SECRET

OFFICE OF THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

DEFENSE SCIENCE BOARD

DECLASSIFIED IN FULL
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

9 March 1981

MEMORANDUM FOR MEMBERS, DSB TASK FORCE ON REVIEW OF DOD STUDY ON SPACE-BASED LASER WEAPONS

SUBJECT: DoD Report

Attached is the Secret report to the Congress on Space-Based Laser Weapons. I hope it has arrived in your office in sufficient time for you to review the report prior to our meeting on 27 March. I will also have copies available during the meeting for reference.

Because of the sensitive nature of the subject, it is requested that this report not be read or distributed to anyone outside of the DSB Task Force.

Carol Yarnall

Carol A. Yarnall
Lt. Col., USAF
Executive Secretary
Task Force on Review of DoD Study on Space-Based Laser Weapons

Missile Defense Agency Declassification Review	
REVIEW DATE 10/27/11 NAME S. Lloyd	Determination (Circle Number(s)) 1 CLASSIFICATION RETAINED 2 CLASSIFICATION CHANGED TO 3 CONTAINS NO CLASSIFIED INFO (4) COORDINATE WITH 1DOE 5 CLASSIFICATION CANCELED (6) CLASSIFICATION INFO BRACKETED 7 EXCLUDED CONTAINS RD OR FRD 8 Other (Specify)
DECLASSIFICATION AUTHORITY DATE 11/3/11 NAME K. Gein	

Attachment:
As Stated

Copy to:
Major Johnson

Department of Energy Declassification Review	
1st Review Date: 1/18/12 Authority: [x] DC [ ] DD Name: KE Schaffter 2nd Review Date: 1-29-12 Authority: (DD) Name: JW brothon	Determination: [Circle Number(s)] 1. Classification Retained 2. Classification Changed To: (3) Contains No DOE Classified Info 4. Coordinate With: 5. Classification Cancelled 6. Classified Info Bracketed (7) Other (Specify) #6 p 2-5

Office of the Secretary of Defense 5 USC 552 and
Chief, RDD, ESD, WHS
Date: 23JUL2013 Authority: EO 13526
Declassify: ______ Deny in Full: ______
Declassify in Part: X
Reason: 3.3(b)(4), (6), (8)
MDR: 12-M-0636

~~UPON REMOVAL OF ATTACHMENTS THIS DOCUMENT BECOMES UNCLASSIFIED~~

12-M-0636 (1)
ORIG.
08-M-2763

SECRET

SECRET NOFORN

DRAFT

REPORT TO THE CONGRESS

ON

SPACE LASER WEAPONS (U)

26 February 1981

Office of the Under Secretary of Defense for
Research and Engineering
Washington, D.C.

Classified by: USDRE
Review on: 31 December 2000
Reason: 2-301 c.6

SECRET NOFORN

TABLE OF CONTENTS

DRAFT

~~THIS PAGE IS UNCLASSIFIED.~~

1.0 (U) INTRODUCTION

1.1 (U) Charge of the Senate Armed Services Committee

(U) The Senate Armed Services Committee (SASC) requested that the Secretary of Defense provide to the House and Senate Armed Services Committees: (1) an "analysis of the technical, schedule, and cost risks of accelerating the development of space laser weapons," and (2) a "detailed program plan for the earliest feasible on-orbit deployment of such a weapon."

(U) This report responds to that request by addressing the specific questions raised by the Congress. In addition, the report examines the military utility of different space laser weapon performance levels and the resulting desirability of accelerating space-based laser efforts.

1.2 (U) Background

(U) The question posed by Congress to the Secretary of Defense was asked in the context of defense against strategic attack on the United States. There are, in addition, several potential applications of lasers in space including antisatellite, satellite defense, and antiaircraft. Of all these applications, ballistic missile defense against major attacks is the most demanding.

(U) Conceptually, a space-based laser weapon platform consists of several components. The laser itself can be compared to a rocket engine, since it derives its power from the burning of chemical fuels stored as liquids. A set of mirrors is used to extract the laser radiation from this gas flow which is analogous to the exhaust of the rocket. To provide a capability to destroy targets rapidly, the laser device must generate millions of watts of power. Another set of mirrors is used to point this laser beam accurately at the target. These pointing mirrors also hold the beam to a small spot on the target. At the long (several thousand kilometers) ranges of space-based lasers, this focus requires the final or primary mirror in the optical train to be of large diameter (many meters).

(U) The weapon platform must also contain a tracking device. Receiving handover instructions from a surveillance and warning system, the tracker commands the primary mirror to point the laser beam at the target. Extreme accuracy is required. A one meter diameter target at a range of 1000 kilometers subtends an angle of one microradian, about a thousand times smaller than the angle that can be resolved by the unaided human eye. Boresight between the tracking and pointing systems must be held to microradian or better tolerance to obtain an initial "hit" on the target. Some means must then be provided for sensing any miss distance and providing adequate correction.

(U) A space-based laser weapon system would then be composed of many such long range weapon platforms orbiting the earth and the required surveillance systems also consisting of orbiting satellites. Command and control facilities must be provided to support a commander in his management of the battle. In the more demanding applications, these facilities must be highly automated to react to a rapidly developing threat.

DRAFT

(C) The current space laser program is part of a broad-based laser technology program (approximately $100 million of the total $200 million per year). The overall program is structured to evaluate potential applications of high energy lasers in the tactical as well as strategic missions. All basing modes (satellite, aircraft, ship and ground vehicles) are included. Applications other than space-based have substantially less potential global impact and can be achieved with substantially lower system performance. The programs addressing them will yield some system integration and countermeasures data relevant to space applications in the near term. For example, field experiments at White Sands Missile Range against real targets will occur in 1984.

2.0 (U) EXECUTIVE SUMMARY

(U) At least four aspects of space laser weapons should be addressed before decisions are made with respect to the rate of investment in their development. These aspects are:

- (U) The potential utility of space-based laser weapons;
- (U) The current state of technology and projected rate of attainment of required technology levels, together with associated costs and risks;
- (U) The possible weapon deployment options, together with their schedules and costs, and comparison with alternate means to accomplish military missions; and,
- (U) The impact of the development and deployment on national policy.

2.1 (U) Overview

(U) A network of high energy lasers operating from space could provide instantaneous global projection of force. Destructive energy could be delivered to several thousand kilometers range at the speed of light against targets on the ground, in the air, and in space. Development of an effective and survivable space-based laser force could have a decisive impact on the character of warfare and on the strategic balance of power while representing a revolutionary change in types of weapons used in warfare.

(U) There are, however, areas of major uncertainty in our ability to realize this potential. Substantial advancement beyond current technology is required, not only in lasers but also in surveillance, command and control, and launch vehicle capabilities. The ability of the laser weapon system to survive against the many potential threats and levels of attack which might be anticipated, consistent with the prospective military impact of the lasers, is a concern and must be also examined in detail. Finally, the costs will be high, although the cost estimates are very uncertain because of the degree of extrapolation required to estimate the technologies and system designs.

(S) The earliest time frame such weapons could make a contribution to U.S. military posture is in the mid 1990s. There is a need now, however, to understand their potential so we can plan an intelligent response in the event that an adversary should deploy such weapons. Thus, the primary questions to be addressed are whether the future military potential of such weapons, as judged today, warrant acceleration of the space laser program and if so, to what degree.

2.2 (U) Soviet Space-Based Lasers

(S) The same potentials and issues for application of space-based lasers to antisatellite, antiaircraft and ballistic missile defense apply to the Soviets. How they might be applied and their utility relative to other weapon systems will differ due to asymmetries in the Soviet vs. U.S. force structure. For example, a Soviet space laser weapon system used

DRAFT

in conjunction with a massive first strike against the U.S. land-based ICBM force might be effective in limiting the U.S. retaliatory strike capability while requiring a substantially less capable laser force size than needed for most U.S. ballistic missile defense scenarios.

(S/NF) Intelligence estimates indicate that the total Soviet laser development program is perhaps 3 to 5 times the size of the U.S. program. Evidence within the past year reinforces the Scientific and Technical Intelligence Committee's belief that the Soviets have been conducting research and development for at least one space-based laser weapon. [redacted] However, it cannot be stated that such development is not occurring. DIA 1.4(d) OSD 3.3(b)(6)

(U) It is important that active monitoring of these indicators of a Soviet decision to develop or deploy a system be maintained. The potential impact on the U.S. defense posture requires such monitoring regardless of decisions made on the pace of the U.S. program and it would be prudent to develop countermeasures technology.

2.3 (U) Potential Utility of Space-Based Lasers

(U) This section summarizes the potential utility of space-based laser weapons based on nominal target hardness levels, assumed adequate survivability of the laser weapon systems, and the best cost estimates which could be made. The subsequent section discusses the significant uncertainties in these areas.

(S) The least demanding potential mission for space-based lasers is the antisatellite mission. Offensive antisatellite operations against a few key satellites can be accomplished with a maneuverable laser satellite that has a system brightness* that is on the order [redacted] satellites of [redacted] would have

USAF 1.4(a),(e),(g); 3.3(b)(4),(8) OSD 3.3(b)(4),(8)

*(U) Brightness is a measure of the capability of a laser system to concentrate its power onto a small spot at ranges of interests, i.e., a measure of system radiant intensity. Three brightness levels of chemical lasers are frequently cited in the report:

Brightness (watts/steradian)	Power (megawatts)	Aperture Diameter (meters)	Beam Spread (microradians)
[redacted]			

USAF 1.4(a),(e); 3.3(b)(4)
MDA 3.3(b)(4)

OSD 3.3(b)(4)

DRAFT

DIA 1.4(d)

a capability to engage, [redacted] Soviet satellites whose orbits are below 4000 kilometers. Cost effectiveness should, however, be examined in comparison with other antisatellite weapon system concepts.

OSD 3.3(b)(4),(6)

(S) Another military application of space-based lasers appears to be against aircraft targets. A space-based laser force could provide the potential for rapid global projection of U.S. power into conflicts of limited nature. It could provide simultaneous continental United States and fleet air defense and could be used to attack airlift lines of supply and airborne warning and control aircraft. This ability is considered unique since no other system has potentially instantaneous, global, antiaircraft coverage. It is estimated that this capability would be provided against hardened [redacted] targets by a configuration of eight satellites* each with a brightness level of approximately [redacted] steradian [redacted] and a total cost of approximately $50 billion.** Such a system also has an inherent rapid antisatellite capability against all low altitude (up to 5000 km) satellites and some capability against limited numbers of ballistic missiles. A system of lesser capability [redacted] would provide the antisatellite capability alone but would have limited capability against hardened aircraft and almost no potential for significant ballistic missile defense.

USAF 1.4(a),(e); 3.3(b)(4) DIA 1.4(d) OSD 3.3(b)(4),(6)

(S) In the most demanding application, ballistic missile defense, space-based lasers, in conjunction with conventional ballistic missile defense systems, might be able to provide an effective ballistic missile defense. The magnitude of a system for this purpose is quite uncertain, largely because of uncertainty in the hardness achievable in future Soviet ballistic missiles in response to U.S. development of space-based laser weapons. [redacted]

DIA 1.4(d) MDA 3.3(b)(4) OSD 3.3(b)(4)

(S) Redundancy required for reliability and to compensate for attrition and any additional target hardening would increase the number and required capability of individual satellites. Even the most modest of these ballistic missile defense systems would have an instantaneous and global capability against very large numbers of aircraft and satellites. Since the potential hardness of future Soviet ballistic missiles is uncertain, the development of very high brightness laser systems based on short wavelength devices may be preferred.

---

*(U) Full equatorial coverage without exploitable gaps may require additional satellites.

**(U) All costs herein are given in FY 81 dollars and are highly uncertain. Cost estimates are 10-year life cycle costs. They assume a 3-year on-orbit lifetime for space-based laser satellites with replacement at end of life. All costs for research and development, surveillance, command and control, communications, launch vehicles, operations and support, and program management related items are included. Costs could be reduced if the satellite lifetime is increased and/or if costs for required support systems are shared with other programs.

DRAFT

2.4 (U) Uncertainties in Achieving Space Laser Weapons

(U) While the overall impact of a successful space laser system development on the strategic balance is potentially extreme, major uncertainties remain in areas such as survivability, weapon lethality, technology availability, and systems engineering. These must be resolved through analysis, design, development, and measurements.

(U) There are basic issues about the survivability of a space-based laser weapon system. For example, a space-based laser system would be deployed only if it provided a major military advantage and, therefore, would represent a high value target. A potential enemy could be expected to commit significant resources to negate the effectiveness of such a system. There are many potential countermeasures to the space-based laser system and these require analysis in depth.

(U) The uncertainty in target hardness reflects on all conclusions with respect to mission utility. The development and deployment of a space-based laser system would be a major and visible undertaking and, clearly, any potential enemy will develop countermeasures in parallel. Laser weapon systems, therefore, must be designed against responsive targets, not those which exist today. The degrees of hardening which can be achieved in 15 to 30 years are uncertain. In this report, examples have been given which reflect estimates of hardening using experimental data and reasonable weight penalties for existing boosters and aircraft. The uncertainties for new materials or new target vehicles of the future are large. Since system sizing (i.e., number of laser weapons required) is directly related to the target's hardness level, an increase over the hardening assumed in these examples would commensurately increase the required numbers of laser weapons for the same level of force capability.

~~(S)~~ Uncertainties in future technology availability result from the relative immaturity of today's high energy laser systems technology. No high power laser has been tested in space. [redacted] The Airborne Laser Laboratory (ALL) has demonstrated a system brightness of [redacted] early this year. The highest system brightness demonstrated prior to the Airborne Laser Laboratory was [redacted] in the Unified Navy Field Test Program in March 1978. A major limitation on achievable brightness for these ground applications is atmospheric turbulence. In space applications the lack of atmospheric turbulence may allow effective use of large mirror apertures to achieve very small laser beam spread and thus commensurately increase the brightness, if the difficult vibration environment of large lasers can be neutralized. USAF 1.4(a),(e), 3.3(b)(4) MDA and OSD 3.3(b)(4)

(U) Finally, there are significant issues to be addressed in engineering a space laser weapon system. Such issues involve the overall system of surveillance, control, support, logistics, etc., that the weapon needs to perform effectively and those associated with integrating the major laser subsystems

DRAFT

in a space qualified vehicle. No operational high energy laser weapons have ever been produced or deployed, and experience in integrating the major subsystems of a laser weapon is limited. Many functions required for weapon effectiveness are not well characterized.

2.5 (U) State of Technology and Developments Needed

[redacted]

USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

(U) Since brightness is inversely proportional to laser wavelength, lasers with wavelength shorter than those of HF or DF lasers become increasingly more attractive to fulfill the requirements of more stressing potential missions (i.e., ballistic missile defense against large numbers of hardened missiles). The technology of short wavelength laser systems is even less mature than that of the HF or DF systems.

[redacted]

USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

(S) Advanced space-based surveillance systems, not currently planned, would be necessary to detect and track large numbers of targets for significant space-based laser missions. The separate surveillance systems required for aircraft or ballistic missile targets would be major systems developments in their own right. While the technology for such surveillance is under development, there are no current plans to deploy such systems.

(U) An advanced launch system such as the proposed shuttle derivative launch vehicle (SDLV) or heavy lift launch vehicle (HLV) would be required to place space-based laser systems in orbit in a single launch. Otherwise, multiple shuttle launches and in-space assembly would be necessary.

(S) An essential but expensive element of any program to develop space-based laser weapons is an on-orbit experiment which integrates a high power laser, large optics, precise pointing and tracking, and the appropriate surveillance. At some stage in system development, integrated system level testing in space is essential to (1) verify beam control performance in the presence of high power laser operation with attendant vibration, exhaust effluents and thermal

DRAFT

loads, (2) verify weapon platform end-to-end thermal management and laser exhaust control, (3) provide a credible basis for cost estimates, and (4) uncover unrecognized system level problems. The experiment could logically be carried out with a system that, with reasonable technical risk, can be launched in a single shuttle load. The objective would be to provide the best opportunity for realistic scalable data at a performance level which approximates that useful to potential missions applications.

(S) The earliest date by which an on-orbit feasibility demonstration could be accomplished is around the end of this decade. This assumes an aggressive program with funding on the order of $5 billion for the demonstration and supporting technology development, but not including the surveillance systems.

2.6 (U) Possible Accelerated Development

(U) The current technology program could be accelerated to seek a resolution by the mid 1980s of the major uncertainties cited previously prior to any commitment to on-orbit demonstration or deployment. The cost of such an accelerated technology effort would be $1 to $2 billion for FY 82 through FY 86, depending on the depth of the effort.

(S) An on-orbit demonstration at approximately the [redacted] level, coupled with an accelerated technology effort, could be accomplished by the end of the decade. Advanced space-based chemical laser technology would be developed and ground-based, space-relayed laser systems of shorter wavelength would be demonstrated. This would provide a basis for weapon system commitments. The total cost is on the order of $5 billion.

(S) The shortest but highest risk path to a weapon prototype demonstration at the [redacted] would by-pass the feasibility demonstration and permit a launch at the beginning of the 1990s. To moderate the technical risk, the prototype development would be supported by a technology limited effort addressing all known technical issues. Such a program, including the prototype demonstration, would cost approximately $10 billion. USAF 1.4(a), (e); 3.3(b)(

2.7 (U) Earliest Possible Deployment

OSD 3.3(b)(4)

(S) A plan which provides the earliest possible on-orbit deployment of a space-based laser weapon is based on development of a system with brightness the order of [redacted]. It implicitly accepts the very high risk of attempting to initiate immediately a prototype space laser satellite. Included in the plan is an enhanced technology development program (pertinent only to the [redacted] class system) in an attempt to limit the development risk. The projected earliest dates for the prototype test and subsequent initial operational capability are 1990 and 1994, respectively. Innovative procurement methods would be required to accomplish an initial operational capability so soon after prototype demonstration. The cost through prototype demonstration would be approximately $4 billion. The prototype demonstration would not include the surveillance, command and control systems. The capability of such a system would be largely limited to antisatellite missions and would have no growth potential to satisfy the more demanding missions such as antiaircraft or ballistic missile defense.

DRAFT

2.8 (U) Earliest Deployment of a More Capable System

[redacted]

USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

(S) Development and deployment costs, including launch costs for this eight laser battle station system designated for an antiaircraft mission, assuming a 10-year life cycle, are estimated to be $25 to $55 billion. Such costs can only be estimated at the present time with substantial uncertainty.

(U) A considerable effort is required to further investigate such items as mission effectiveness, survivability, hardness and lethality, system level performance of surveillance, and command and control, in addition to laser technology, in order to determine the military usefulness of such a system. The risk in cost and schedule involved in developing such a space-based laser weapon system on the specified schedule is very high. A program with more moderate risk would delay full operational capability until well after the year 2000.

2.9 (U) Policy Issues

(S) The potential contribution of space-based laser weapons to ballistic missile defense, air defense, and antisatellite capabilities must be viewed in the light of existing U.S. policies governing the employment and deployment of strategic offensive and defensive forces. The early stages of space-based laser technology development precludes a precise assessment of these weapons with respect to existing strategic policies and make it difficult to predict the substances of future policy issues in this area. The development of these capabilities--consistent with existing treaty obligations--augments and contributes to our general national policy objective of deterrence. Such capabilities would support our objective of being able to respond at any level of aggression that an opponent elects to initiate, and to deny him victory, however he defines it. Specifically, the development of space-based laser capabilities has the potential of contributing to our goals of assuring the survivability of strategic offensive retaliatory forces, defending continential United States based assets against a precursor and/or follow-on bomber attack, protecting key U.S. satellites, and providing the options of selectively degrading hostile space-based assets. Furthermore, pursuit of permitted research and development in this area would contribute to our arms control policy objectives by increasing the incentives for the USSR to comply with the ABM Treaty,

DRAFT

by providing a necessary hedge against a Soviet withdrawal or breakout from the Treaty, and by providing a corresponding U.S. antisatellite capability which could prove useful in realizing a stabilizing agreement in this area.

(U) The ABM Treaty constrains deployment, and to a lesser extent development, of space-based laser weapons. High energy laser research programs are not constrained by existing arms control agreements. The ABM Treaty does ban the development, testing, and deployment of all ABM systems and components that are sea-based, air-based, space-based, or mobile land-based. The Treaty permits the development and testing of fixed, land-based ABM systems and components based on other physical principles (such as lasers and particle beams), and including components capable of substituting for ABM interceptor missiles, ABM launchers, or ABM radars. However, the Treaty prohibits the deployment of such land-based systems and components unless the Parties consult and amend the Treaty.

(U) Only the actual use of space-based laser weapon systems to interfere with Soviet satellites used to verify compliance with strategic arms control agreements--as opposed to development, testing, or deployment of systems that could be used in such roles--is prohibited under the provisions of the ABM Treaty (Article XII), and the SALT I Interim Agreement (Article V), and the SALT II Agreement (Article XV).

(U) Several provisions of the Outer Space Treaty are representative of the image the U.S. has maintained on the use of space but do not prohibit the deployment of laser weapons in space. In Article III, the signatories agree to the use of outer space for activities which are "in the interest of maintaining international peace and security and promoting international cooperation and understanding." In Article IV, the Parties undertake not to place in space "any objects carrying nuclear weapons, or any other kinds of weapons of mass destruction." Article IX requires international consultations prior to any planned activity or experiment, if the sponsor of such activity or experiment has reason to believe it would cause potentially harmful interference with the peaceful space activities of others.

2.10 (U) Discussion of Options

(U) Four options were considered to illustrate a range of levels of effort. They are not meant to be exclusive, that is intermediate or mixtures of these options are equally credible. In particular, if the option to accelerate technology development were selected, the one presented below (Option 2) could be decreased in scope to reduce costs with a corresponding delay in achieving a given level of technical capability, or could be increased in scope to address a wider variety of possible technological innovations. The particular effort described in Option 2 is based on resolving the technical uncertainties with respect to the utility of space-based laser weapons in the shortest time consistent with an orderly program.

1. (U) Continue with the currently planned level of effort to develop technology.

(S) This program will result in a space demonstration of pointing and tracking and ground demonstration of the technology to support a brightness of [redacted]

USAF 1.4(a), (e), 3.3(b)(4)   OSD 3.3(b)(4)

DRAFT

USAF 1.4(a),(e); 3.3(b)(4) OSD 3.3(b)(4)

[redacted] by 1987. It includes limited technology work on advanced laser devices leading to higher brightness. It is not intended or structured to resolve issues associated with development of space-based laser weapons. Decision on an on-orbit demonstration or space-based weapon system development, based on successful completion of current efforts, could not occur before 1987.

(U) This is a conservative approach which concentrates on development of technology for future decisions on weapon systems. It is not structured to support a weapon systems development and the additional technology effort required is not consistent with a space-based laser weapon system initial operational capability before 2000. It does maintain technical competence and awareness to permit evaluation of Soviet progress.

2. (U) Accelerate technology development.

(S) This option is directed towards resolving rapidly the currently known major technical deficiencies/uncertainties. It provides a better basis for a decision in a timely fashion for an on-orbit demonstration of a space-based weapon system. It addresses the technology issues in surveillance, target vulnerability, lethality, countermeasures, space-based laser survivability, and command and control as well as parallel development of advanced laser devices. An important element of the effort is development of technology for U.S. response to a Soviet space-based laser including hardening and countermeasures. The program defined addresses on a technology-limited schedule only those issues essential to reducing the risk and technical uncertainties associated with a decision to proceed with a demonstration or weapon system.

(S) This option, as described, permits a decision for weapon system development based on technology demonstration and therefore reduced risk to be made two or three years earlier than Option 1. Feasible initial operational capability of a space-based laser weapon could be as early as the late 1990's. It requires a rate of expenditure (approximately $250 million per year) for four or five years which is higher than any other technology effort underway in the Department of Defense. Lower levels of effort would stretch out the decision date and/or increase the risks associated with such a decision.

3. (U) Perform an on-orbit demonstration of a space laser integrated with its optics and pointing and tracking system in addition to an accelerated technology program.

(S) A decision now to perform an on-orbit demonstration could result in a launch as early as 1988 at a cost of $2 billion for the demonstration with significant risk in achieving that schedule at that cost. The technology effort described in Option 2 is required to support the on-orbit demonstration. The total cost for this option is approximately $5 billion at annual rates between $400 million and $800 million. This option reduces by five or six years the time required to do the on-orbit demonstration from Option 2, and the time for eventual deployment of a space-based laser weapon system by six to ten years. This is a high risk program with substantial costs.

DRAFT

(S) Under this option, a weapon system initial operational capability in the mid 1990s may be possible. It permit demonstration of U.S. technical capabilities in an advanced technology area, provides an early focus for the technology effort described in Option 2, and forces near-term attention to "real-world" engineering and integration issues. Without a commitment to eventual development and deployment of a space-based laser weapon system, the effort could be dead-ended.

4. (U) Develop the earliest, feasible space-based laser weapon system.

(S) This is the highest risk option. It could produce, at the earliest, a space-based laser weapon capability by 1994 to perform antisatellite missions. It will not produce a system with, or technology foundation for, significant growth capability to accomplish antiaircraft or ballistic missile defense missions. Because of the very high levels of technical risk associated with this option, the costs and schedules associated with prototype development and a subsequent weapon deployment must be considered even more uncertain than those given in other options. The cost through prototype demonstration will be no less than $4 billion and it can occur no earlier than 1990.

DRAFT

3.0 (U) POTENTIAL UTILITY OF SPACE-BASED LASERS

3.1 (U) Introduction

(U) With the potential to project destructive energy levels over great ranges at the speed of light, laser weapons offer unique capabilities. If these high energy lasers can be based in space, their capabilities are freed from many of the constraints imposed by the earth's atmosphere and, additionally, the weapons could be brought to bear over almost any geographic area very quickly.

(U) The attractiveness of these powerful potentials to the weapon system designer is clear. However, the actual value of a space-based laser in any specific military mission depends on a variety of factors. These include the expected vulnerability of the targets, geometric considerations of range and coverage, the ability to combine the space-based laser with surveillance and other system components to accomplish the whole job, comparison with alternate means of accomplishing the same mission, and the ability of the space-based laser system to survive to the extent necessary to accomplish its purpose. Given all these factors, the following discussion addresses which of the possible applications of space-based laser weapons appear promising and which do not.

(S) The low altitude space-based laser has considerable potential against satellites whose orbit brings them below about 5000 km. The space-based laser is particularly attractive where very rapid negation of large numbers of such enemy satellites is required. A space-based laser system with brightness of [redacted] or higher could provide this antisatellite potential. However, it is not clear that a space-based laser is a cost effective solution for this in comparison with other methods of achieving antisatellite capability unless the very rapid response is needed. A space-based laser system built for other missions will inherently have this antisatellite capability.

USAF 1.4(a),(e); 3.3(b)(4) OSD 3.3(b)(4)

(U) A promising military application of space-based lasers appears to be against aircraft targets. This could provide a rapid projection of U.S. power and could, for example, simultaneously provide for defense of the continental U.S., fleet defense, and a capability for attack on airlift lines of supply and airborne warning and control aircraft systems. The capability is unique in that these are missions we are not able to accomplish now except by using forward-based interceptor aircraft.

(S) In addition to a worldwide capability against aircraft and satellite targets, the space-based laser has potential for ballistic missile defense with very advanced technology. Several of the major reasons are:

- (U) The laser can engage the ballistic missile in the boost or bus phases where multiple weapons can be killed as a single target. In addition, in the bus or boost phase the missile is more easily tracked, is more vulnerable, and is not located over U.S. territory.

- (U) The space-based laser could defend a diverse set of targets against attacks by both ICBMs and SLBMs.

DRAFT

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

~~SECRET~~

(U) However, the space-based laser (or for that matter any single weapon system) cannot provide a stand-alone capability to limit damage to the U.S. to levels that could motivate a major strategy change. Coupled with midcourse and terminal phase ballistic missile defense and supplemented by civil and industrial defense planning, it could offer an eventual potential for damage limiting.

(U) The survivability of the space-based laser system against a concerted enemy attack is a matter of concern. There is little doubt that a laser battle station could be destroyed by dedicated attackers. A space-based laser system would cause a major shift in the military balance if not countered, so it is clear that the Soviets would work toward negation of the system during the period it would take to develop and deploy. More work must be done in this area before space-based laser system survivability is well understood.

[redacted]

MDA and OSD 3.3(b)(4)

3.2 (U) [illegible]lite Application

(U) The space-based laser has considerable potential against satellites in an antisatellite role. The following apply.

- ~~(S)~~ The vulnerability of current Soviet satellites is quite uncertain and varied, but conservative estimates are th[redacted] Hardenin[redacted] should be anticipated.

- ~~(S)~~ Brightness level of [redacted] are adequate for effective antisatellite space-based laser systems.

- ~~(S)~~ With as few as two space-based laser stations o[redacted] the JCS requirements for negation of certain Soviet low earth orbit and elliptical orbit targets can be met[redacted] Even a single space-based laser can provide partial, but useful performance.

- (U) The principal benefit of a space-based laser antisatellite weapon is the very rapid negation rate and the relative insensitivity to the numbers of targets to be negated and the number requiring near-simultaneous kill.

USAF 1.4(a),(e); 3.3(b)(4) OSD 3.3(b)(4),(6) DIA 1.4(d)

*(U) This ignores specific weak points such as sensors, antennas, and the like so a given satellite might be much softer than the values given.

DRAFT

~~SECRET~~

(U) Thus, the space-based laser would provide an effective antisatellite capability although the cost effectiveness of a stand-alone space-based laser for this role should be further compared with other methods of achieving the same capability. If a space-based laser system is deployed for any other purpose, it would inherently have a powerful antisatellite capability.

3.3 (U) The Antiaircraft Application

(U) It is obvious that an ability to destroy aircraft worldwide would provide a powerful military capability. The characteristics of a space-based laser weapon system suggest that it might be well matched to this role.

(U) A typical space-based laser deployment will provide worldwide coverage, perhaps with some gaps in the instantaneous geographic coverage which are filled in time as the constellation moves. If one laser battle station fails or is destroyed, this creates or increases the gaps, but the effect is similar. The laser kill mechanism is rapid and non-nuclear, implying, for example, that it could be used in conventional as well as nuclear conflicts and that it could engage more quickly than forces not already based in the area. The total system size and cost for the range of missions considered is driven by the requirements for peak kill rate, implying a preferential role in extended time (e.g., antiaircraft) rather than short time (e.g., antimissile) engagements.

(U) The gaps mentioned are more than a minor factor since a single laser battle station may not survive a dedicated attack, especially in a nuclear engagement. If, for example, the space-based laser role is killing many closely spaced targets in a short period (as it would be in a damage limiting ballistic missile defense), the removal of a small fraction of the stations could reduce the effectiveness of the laser system at the crucial time. If, on the other hand, the role is one of attacking an airlift which takes place over several hours or even days, even a few laser battle stations could kill the aircraft involved over time and the battle station survivability is a less critical issue.

(U) These are some of the factors which make the antiaircraft mission attractive. The following additional comments apply:

- (U) Potential antiaircraft missions include defense of the continental U.S., fleet defense, suppression of Soviet airborne warning and control aircraft, destruction of any airborne command posts, airlift interdiction.*

- (U) Most of the missions listed are characterized by long flight paths, repeated flights over extended periods, or both. In either case, the existence of short (compared with aircraft exposure times) time gaps for any geographic area is unimportant and its likely that a large fraction of the total laser battle station constellation could take part in the battle.

---

*(U) Since the U.S. relies more heavily than the Soviets on aircraft in most of these roles, there may also be strong motivation for the Soviets to consider space-based lasers for this mission as well as to consider counter-measures to space-based laser weapon systems.

USAF 1.4(a),(e); 3.3(b)(4) ~~SECRET~~ OSD 3.3(b)(4),(6) DIA 1.4(d),

- [redacted]

- [redacted]

TABLE 3.1 ~~(S)~~
EXAMPLE SPACE-BASED LASER FORCES
FOR WORLDWIDE[1] AIR DEFENSE (U)

[redacted]

Number stations	8
Estimated cost[2]	$25 to 55 billion

NOTES: DIA 1.4(d) OSD 3.3(b)(4),(6)

1. Full equatorial coverage without exploitable gaps may require some additional laser satellites.

2. Cost estimates include RDT&E and procurement. Upper value includes developing and using a new space launch capability and a new surveillance system and assumes three-year replacement for laser satellites. Lower value does not include development of launch and surveillance and assumes five-year life satellites.

- (U) The antiaircraft role for space-based lasers would impose a corollary need for surveillance and target identification which cannot be met by any existing or programmed systems. There are technology efforts addressing both radar and infrared for space-based surveillance of aircraft, but these would have to be pursued more aggressively and integrated with the space-based laser system to support a realistic antiaircraft role.

- (U) DF laser wavelengths are strongly preferred because of the atmospheric transmission properties, although other roles such as anti-satellite and ballistic missile defense suffer mildly in comparsion with HF space-based lasers.

- (U) Since laser wavelengths will not penetrate clouds, the cloud-free-line-of-sight statistics are important to establish expected performance. Obviously, the lower a target aircraft flies, the more likely it is to be protected by cloud cover, so within the constraints of the aircraft mission, low-altitude tactics must be anticipated. Generally, however, it appears that long flight times will

[redacted]

DIA 1.4(d)

~~SECRET~~

OSD 3.3(b)(4),(6)

DRAFT

translate to reasonable target exposure to the space-based laser while short flights will allow the enemy to take advantage of local weather.

3.4 (U) The Ballistic Missile Defense Applications

(U) There is strong motivation for considering space-based lasers for ballistic missile defense for several reasons. The laser engages the ballistic missile in the boost or bus phases where multiple weapons could be killed as a single target. The space-based laser system could simultaneously defend a diverse set of targets from attacks by both ICBMs and SLBMs. In order to make maximum use of its capabilities, the space-based laser system could selectively engage targets. The following comments apply to ballistic missile defense.

- (U) Denying damage in the U.S. from a ballistic missile attack is obviously an overwhelming rationale for any defense system. Such "damage denial"* ballistic missile defense is not possible by any stand-alone, currently known system, and space-based lasers are no exception. In the time frame of interest, the Soviet ICBM/SLBM force will provide on the order of fifteen to twenty thousand reentry vehicles (RVs) and achievable leakage levels could exceed ten percent,** implying well in excess of a thousand RVs landing on U.S. soil with defense by a stand-alone system.

- (U) It is obviously difficult to quantify the value of reducing the number of weapons detonated on the U.S., for example, excluding those in our ICBM-base areas, from perhaps 6000 to 2000. Generally, the destruction would be very severe in either case, and the value of damage limiting with a stand-alone system is uncertain.

(S) A stand-alone space-based laser system to limit damage in the U.S. from a major Soviet attack, [redacted] would be sized as follows for the laser weapon brightness levels of possible interest, against an attack of 1280 ICBM boosters (10,000 counterforce and 2,000 countervalue warheads) and 528 SLBM boosters (4800 warheads):

USAF 1.4(a),(e); 3.3(b)(4)
DIA 1.4(d)
OSD 3.3(b)(4)

*(U) "Damage limiting" ballistic missile defense is taken to mean general defense of the population and the national resources in order to restrict the destruction (as opposed to ICBM defense which implies protection only for our hardened ICBM offensive forces). "Damage denial" is just the extreme of damage limiting.

[redacted]

DRAFT

[redacted]

[redacted]		
Number battle stations	54	11
10-year cost ($B)*	100 to 200	
[redacted]		
Number battle stations	165	25
10-year cost ($B)*	300 to 500	
[redacted]		
Number battle stations	285	37
10-year cost ($B)*	500 to 800	

(U) It is not possible at this stage to provide any meaningful estimates of the cost of the ultraviolet or visible systems because of the extreme extrapolation beyond current technology required for such an estimate. These are minimum-sized constellations to achieve the requisite kill rates and do not include allowances for failures, enemy disruption, etc.

(U) Another approach for damage limiting might be the combination of a space-based laser system and a conventional ballistic missile defense system. With the space-based laser system of the same magnitude described above, and an effective exoatmospheric ballistic missile defense system, it might be possible to reduce the damage levels. For example, if each system individually could achieve 20 percent of leakage (this is a realistic but not easy goal), the combined leakage would be about 4 percent or a few hundred reentry vehicles. The following comments apply:

- (U) Each of the space-based lasers and conventional systems should be sized with robustness (including surveillance and launch vehicles) for the anticipated level of attack.

- (U) Parallel developments of the space-based laser system, exoatmospheric ballistic missile defense system, and civil defense are needed.

---

*(U) Cost estimates include RDT&E and procurement. Upper value includes developing and using a new space launch capability and a new surveillance system and assumes three-year replacement for laser satellites. Lower value does not include development of launch and surveillance systems, and assumes a five-year satellite lifetime.

DRAFT

(U) A space-based laser system to protect the U.S. ICBM force is similar in size to that for damage limiting. In either case, the system must deal with all ICBMs launched, although the system for the defense of the missile force will be somewhat smaller since it can tolerate higher leakage rates.

(U) There are less demanding ballistic missile defense missions which might be considered for space-based lasers. Examples of those examined include:

- (U) Defense against pre-emptive SLBM attacks; e.g, against national command authority; command, control, and communications, etc.

- (U) Defense against relatively small attacks such as third country or accidental launches.

[redacted]

(U) Survival of the space-based laser weapon stations is critical. Since typically only 20 to 30 percent of the stations will be in a position to engage the ICBMs in a scenario of simultaneous launch, the removal of a small fraction of these could defeat the purpose (i.e., damage denial) of the system until some satellites are repositioned.

(U) It should be noted that there probably are significant asymmetries between the U.S. and USSR in measuring the value of space-based laser ballistic missile defense. For example, a laser weapon system used in conjunction with a massive first strike against the U.S. land-based ICBM force might be quite effective. Thus, it is important to develop a base of understanding which would allow us to counter a Soviet space-based laser deployment, as part of maintaining a viable second strike ICBM force. This implies development and understanding of hardening technology, ground-based laser antisatellite capabilities, and appropriate other weapons to be used against space-based laser systems.

[redacted] We would expect to see at least one new generation of missiles on this time scale. With current Soviet [redacted]

DIA 1.4(d) OSD 3.3(b)(4)

USAF 1.4(a),(e); 3.3(b)(4)

DRAFT

3.5 (U) Survival of Laser Battle Stations

(U) Deploying a space-based laser system is a major and visibly obvious step and would only be done to create a dramatic advantage. If, for example, the space-based laser system threatened a major fraction of the Soviet strategic offensive force or endangered all of their aircraft, wherever located, it would become a prime target for countermeasures and would warrant enormous commitment of resources to neutralize it. In the two decades being projected for us to deploy an effective space-based laser weapon system, the Soviets could deploy countermeasures that would significantly impact the ability of the laser system to perform the missions of interests. Target hardening has been discussed in Section 3.2, 3.3, and 3.4; this section discusses survivability.

(U) The survivability of the laser weapon system against a concerted enemy attack is a matter of concern. There is little doubt, that like most weapon systems, space-based laser battle stations could be destroyed by a dedicated attack. Analysis to date of survivability is limited and this lack of analysis is a major caveat for all of the conclusions drawn.

(U) It is difficult to imagine the Soviets or U.S. watching the launch and assembly of a constellation of weapons in space that could even be perceived as potentially tilting the strategic balance without taking some strong countermeasure actions. Neither side is likely to permit it to be done by the other and any planned deployment of space-based lasers must take this possibility into account.

(U) Satellites are vulnerable to threats ranging from impact weapons to nuclear effects at long ranges. The space-based laser must be able to cope with threats to survive. To accomplish this, the space based laser must be able to employ all of the measures that other weapon systems use to minimize the impact of attacks, i.e., engage and destroy the attackers before damage, avoid the attackers, and design systems and deploy force sizes that are resistant to significant damage from credible threats. This complex interaction of forces has not be examined. Rather, the following comments are basically addressed to a single laser station defending itself.

- (S) The existing Soviet conventional co-orbital antisatellite weapon has little credible capability against a space-based laser once it is operating but could be used to attack the station during deployment.

- (S) A Soviet mirror-image of the U.S. Miniature Homing Vehicle anti-satellite weapon represents a greater threat, against even an operating space-based laser. The Miniature Homing Vehicle may be either air launched by an F-15 or lofted with small boosters (SRAM-ALTAIR) which would be much more difficult to detect than an ICBM or SLBM launch. [redacted]

USAF 1.4(a),(e); 3.3(b)(4)

DRAFT

OSD 3.3(b)(4)

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

SECRET

USAF 1.4(a)(e); 3.3(b)(4)

Miniature Homing Vehicle could readily be destroyed by the space-based laser if it is located in time, [redacted]

OSD 3.3(b)(4)

(U) Another threat to the space-based laser is the "space mine" or "fellow traveler." This concept is a conventional or nuclear weapon launched into orbit accompanying the prospective target (the space-based laser in this case). It would be possible to detonate the space mine on the basis of either ground command or autonomously. The space-based laser system problems then would be to prevent the mine from ever getting within lethal range in the first place. Assuming that these mining tactics can be recognized when first employed near individual space-based laser stations, the space-based laser would have to enforce a sterile zone around each space-based laser.

[redacted]

MDA and OSD 3.3(b)(4)

(U) Finally, in direct attack, a laser antisatellite weapon must be considered. Several analyses of the space-based laser satellite defense weapon versus antisatellite weapon have been undertaken with the common assumption that our technology is always better than the Soviets so that our satellite defense weapon has a brightness well in excess of the attacking antisatellite weapon. All other things being equal, our more powerful space-based laser wins in the encounter as would be expected. However, considering that the Soviets have also invested heavily in this area and that they too have 20 years to compete, this a priori assumption of superiority may not be reasonable, particularly since there are current claims that the Soviets lead us in this area. A ground-based laser antisatellite weapon may also be attractive as a counter to the space-based laser, although there has not been an adequate analysis of the space-based laser ground-based laser battle to be sure of this.

(U) None of these threats are conclusive and the force-on-force aspects have not been adequately examined. However, the survivability of the space-based laser system against a concerted enemy attack remains a matter of major concern.

3.6 (U) Cost-Estimating Uncertainties

(U) All of the costs quoted are highly uncertain. Only conceptual designs are available for space-based lasers. There is little choice but to use historical

[redacted]

MDA and OSD 3.3(b)(4)

DRAFT

SECRET

costs based on spacecraft we have built, and extrapolate spacecraft cost by the standard approach of cost per unit weight. Of course, the weights are also uncertain. Laser system costs can only be estimated using best engineering judgment by extrapolating from the state-of-the-art of subsystem components. While the estimates include factors for surveillance, acquisition, tracking, command and control, and the like, these systems have, in general, not even been designed, thus adding to the uncertainty in cost estimates.

4.0 (U) CURRENT TECHNOLOGY DEVELOPMENT PROGRAMS

4.1 (U) Introduction

(U) This section describes the current programs which collectively form the technology base for space laser development. No attempt has been made to make the discussion complete; rather, emphasis has been placed on the major programs.

4.2 (U) DARPA Space Laser TRIAD Program

(U) The DARPA program is structured to develop the key technologies required for a space-based laser weapon system. The focus of the program is the space laser TRIAD: ALPHA, LODE, and Talon Gold.

[redacted]

USAF 1.4(a),(e); 3.3(b)4 MDA and OSD 3.3(b)(4)

(S) The objective of the Large Optics Demonstration Experiment (LODE) is to demonstrate the critical beam control technology essential for the development of space laser weapon systems. Specific program objectives include demonstration of the ability to manufacture a [redacted] mirror, wavefront control and alignment, large space structure performance, and energy management in an overall beam control system that yields better than [redacted] wave optical quality and [redacted] microradian pointing stability in a simulated operational environment. The actual demonstration will be conducted in ground-based facilities using a low power laser and simulator techniques to establish with high confidence the required beam control performance. The program is currently in the concept definition phase. The preliminary design review and critical design review are scheduled for mid FY 1981 and late FY 1982, respectively. Low-power testing with a [redacted] primary mirror is scheduled to begin in the fourth quarter of FY 1984. Testing with a [redacted] will follow one year later in FY 1985.

(S) The objective of the Talon Gold Program is to develop and test the advanced acquisition, tracking and precision pointing capability required by a space-based laser weapon system. The major element of the program is a space-based, low-power laser experiment which will demonstrate the technology for cold-body acquisition and tracking at ranges up to 1500 km with a pointing accuracy of [redacted] The test program will be conducted as a sortie flight of the space shuttle, and will utilize both high altitude aircraft and space targets to obtain realistic target kinematics, signatures and backgrounds. This work has only limited value for ballistic missile defense applications of space-based lasers, since it is not designed to cope with missile-type targets.

USAF 1.4(a),(e); 3.3(b)(4)

OSD 3.3(b)(4)

DRAFT

(S) The program is currently in the preliminary design phase with preliminary design review scheduled for the third quarter of FY 1981. The critical design review will occur in mid FY 1983, and the launch and space test are anticipated to occur at the end of FY 1986.

4.3 (U) Technology Base Development

(U) Technology base development efforts include the DARPA funded Novel Resonator Program, the objective of which is to develop, through analysis and experiment, advanced resonator concepts for cylindrical chemical lasers in the 5 to 25 MW power regime. Similarly, the Army supported Chemical Laser Nozzle Technology (CLNT) Program is developing second-generation, low-pressure nozzle concepts with improved performance and fuel efficiency. The DARPA Laser Scaling Evaluation Program (LSEP) is developing an extensive data base for the temporal, spatial and spectral characteristics of a low-pressure HF chemical laser gain medium.

(S) Deuterium fluoride chemical lasers have demonstrated the highest average power to date in the DoD high energy laser program although none of the DF chemical laser programs is specifically designed to demonstrate space laser technology. Power levels in excess of [redacted] have recently been achieved and other experimental high power DF lasers have been integrated with optical pointing systems for demonstrations which exceed 100 seconds of run time. Cylindrical DF lasers, which are designed to scale to multimegawatt power levels, are currently being developed by the Air Force. The Modular Army Demonstration System (MADS) is an Army DF laser which has demonstrated operation with low cavity pressure.

USAF 1.4(a),(e); 3.3(b)(4) OSD 3.3(b)(4)

(S) The Small High Power Optics Program (SHOP) is a DARPA sponsored effort to develop advanced mirror design concepts which provide improved heat transfer performance at reduced jitter. The ADOPT (Advanced Optical Technique) Program is addressing design concepts for large aperture beam control systems up to 30 meters in size. The objective of the ACOSS (Active Control of Space Structures) Program is to develop the technology to actively control the structures for such large beam control systems.

4.4 (U) Advanced Laser Development

(S) Current DARPA efforts relevant to advanced strategic laser weapons utilizing ground-based lasers and space relay mirror(s) include device technology for excimer and free electron lasers, as well as some elements of the beam control technology. The lasers are in the very early stages of development. Power outputs demonstrated to date have been very low.

[redacted]

MDA and OSD 3.3(b)(4)
USAF 1.4(a),(e) and 3.3(b)(4)

DRAFT

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 28 2014

SECRET

[redacted]

MDA and OSD 3.3(b)(4)

(U) The current free electron laser experiments are to verify the analytic models and to demonstrate efficient operation (>10%) utilizing existing RF linear accelerators. These experiments will be continued to recover the RF accelerator electron beam energy following its interaction with the laser radiation in order to increase the efficiency to 30 percent. Further plans include wavelength scaling into the visible spectrum with higher energy linear accelerators, RF linear accelerator stability experiments, and initiation of a moderate average power free electron laser to be completed in FY 1986/1987.

(U) In the area of short wavelength laser beam control, limited work has been supported by DARPA, the Services, and the Department of Energy. Mirror coating technology for ultraviolet lasers, deformable mirrors for compensated imaging and the NASA large space telescope are examples of this. Furthermore, there will be some technology fallout from the DARPA Strategic Laser Communications Program that will be of benefit to the high power visible laser beam control program.

(U) The current Ballistic Missile Defense Advanced Technology Center advanced laser program has two potential laser candidates under development - chemically pumped visible lasers, and electrically pumped vibrational-to-electronic energy transfer lasers. The visible chemical laser would use the reaction of tin atoms with nitrous oxide to yield a population inversion in tin oxide and potential lasing at 570 nm. The vibrational-to-electronic laser concept is based upon the resonant transfer of energy between the vibrational states of carbon monoxide and the electronic excited states of nitric oxide. The resulting laser would be ultra-violet, yet retain the pumping efficiency possible for vibrational excited states. Current efforts on both programs are concentrated on demonstrating laser action and determining the critical kinetic rate constants.

(U) Currently the Air Force is developing the CW chemically pumped iodine laser and the potential magnesium-calcium (Mg-Ca) transfer laser. The CW iodine laser, developed at the Air Force Weapons Laboratory (AFWL), produces excited oxygen in a "chemical generator." The oxygen then transfers its energy to atomic iodine, which lases at 1.315 micrometers. The iodine program has demonstrated that mass flow efficiencies of 100 kJ/kg can be achieved in the CW iodine laser; however, the physical size and pressure of the current chemical generators are not yet suitable to weapon applications. The current thrust of the program is to resolve uncertainties in critical kinetic rate constants and to demonstrate scaling to tens of kilowatts. The Mg-Ca concept utilizes a chemical generator to produce excited Mg which transfers its energy to Ca which lases at 657 nm. Currently, the Air Force is developing generator technology for this concept and is funding studies to determine the critical kinetic rate constants.

DRAFT

SECRET

5.0 (U) ACCELERATED TECHNOLOGY DEVELOPMENT OPTIONS

USAF 1.4(a),(e); 3.3(b)(4)
MDA and OSD 3.3(b)(4)

5.1 (U) Introduction

(U) The section presents program options to accelerate the resolution of technical uncertainties in the development of space laser weapons. These options are based upon an in depth assessment of the current state-of-the-art of laser technology, the major findings of which are as follows:

1. ~~(S)~~ [redacted]

2. ~~(S)~~ [redacted]

3. (U) An on-orbit feasibility demonstration is a necessary step toward weapon development.

4. ~~(S)~~ [redacted]

5. ~~(S)~~ Significant uncertainties must be resolved before a confident commitment to weaponization can be made. These uncertainties are associated with technical feasibility, threat vulnerability, laser survivability, and total weapon system cost.

(U) The efforts to resolve the uncertainties fall into four general categories:

1. (U) Achieving the required state-of-art in the technology base.

2. (U) Understanding the system engineering issues such as surveillance; command, control, and communications; and transportation to the depth needed to support fundamental assessments of utility in military missions.

3. (U) Determining, to the depth needed for confident assessment and projection, the lethality of a laser weapon against the current target base and against a responsive target base hardened against laser radiation.

4. (U) Assessing the system and force level survivability of a space laser deployment against a determined attacker.

DRAFT

USAF 1.4(a),(e); 3.3(b)(4)

OSD 3.3(b)(4)

(U) The options consider the pace and degree of risk at which one addresses:

- (S) Availability of "entry level" state-of-the-art brightness (assumed to be [redacted]
- (U) Resolution of initial "engineering" issues (size, weight, space qualification, space craft integration, etc.)
- (U) Resolution of initial "lethality" issues (analysis and experiments on target vulnerability and responsive countermeasures).
- (U) State-of-the-art advances laser devices and beam control for growth potential.
- (U) Laser system survivability issues (hardening, countermeasures, tactics, self defense).
- (U) On-orbit, weapon-level feasibility demonstration (integration; command, control, and communications; surveillance handover; lethality).
- (U) Engineering development to prototype weapon.

(U) The four optional development programs described below present increasing levels of acceleration of the space laser program. They can be characterized as follows:

(U) OPTION 1: Continue with current level of effort of technology development.

(U) OPTION 2: Accelerate current technology program to resolve key technical uncertainties at an early date.

(U) OPTION 3: Perform an on-orbit demonstration of a space laser integrated with its optics and pointing system in addition to an accelerated technology program.

(U) OPTION 4: Develop the earliest feasible space-based laser weapon system.

5.2 (U) <u>Option 1: Continue Current Level of Effort</u>

(S) <u>Goals</u>. This option has the typical of developing a level of technology that will provide a basis for decisions to proceed to an on-orbit feasibility demonstration or to weapon prototyping. Specifically, the goals provide a TRIAD chemical laser technology-development at levels of [redacted] Advanced concepts are, in the near-term, focused on shorter wavelength, advanced laser devices, and nanoradian pointing accuracy.

USAF 1.4(a),(e); 3.3(b)(4)

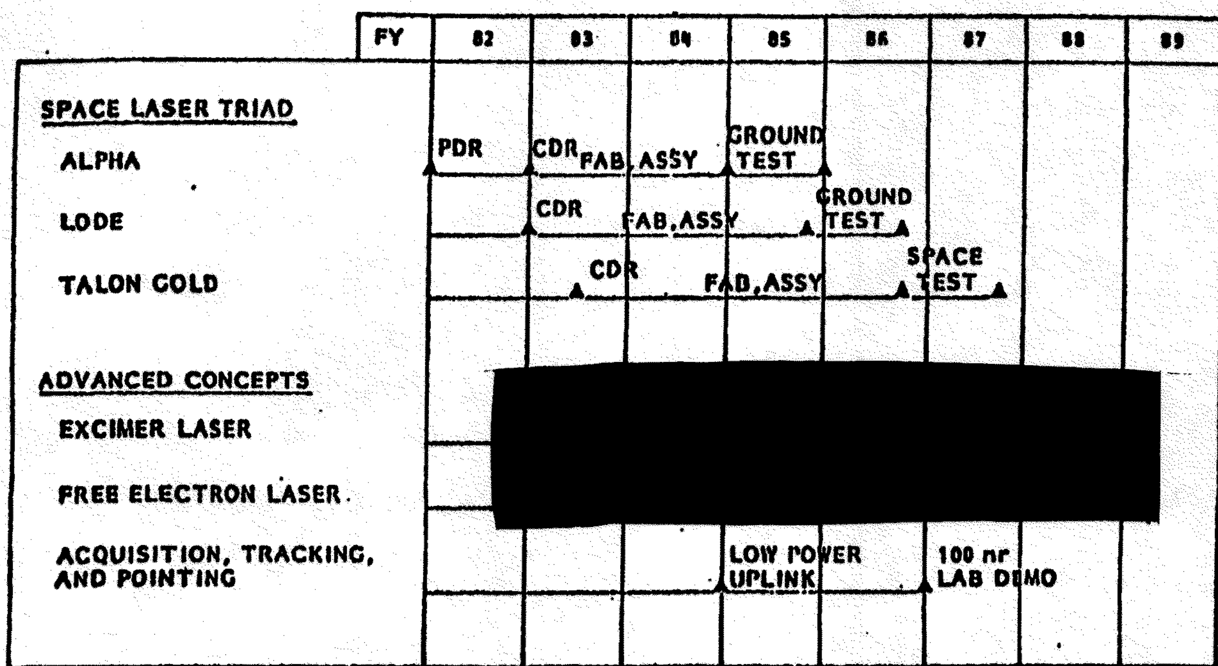
OSD 3.3(b)(4)

DRAFT

(U) Schedule/Milestones are shown in Figure 5.1 and include a 1987 completion of the TRIAD.

OPTION 1: CONTINUE CURRENT LEVEL OF EFFORT (U)

THIS FIGURE IS ~~SECRET~~



USAF 1.4(a),(e); 7.3(b)(4) OSD 3.3(b)(4)

~~(C)~~ Costs. Estimated costs to accomplish the goals of this option are shown in Table 5.1 and total $586M.

TABLE 5.1 ~~(C)~~

ESTIMATED COSTS (FY 1981 Dollars in Millions)
OPTION 1: CONTINUE CURRENT LEVEL OF EFFORT (U)

FY	1982	1983	1984	1985	1986	1982-86	TOTAL 1982-88
Space Laser TRIAD	70	77	100	66	43	356	376
Advanced (UV/visible) Concepts	19	23	32	35	40	149	210
TOTAL	89	100	132	101	83	505	586

DRAFT

5.3 (U) Option 2: Accelerate Technology Development

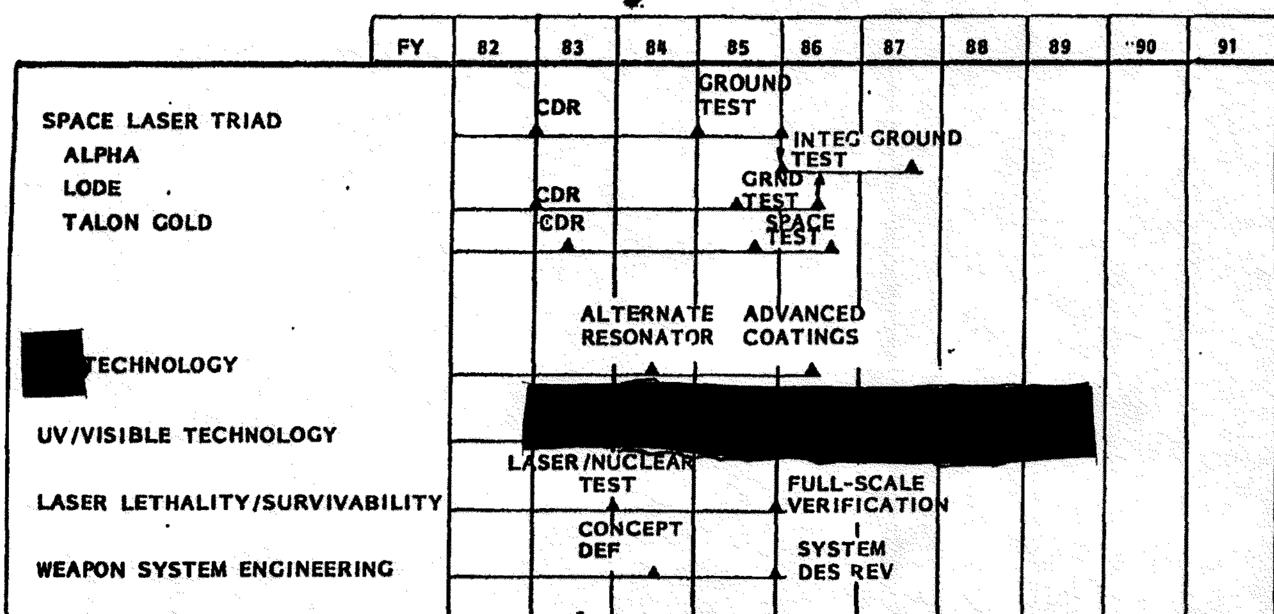
(U) Goals. This option provides an aggressive program to advance the state-of-the-art while providing for an examination by the mid 1980s of the most critical issues. It continues the serial approach of Option 1 by establishing technology at the major subsystem level before beginning any effort on an on-orbit feasibility demonstrator. The program defined addresses on a technology-limited schedule only those issues essential to reducing the risk and technical uncertainties associated with a decision to proceed with an on-orbit demonstration or weapon system.

[redacted]

USAF 1.4(a),(e); 3.3(b)(4)
MDA and OSD 3.3(b)(4)

OPTION 2: ACCELERATED TECHNOLOGY

THIS FIGURE IS SECRET



USAF 1.4(a),(e); 3.3(b)(4) OSD 3.3(b)(4)

DRAFT

(S) Costs. Costs of this option to completion in FY 1988 total $1325 million. Estimated costs are shown in Table 5.2.

TABLE 5.2 (S)

ESTIMATED COSTS (FY 1981 Dollars in Millions)
OPTION 2: ACCELERATED TECHNOLOGY DEVELOPMENT (U)

FY	1982	1983	1984	1985	1986	1982-86	TOTAL 1982 88
Space Laser TRIAD	105	175	180	90	45	595	620
[redacted] Technology	70	80	90	60	10	310	310
UV/Visible Technology	20	25	35	40	50	170	230
Lethality/ Survivability	15	30	40	30	--	115	115
Weapon System Engineering	10	15	15	10	--	50	50
TOTALS	220	325	360	230	105	1240	1325

USAF 1.4(a),(c); 3.3(b)(4) OSD 3.3(b)(4)

(U) There are many variations of Option 2 which will address selected portions of the technical uncertainties with a reduced level of funding, but with a consequent increase in risk and uncertainty in the areas not fully funded. For example, an alternate to the Option 2 presented above could concentrate on only a limited number of issues such as concept definition, utility assessment and laser survivability and lethality.

5.4 (U) Option 3: Perform On-Orbit Demonstration of Space-Based Lasers

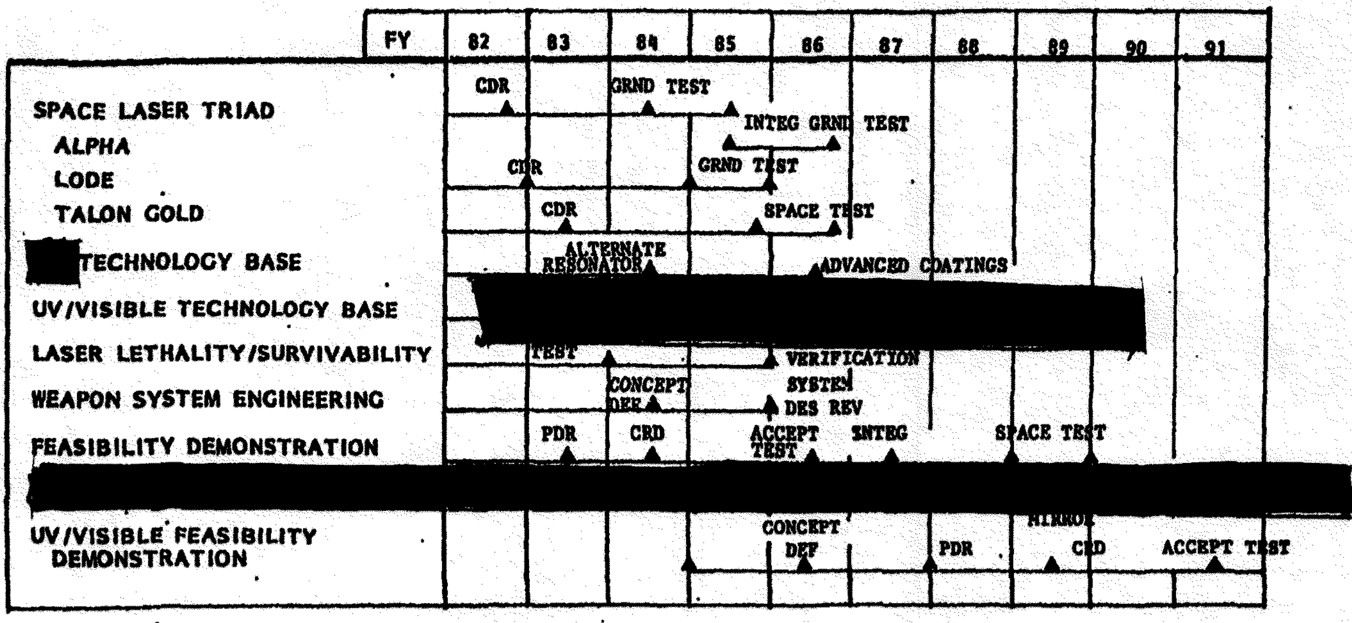
(S) Goals. This option commits now to the earliest possible demonstration of a space-based laser on-orbit. It includes the accelerated and enhanced technology efforts of Option 2 with additional acceleration of the Space Laser TRIAD. This option, therefore, provides for a mid 1980s re-examination of the commitment to a demonstration at the critical design review stage. [redacted] MDA and OSD 3.3(b)(4)

(S) Schedule/Milestones. A decision to proceed immediately with an on-orbit demonstration (verified in FY 1984 and 1986) yields a flight in late FY 1988. Figure 5.3 contains detailed milestones.

DRAFT

OPTION 3: EARLIEST POSSIBLE FEASIBILITY DEMONSTRATION (U)

THIS FIGURE IS SECRET



(S) Costs. Costs to completion in FY 1991 total approximately $5 billion. Details are shown in Table 5.3.

USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

TABLE 5.3 (S)

ESTIMATED COSTS (FY 1981 Dollars in Millions)
OPTION 3: ON-ORBIT DEMONSTRATION (U)

FY	1982	1983	1984	1985	1986	1982-86	TOTAL 1982-91
Space Laser TRIAD	115	190	170	105	35	615	620
[redacted] Technology	80	110	110	70	10	380	380
UV/Visible Technology	20	25	35	40	50	170	230
Lethality/ Survivability	15	30	40	30	--	115	115
Weapon System Engineering	10	15	15	10	--	50	50
Feasibility Demonstration	130	235	340	350	360	1415	1990
[redacted] Technology	--	--	--	65	95	160	950
UV/Visible Feasibility Demonstration	--	--	--	5	10	15	700
TOTALS	370	605	710	675	560	2920	4945

DRAFT

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

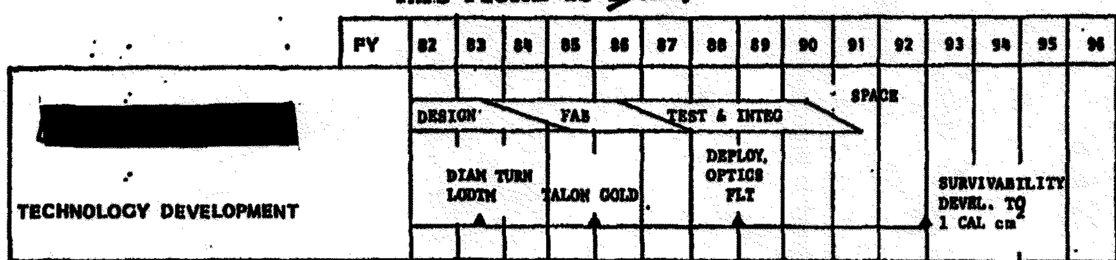
5.5 (U) Option 4: Develop Earliest Feasible Space-Based Laser Weapon System

~~(S)~~ Goals. This option accepts the high risk of attempting to begin now to prototype a space laser weapon at [redacted] To reduce this risk, an enhanced technology development program is included. Successful execution of this option will yield the earliest possible flight of a prototype space laser weapon in 1990 with initial operational capability in 1994. The capability of such a system would be largely limited to antisatellite missions and would have no growth potential to satisfy the more demanding missions such as antiaircraft or ballistic missile defense. It is recommended that this option not be seriously considered. A system with greater utility and growth potential is described in Section VI. It could also have a prototype launch in 2000 and initial operational capability IOC in 2003.

~~(S)~~ Schedules/Milestones. The major milestone is an FY 1990 launch of a [redacted] prototype. Decision milestones are provided in mid FY 1984 and FY 1986 to continue prototype development. Details are shown in Figure 5.4.

OPTION 4: PROTOTYPE DEVELOPMENT (U)

THIS FIGURE IS ~~SECRET~~



~~(C)~~ Costs. Costs to completion in FY 1996 total approximately $4B. Details are shown in Table 5.4.

OSD 3.3(b)(4)

USAF 1.4(a),(e); 3.3(b)(4)

TABLE 5.4 ~~(S)~~

ESTIMATED COSTS (FY 1981 Dollars in Millions)
OPTION 4: DEVELOP EARLIER FEASIBLE SPACE-BASED LASER WEAPON SYSTEM

FY	1982	1983	1984	1985	1986	CUM. 1982-86	TOTAL 1982-96
[redacted]	150	270	400	490	500	1810	2700
Accelerated Tech Development	220	325	360	230	105	1240	1325*
TOTALS	370	595	760	720	605	3050	4025*

*To 1988

DRAFT

5.6 (U) Other Supporting Technology Programs

(U) The structure of these options assumes that a few on-going technology programs will continue and can be used to implement any space laser weapon development. They include: Teal Ruby, Mini-Halo, and SIRE.

DRAFT

6.0 (U) OPTIONS FOR SYSTEM DEVELOPMENT

6.1 (U) Introduction

USAF 1.4(a),(e); 3.3(b)(4)
MDA 3.3(b)(2),(4) OSD 3.3(b)(4)

(S) Classes of space-based lasers considered for development planning include [redacted] The focus of the current DARPA TRIAD program leads to tests of major [redacted] class subsystems (see Section IV). Options to accelerate space-based laser technology (Section V) build on the TRIAD program. Accordingly, the earliest on-orbit deployment of a space-based laser system could consist of constellations of [redacted] (or lesser) class weapons. A [redacted] system would have reasonably good capability against low earth orbit satellites; however, an excessive number of space platforms would be required for multimission use, and no growth to useful ballistic missile defense capability is predicted.

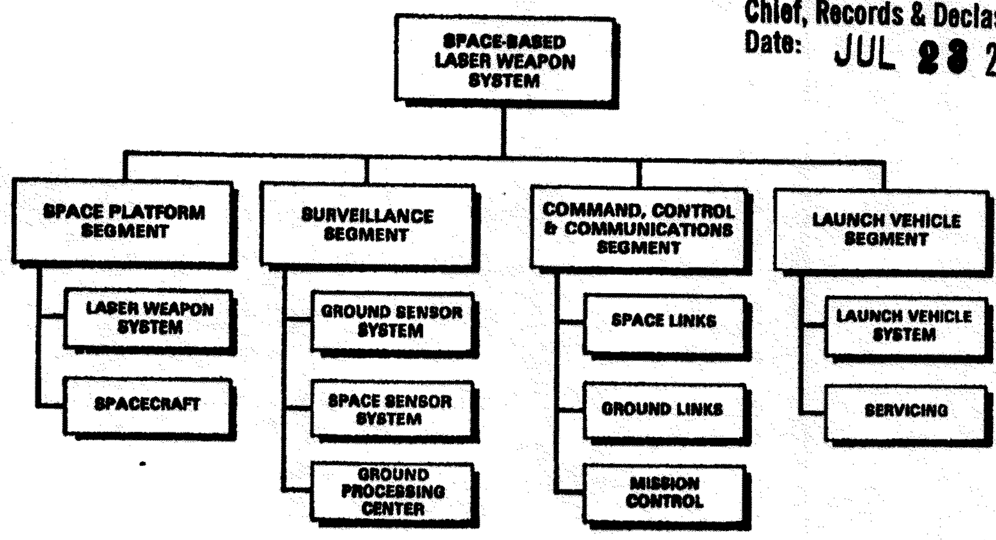
[redacted]

(S) A space-based laser requires supporting segments including launch capability, surveillance and targeting, command and control, spacecraft housekeeping, etc. It was necessary to address the constituents of the total system in order to assess impacts on space-based laser effectiveness and to understand the nature/size/cost of everything needed to make a space-based laser viable. This section outlines the total system architecture needed to accommodate these factors. Later, system development planning, costs and multimission sizing are discussed.

6.2 (U) Space System Architecture

6.2.1 (U) The four segments of the total space-based laser weapon system are shown in block diagram form in Figure 6-1. Each segment is discussed in the following paragraphs.

DRAFT



(U) Figure 6-1 TOTAL SYSTEM DEFINITION

6.2.2 (U) Surveillance/Command, Control, and Communications Concepts

(S) Advanced sensor and command, control, and communications capabilities are required to realize the full potential of the space-based laser, but modification to existing capabilities will support the system development through a validation phase.

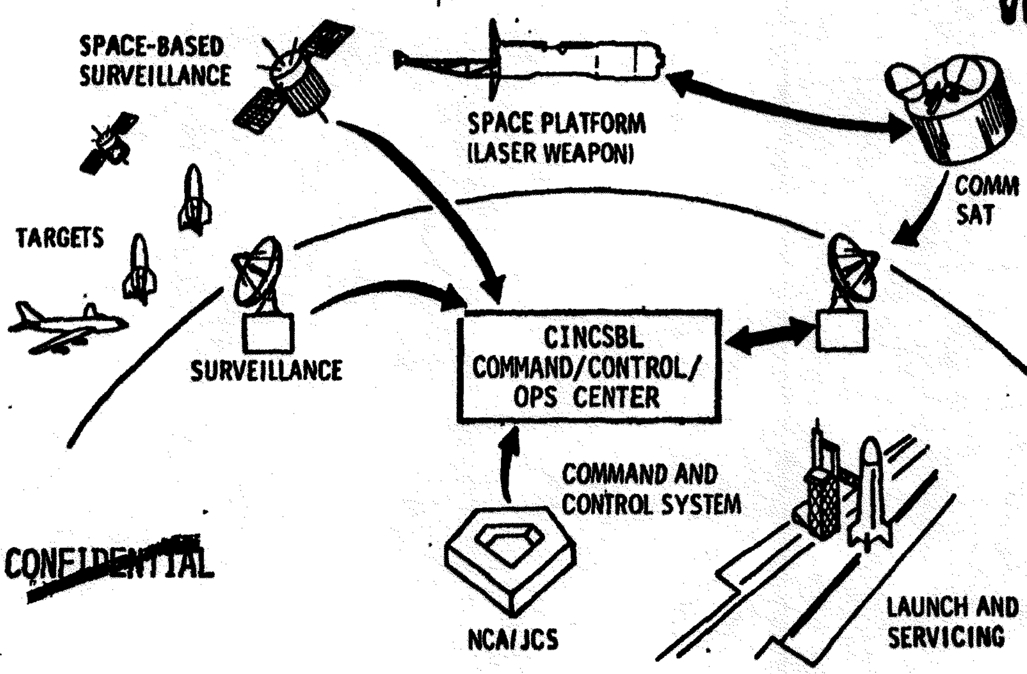
(C) Figure 6-2 shows the elements of the surveillance/command, control, and communications system. The generic structure has surveillance sensors detecting and tracking targets and providing target data to a command and control/operations center. The commander of the space-based laser system obtains weapons release authority from the Joint Chiefs of Staff/National Command Authority unless it was previously delegated to him. Target allocation and battle management are accomplished in the operations center. A mission control center--which passes action commands to the laser weapons--may or may not be collocated with the operations center. Surveillance data is passed over landlines and/or military communications satellite. The control of the laser weapon is accomplished via a military communications satellite link and/or direct link to the space platforms.

6.2.3. (U) Surveillance Segment

(S) New surveillance capabilities are required to support the responsive, global capabilities of a space-based laser weapon system. A space-based radar or space-based infrared system is required for aircraft detection and tracking. Comparative analyses between the space-based radar and the space-based infrared were not made. For missile detection, an advanced infrared system would be required to discriminate large numbers of targets simultaneously and to provide warning times within a short time after launch. A space-based infrared sensor in low earth orbit could supplement the Space Detection and Tracking System and enhance the capability to detect newly launched and maneuvering satellites. Survivability of the surveillance segment is a critical issue which must be addressed.

DRAFT

SECRET



CONFIDENTIAL

(U) Figure 6-2. SURVEILLANCE/COMMAND, CONTROL, AND COMMUNICATIONS -- OVERVIEW

(S) Sensors and automatic processing are required on the space-based laser platform to provide surveillance to allow the laser weapon to participate in its own defense. [redacted] were incorporated into the space-based laser space platform conceptual design. USAF 1.4 (a),(e); 3.3(b)(4) OSD 3.3(b)(4)

6.2.4 (U) Command, Control, and Communications Segment

(S) Command of a space laser weapon can be accomplished within the current Joint Chiefs of Staff/unified/specifed command structure. Conceptually, the space-based laser can be controlled by modifying existing capabilities, however, an operations center and mission control center were included in the operational concepts and costs.

(C) Communications with the space-based laser can be supported by allocating existing communication channels on military communications satellites. Cross-linking between synchronous satellites will be required to command and control the space-based laser without overseas station links. The space platform must have tracking communications antennas to link via military communications satellite. A separate communications satellite constellation was priced to indicate the cost impact if present communications satellite assets were not allocated for space-based laser use or if the survivability of existing communications satellites prohibited their use.

DRAFT

SECRET

(S) Antonomous operation is required in the space-based laser system for self defense and ballistic missile defense. The man-in-the-loop decision timelines through the National Command Authority to commander of the space-based laser system can support the other missions considered. The autonomous operation will require greatly improved, high confidence target discrimination by the surveillance system.

6.2.5 (U) Space Platform Segment

(U) The laser weapon subsystems include: laser device and reactant supply, beam control, acquisition and tracking sensors, and attack warning sensors. The spacecraft subsystems include: thermal control, structures, guidance and navigation, attitude control, telemetry, tracking, and communication; electrical power; and propulsion. The subsystems were then integrated into an overall space platform configuration. The weights, volumes and orbital deployments of each of the space platforms were estimated in order to determine launch vehicle requirements (see paragraph 6.2.6) and onboard (spacecraft) propulsion requirements.

(S) Weight estimates are shown in Table 6.1 for the three configurations [redacted] The mission equipment weights include all of the subsystems of the laser weapon described above plus a contingency allowance of 34 percent of the dry vehicle weight to cover hardening and the weight growth that typically occur during the detail design phase.

USAF 1.4(a)(e); 3.3(b)(4) OSD 3.3(b)(4)

(U) Table 6-1. WEIGHT SUMMARY (Pounds)

ITEM	Single Launch HF/DF [redacted]		
Mission Equipment (No Reactants)	36,800	41,700	58,600
Spacecraft Subsystems	16,000	20,800	36,700
Hardening and Contingency	17,900	21,200	32,300
Laser Reactants	12,700	20,400	31,300
Propellants*	11,600	21,100	31,100
Total Orbiting Vehicle	95,000	125,200	190,000
Aerospace Support Equipment	10,000	0	0
Nose Fairing & Adapter	0	7,000	10,000
Total Cargo Weight	105,000	132,200	200,000

*For altitude control and orbit adjust system

USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

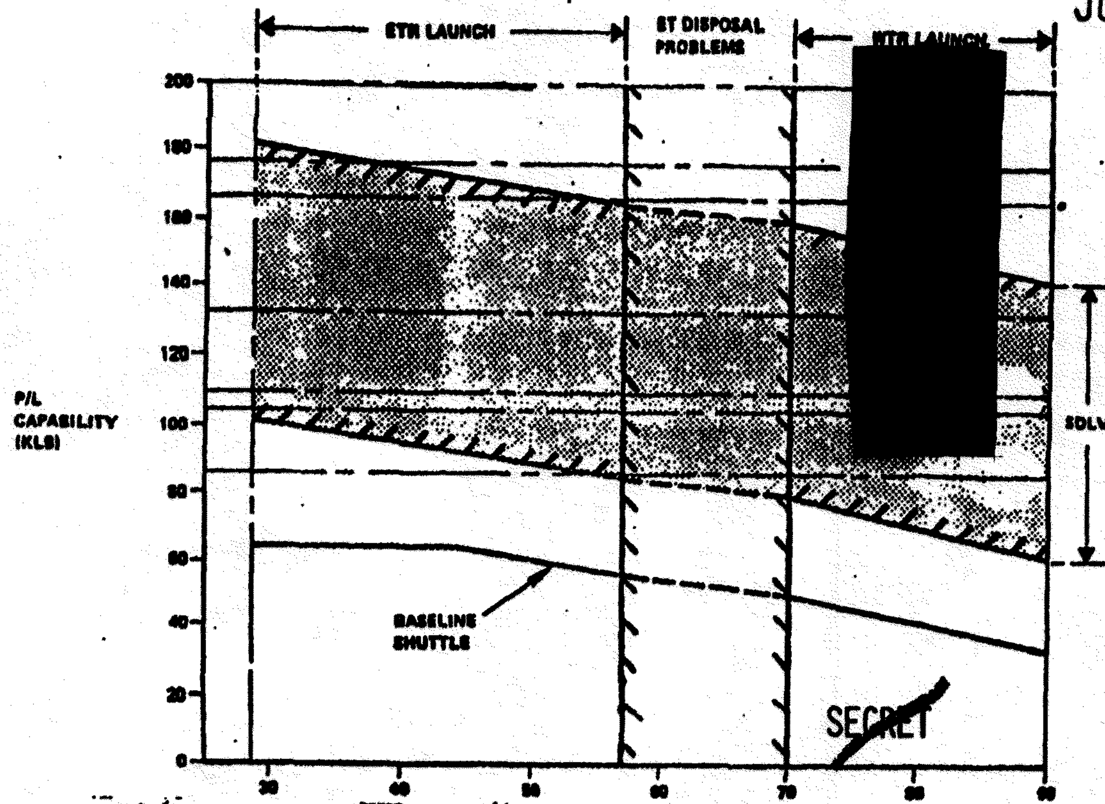
6.2.6 (U) Launch Vehicle Segment

(S) Launch vehicles will deliver the space platforms to an initial low earth orbit altitude of approximately 150 nm (280 km). Transfer of the space platforms to their operational orbits is accomplished by onboard propulsion systems. The baseline shuttle now under development is the only launch vehicle programmed for

DRAFT

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

SECRET



USAF 1.4(a),(a); 3.3(b)(4) (U) ORBIT INCLINATION (DEG) MDA and OSD 3.3(b)(4)

(U) Figure 6.3. LAUNCH VEHICLE CAPABILITY TO LOW EARTH ORBIT

the future. A number of studies have been conducted of potential future heavy-lift launch vehicles including the shuttle-derivative launch vehicle. Figure 6.3 shows both the baseline shuttle and the band of potential shuttle-derivative launch vehicle payload weight capabilities to low earth orbit. The shuttle-derivative launch vehicle capability band is based on the provision of a payload capsule fully enclosing the payload during launch. The lower edge of the shuttle-derivative launch vehicle band is for shuttle engines with solid boosters and a recoverable payload capsule; the upper edge of the band is for uprated engines plus liquid boosters and a nonrecoverable capsule.

(S) From Figure 6-3, it can be seen that the baseline shuttle capability is inadequate for launching any of the space-based lasers as a single payload. All space platform lengths also exceed the current 60 ft (18.3-meters) length of the orbiter bay. Either a larger payload bay or multiple launches are required. The diameter of the large optical elements must also be considered. Current studies suggest that fixed elements of up to 6-meters in diameter could be accommodated by a shuttle-derivative launch vehicle. For elements larger than 6-meters, an enlarged shuttle-derivative launch vehicle payload capsule or on-orbit erection/assembly will be required. The development of a launch capability such as the shuttle-derivative launch vehicle appears mandatory for

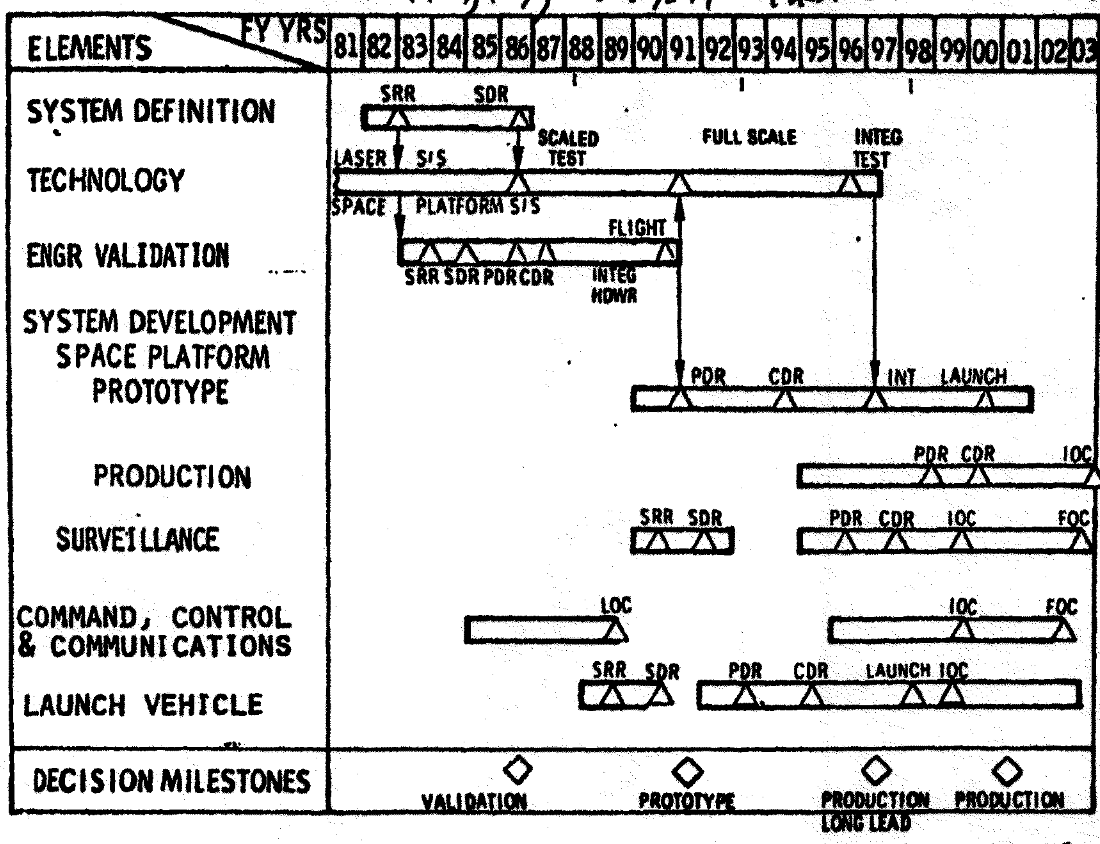
[redacted]

DRAFT

SECRET

6.3 (U) Representative Program Development Plan

6.3.1 (S) The pace of system development is directly dependent on how fast advances in technologies are accomplished. [redacted] The representative plan could be accelerated by increasing the concurrency among phases of the program. Acceleration greatly increases risk, but initial operational capability might be reached by FY 1995 which would be consistent with selection of Option 3 in Section V. USAF 1.4(a),(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)



(U) Figure 6-4. REPRESENTATIVE DEVELOPMENT PLAN (SECRET)

(U) As shown in Figure 6-4, system definition is focused through a system requirements review and system design review. Definition of system requirements gives guidance to the technology and validation efforts in the first five years of the program.

DRAFT

USAF 1.4(a),(a); 3.3(b)(4) MDA and OSD 3.3(b)(4)

(S) Both the laser subsystems and spacecraft subsystem technology developments are to be addressed under "Technology." The overall pace of space-based laser development is directly keyed to the pace of technological development (see previous Section V of this report). This space-based laser system development plan assumes that laser subscale (e.g. [redacted] class) would be available in 1986 and that integrated ground test through 1989 would follow. Flight weight [redacted] hardware would be in integrated ground test by FY 1996.

(S) Due to high technological and integration risks, an engineering validation is necessary at some point. This would force attention to the hard engineering and integration problems inherent in a space-based laser.

(S) An on-orbit validator would resolve issues of laser integration and spacecraft operation in the space environment. The validator would be a well-instrumented unit, sized for a single launch. It would be on-orbit for less than one year of test and evaluation and could be recovered for examination prior to developing an operational prototype. Realistic surveillance and command, contro, and communications issues could also be addressed to refine operational and battle management concepts. [redacted] Figure 6.4 shows an example schedule for an on-orbit validation. The system design review for "System Definition," [redacted] class hardware, and validator preliminary design review are all available at the decision milestone to preceed to validation.

(S) On-orbit validation would not require the full-up surveillance and command and control capability described in Section 6.2; however, detailed test and operations planning will be necessary to operate through existing and planned networks (e.g. Space Detection and Tracking System, Consolidated Space Operations Center, Space Defense Operations Center, etc.). Facilities would be required for assembly, ground test, and integration, and equipment would be required for monitoring/controlling ground and orbital operations.

[redacted]

(S) The production decision is based on the results of prototype operational test and evaluation. However, the decision to proceed with initial production planning, design and acquisition of long lead items must occur about 1997 to support initial operational capability in 2003.

(S) The initial operational capability is defined as the first operational space-based laser space platform on-orbit. A launch rate of four per year is assumed yielding a full operational capability of an eight-satellite constellation in 2005. Production would continue to either support on-orbit replacement at the end of useful life (three and five year lifetimes were costed) or on-orbit servicing. Detailed trade-offs will be needed to determine the most cost-effective strategy for maintaining on-orbit operation.

DRAFT

(S) Advanced surveillance/command, control, and communications full operational capability could occur by the time frame of space-based laser initial operational capability. For example, current planning estimates are that a heavy launch vehicle could be developed/fielded in four to seven years. Figure 6.4 shows eight years from launch vehicle system design review to initial operational capability. Space-based radar designs are only vaguely conceptualized; however, some key technologies are being sponsored by DARPA. Space-based radar initial operational capability is not needed until launch of the space-based laser prototype.

(U) Finally, assembly and integration facilities as well as ground support/processing station(s) are projected to support the system deployment.

6.4 (U) Early On-Orbit Deployment of a System

6.4.1 (S) Should the [redacted] class space-based laser be selected for prototype and production, initial operational capability might be reached by 1997. This would require:

- (U) Engineering validation be initiated immediately.
- (S) Acquisition of prototype long lead items begins immediately after TRIAD testing (1986) and before launch of the on-orbit validator.
- (S) Work begins in 1984-85 on a shuttle-derivative launch vehicle to complete development before need for space-based laser prototype integration in 1991-92.
- (S) Surveillance and command, control, and communications assets reach initial operational capability by 1992-94.
- (S) Prototype launch occurs in 1993-94.
- (U) Production go ahead be given shortly after the prototype launch.
- (S) First production space-based laser launch occurs in 1997.

6.4.2 (S) Acceleration of the [redacted] class system initial operational capability could be accomplished by skipping engineering validation and conducting design, fabrication, and test of the prototype launch to FY 1990 and is consistent with Option 4 in Section V. Paralleling production and prototyping could move initial operational capability to FY 1993-94 with attendant higher risk. USAF 1.4(a), (e), 3.3(b)(4) OSD 3.3(b)(4)

6.5 (U) System Costs

6.5.1 (U) Ten year life cycle costs were chosen as the cost measure. Integration, training, mission-peculiar support equipment, test and evaluation and program management are taken as percentages of the recurring production or first unit cost. Costs of major system components (e.g. launch and surveillance systems) are added to the space platform costs.

DRAFT

(U) All costs are presented in 1981 constant dollars. A 40 percent factor was used to cover Government management reserve and management support.

(U) RDT&E costs are estimates based on prior complex systems development programs. Production costs are functions of the first unit cost (spacecraft and laser). Spacecraft costs are based on weights. Laser costs, however, are based on performance parameters and best engineering judgments of extrapolation of state-of-the-art of subsystem components. Ten years of operation and support are included in calculating life cycle costs. Both five-year and three-year lifetimes were considered with satellites completely replaced at the end of their life.

(S) Annual testing was included. It was assumed that each space platform would have one operational test each year. Sufficient fuel (10 percent) was added to cover the test requirements. Aircraft and space targets for testing are also included.

(U) The cost of on-board surveillance sensors and ground-based facilities for data processing are included. Separate external surveillance was considered in the form of the space-based radar. It consisted of ten satellites plus two spares for a total of twelve.

(U) Within the system development program, two full-scale space platform space-based laser prototypes are developed--one for ground qualification and one for space qualification. New facilities needed for development testing, launch site testing, and launch site assembly and integration are also included in the total cost.

6.5.2 (S) Launch Costs

(S) It was assumed that one recoverable launch vehicle system would be acquired during the RDT&E phase and three more during the production phase. The cost associated with the launch-vehicle segment contains a one-time integration cost and a recurring cost-per-launch. These costs are included in all cases.

6.5.3 (U) Total System Cost Estimates

(U) To cover inevitable disagreements concerning the attribution of life cycle costs, upper and lower bounds were calculated for each system. Table 6-2 compares constituents of the lower and upper bounds. The lower bound represents a lowest cost estimate, with only minimal support costs charged to the space-based laser.

DRAFT

TABLE 6-2
(U) LOWER/UPPER BOUND COMPARISON*
~~(SECRET)~~

LOWER	SEGMENT	UPPER
SAME	LASER	SAME
SAME	SPACECRAFT	SAME
SAME	OTHER	SAME
2 TIMES PER 10 YRS (5-year lifetime)	REPLACEMENT	3.33 TIMES PER 10 YRS (3-year lifetime)
$40M/LAUNCH	LAUNCH	$40M/LAUNCH +$6B Development Cost
$.775B	C^3 (GROUND)	.775B + $1.4B for communications satellite deployment
ON-BOARD COST	SURVEILLANCE	ON-BOARD COST + $10B for 12 satellites

* 40% Government management factor not included in these figures.

~~(S)~~ Systems sized for ballistic missile defense are more costly than those sized for antisatellite and antiaircraft. Ballistic missile defense concepts require more on-board surveillance and communications. Additional laser reactants were included to increase run time [redacted] and additional boosters were included when on-orbit deployments exceeded 20.

(U) A concerted effort was made to identify all constituents of the system costs; however, significant uncertainties exist because of the degree of extrapolation of technology and because of the lack of a weapon system design.

6.6 (U) Multimission System Sizing and Costing

~~(S)~~ Table 6.3 summarizes ten-year life cycle for the various classes of space-based laser systems and missions. Two tentative conclusions can be drawn:

[redacted]

USAF 1.4(a)(e); 3.3(b)(4) MDA and OSD 3.3(b)(4)

DRAFT

SECRET

DECLASSIFIED IN PART
Authority: EO 13526
Chief, Records & Declass Div, WHS
Date: JUL 23 2014

TABLE 6-3
(U) SPACE-BASED LASER SYSTEM COMPARISONS
~~(SECRET)~~

MISSION/APPLICATION	CLASS SBL (MW/m)	NUMBER SBLs IN ORBIT*	BOUNDS ON 10-YR LCC (FY 81 $ B) Lower	Upper
Multimission				
Aircraft, limited SLBM (4 boats), ASAT (90% or greater kill in scenarios)	[redacted]			
Antisatellite only	[redacted]	12	20	50
Ballistic Missile Defense**				
Defend US ICBMs, NCA, C^3 Unhardened Hardened	[redacted]			

NOTE * DOES NOT INCLUDE ADDITIONAL PLATFORMS FOR SELF DEFENSE.
** [redacted]

USAF 1.4 (a), (e); 3.3 (b)(4)

MDA and OSD 3.3(b)(4)

DRAFT

SECRET