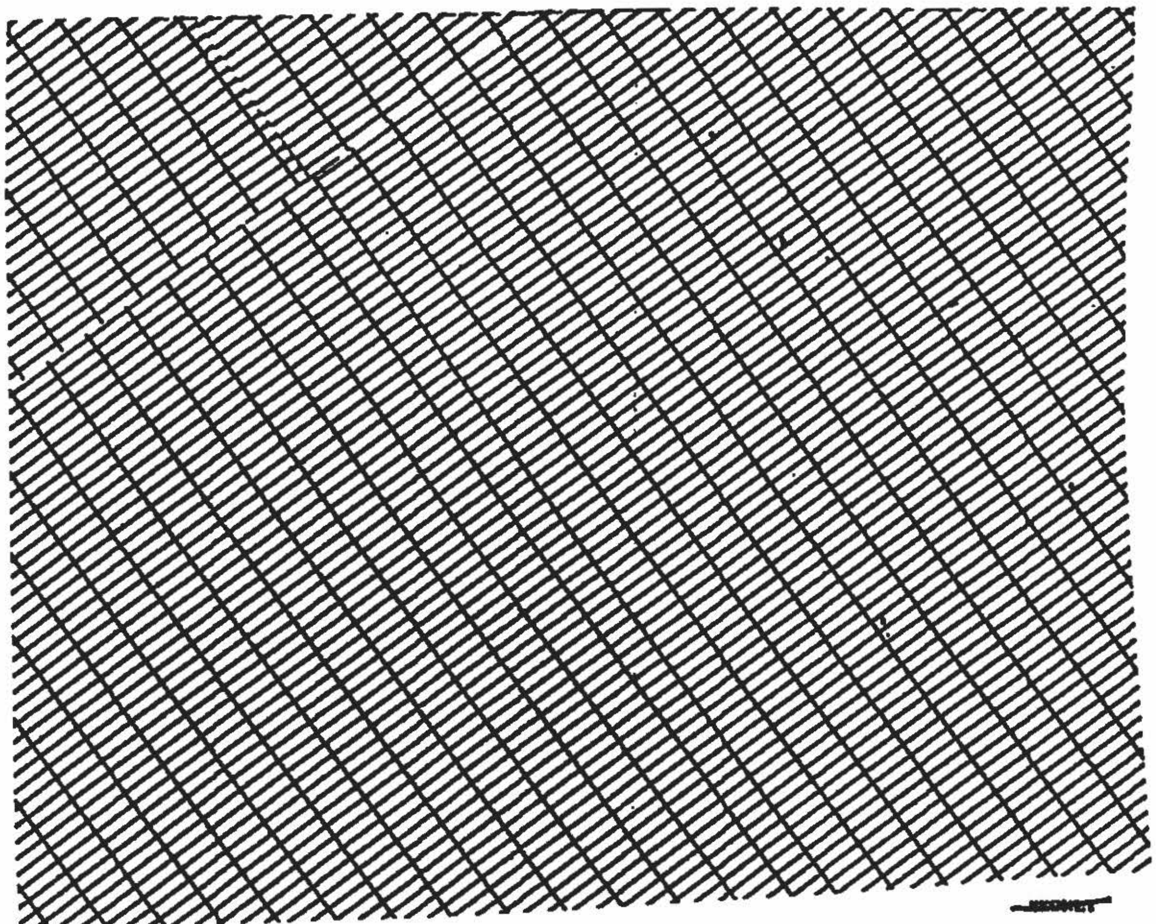


Fig. 9 Soviet Optical Detection (U)

SOVIET DIRECTED ENERGY ASAT TECHNOLOGY CAPABILITIES (U)

of 10-20 cm. An October 1977 TASS news release reported the Soviets have begun development of a new generation of satellite laser range finders, which will have an operational range capability of 40,000 km with a range accuracy of 10 cm. Such a system should have a nighttime operational capability against uncooperative geosynchronous satellites.

(C) ~~(S)~~ The use of satellite laser range finders in conjunction with the optical tracking systems previously described, will allow the Soviets to determine the orbital position of all classes of satellites within a few meters. This accuracy will probably be available after a single observation.

UNCLASSIFIED

SECTION IV SATELLITE DAMAGE AND VULNERABILITY (U)

1. Laser Beam (U)

1.a. Damage Mechanism (U)

(U) (S) Soviet HEL weapons, operating in the CW mode, will cause thermal damage to satellite components and structures. Pulsed lasers can induce both thermal and mechanical damage. [redacted]

1.b. Subsystem Damage Levels (U)

(S) [redacted]

(S) [redacted]

[redacted]

2. Neutral Particle Beam (U)

2.a. Damage Mechanism (U)

(U) (S) Particle beams deposit their energy within the volume of the material. The depth of the beam's penetration depends upon the density of the material and the particle's energy. The only effective shield against particle beams is mass, a particularly expensive penalty for space systems; furthermore, shielding attempts can be countered with nominal increases of beam energy. For example, 60 MeV hydrogen atoms will penetrate about 1 cm of aluminum while 100 MeV atoms will penetrate about 3.7 cm of aluminum.

(U) (S) For particle beams, two kill mechanisms simultaneously contribute to the satellite's destruction. As the particles interact with the material, large amounts of radiation are produced in the form of secondary neutrons, electrons, gamma rays, and X-rays. This intense radiation can disrupt or destroy the various electronic components and some propellants. Secondly, as the radiation is absorbed in the material, the energy deposited heats and melts satellite components. To predict the actual damage that could be produced requires calculations of particle interaction with various satellite models. To date, such calculations have only been done on models of Soviet nuclear warheads and reentry vehicles. Therefore, only general statements about satellite lethality can be given at this time.

2.b. Subsystem Damage Levels (U)

(S) [redacted]

EXP B1

SATELLITE DAMAGE AND VULNERABILITY (U)

[redacted]

EXP
B1

Fig. 10 Satellite Component Laser Damage Levels (U)
(Data provided by AFML)

SATELLITE DAMAGE AND VULNERABILITY (U)

UNCLASSIFIED

[redacted]

(U) [redacted]

(U) Possible consequences of the satellite vulnerabilities discussed in this section and the Soviet directed energy ASAT system capabilities described earlier have already been summarized in Conclusions.

EXP B1

UNCLASSIFIED