SPACE LAUNCH MODERNIZATION PLAN

EXECUTIVE SUMMARY

APRIL 1994

THE SECRETARY OF DEFENSE
WASHINGTON, D.C. 20301

May 6, 1994

Honorable Al Gore
President of the Senate
Washington, DC 20510

Dear Mr. President:

Section 213 of the National Defense Authorization Act for Fiscal Year 1994, directed the Secretary of Defense to develop, in consultation with the Director, Office of Science and Technology Policy, and submit to Congress, a plan that "establishes and clearly defines priorities, goals, and milestones regarding modernization of space launch capabilities for the Department of Defense or, if appropriate, for the Government as a whole." It also directed the Department to examine requirements for a new launch system, identify the means of reducing production costs for current launch systems, and conduct a comprehensive study of the differences between existing U.S. and foreign expendable space launch vehicles.

This latter study on the differences, which is to be completed by October 1, 1994, will be provided separately and is not addressed by this action.

The Department is not now in a position to submit the plan that establishes priorities, goals, and milestones for modernization, as required by section 213. The Department, however, has developed a plan for modernization of space launch capabilities and is forwarding herewith the Executive Summary of that plan. This summary should be viewed as the first step in complying with section 213. The summary identifies the options for modernizing the current expendable launch vehicle fleet, the milestones for each, and associated development and operations costs. At this time, the Department has not selected a specific option, nor have we chosen to implement any of the recommendations. Those actions will be addressed as we formulate the Department's fiscal year 1996 budget. That budget submission will respond fully to section 213, because we will have chosen a specific plan of action, which, in turn, will establish the goals, priorities, and milestones for implementing that plan.

A similar letter has been sent to the Speaker of the House.

Sincerely,

John M. Deutch
Deputy Secretary of Defense

Enclosure

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SPACE COMMAND

5 May 1994

MEMORANDUM FOR DEPUTY SECRETARY OF DEFENSE

FROM: HQ AFSPC/CV
150 Vandenberg Street, Suite 1105
Peterson AFB CO 80914-4020

SUBJECT: Space Launch Modernization Plan

In December 1993, you directed that a study group be formed to address the FY 94 Defense Authorization Act tasking to develop roadmap options establishing priorities, goals, and milestones for the modernization of US space launch capabilities on behalf of the Secretary of Defense. From January through March 1994, an inter-agency study group with participation from each of the nation's four space sectors--defense, intelligence, civil, and commercial--examined this complex issue.

Primary goals of the study were to investigate all facets of space launch, develop a comprehensive understanding and data base, and foster as much consensus among the government agencies as possible. The attached Executive Summary highlights the findings and recommendations of this group and has been coordinated by your staff through all appropriate executive agencies. In addition, detailed sub-panel annexes are being finalized; they should provide supporting data and rationale for the Executive Summary. Finally, a summary briefing is available for presentation to interested parties.

During the course of this three-month intensive effort, the study team developed a set of roadmap options for modernizing US space launch capabilities. These roadmap options include sustaining current space launch systems, evolving current expendable launch systems, developing a new expendable launch system, and developing a new reusable launch system--all keyed to payload user needs to minimize transition costs. For all roadmap options, we recommend revitalizing the US "core" space launch technology program.

Though this study does not recommend a specific program approach, we believe the roadmap options we have defined will provide the Department of Defense a range of choices to help the United States reduce the cost and improve the operational effectiveness of our space launch capabilities.

Thomas S. Moorman Jr.

THOMAS S. MOORMAN, JR.
Lieutenant General, USAF
Chairman, DoD Space Launch Modernization Study

Foreward

Over the past decade, space launch has been a very challenging and unsettled mission for the Department of Defense (DOD). Since the decision in the early 1980s to rely upon the Space Shuttle as the sole access to space for the Nation, there have been costly accidents, significant policy and program changes, and countless studies on future needs and options. In the aftermath of the Challenger accident, the DOD quickly reestablished expendable launch vehicle (ELV) capabilities to regain access to space for critical national security missions. However, these regenerated capabilities were based upon existing launch systems (Titan, Atlas, and Delta) that have significant limitations in terms of cost, operability, and responsiveness. Several efforts have been made in recent years to develop a new ELV system -- Advanced Launch System, National Launch System, Spacelifter -- but all have been terminated. At the same time, competition is growing for launch systems and services from foreign providers, including Europe, Russia, China, and Japan, which creates further policy and economic issues. Thus, there is a growing sense within the Congress, key agencies and offices within the Executive Branch, and influential industry and public interest circles that while space launch is a critical issue for the America's future in space, there is no coherent national plan to guide our actions into the next century.

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SPACE LAUNCH MODERNIZATION PLAN
EXECUTIVE SUMMARY

A. Tasking

Section 213 of the National Defense Authorization Act for Fiscal Year 1994 (Appendix 1) directed the Secretary of Defense (SECDEF) to develop, in consultation with the Director, Office of Science and Technology Policy (OSTP), a plan that "establishes and clearly defines priorities, goals, and milestones regarding modernization of space launch capabilities for the Department of Defense or, if appropriate, for the Government as a whole." It also directed that the plan specify whether the SECDEF intends to allocate funds for a new space launch vehicle or other major space launch development initiative in the next Future Years Defense Program (FYDP). For any new non-man-rated expendable or reusable launch vehicle technology development or acquisition identified in the plan, the Act directed exploration of innovative government - industry funding, management, and acquisition strategies to minimize cost and acquisition time. Additionally, the congressional direction specified that the Plan provide a means of reducing the cost of producing existing launch vehicles. Finally, the Act directed a separate report to provide a comparison between U.S. and foreign expendable launch systems. This separate report is to be prepared in consultation with the Administrator of NASA and, as appropriate, the heads of other federal agencies and experts from industry and academia. That report will be provided separately and is not addressed by this action.

Within the Department of Defense (DOD), the task was assigned to the Undersecretary of Defense for Acquisition and Technology, USD(A&T), who in turn approved the Terms of Reference (TOR) for the Space Launch Modernization Plan (SLMP -- "the Plan") on 23 December 1993 (Appendix 2). The TOR established an interagency Study Group (Appendix 3) to prepare the plan and a Steering Group (Appendix 4) to oversee and guide the effort. In developing the Plan, the TOR tasked the Study Group to examine space launch systems requirements, past studies, reducing production and operations costs for current systems, space launch technology development efforts being conducted in Government, and innovative funding and management.

In addition, the TOR directed the Study Group to compare U.S. and foreign space launch systems in terms of design, manufacturing, processing, management, and infrastructure to assess their effect on cost, reliability, and operational effectiveness. The TOR directed the Plan be submitted to USD(A&T) within 90 days and the comparison with foreign systems be completed by 1 October 1994.

B. Approach

USD(A&T) appointed Lieutenant General Thomas S. Moorman, Jr., Vice Commander of Air Force Space Command, to lead the study. Both the Study and Steering Groups had broad representation from the National Aeronautics and Space Administration (NASA), the Departments of Commerce and Transportation, the military departments, the Joint Staff, U.S. Space Command, Defense agencies, and the Office of the Secretary of Defense (OSD). The Study Group worked continuously during the study period, while the Steering Group met periodically to review and guide the effort. The guiding principle throughout the study was to develop consensus among all sectors--defense, intelligence, civil, and commercial--on space launch needs, solutions, and priorities.

The Study Group established a goal to develop a plan to improve the Nation's space mission accomplishment through an integrated, efficient, and balanced space launch capability. The study goal was supported by the following objectives:

- Establish a comprehensive and accessible *database* of program, technology, policy, and budgetary information
- Understand and synthesize *requirements*
- Identify *deficiencies* in current and planned capabilities
- Examine *options* to correct those deficiencies
- Formulate alternative program *roadmaps* and *strategies*
- Develop *findings* and *recommendations.*

The Study Group was organized into five panels: environment, requirements, technical, operations, and business/management (Appendix 5). The Study Group received more than 130 presentations from Government agencies, industry, laboratories, and think tanks. It conducted interviews and roundtable discussions with congressional members and staff, industry executives, and current and past national space leaders. The Study Group developed a detailed understanding of the Nation's launch capabilities and needs and identified "facts of life" that impact future choices. The group then developed four options with associated alternative roadmaps and assessed each one in terms of requirements satisfaction, cost, and risk. Details on the analysis and findings of each panel and the options and roadmaps are contained in Annexes A through E; classified launch requirements for the intelligence sector are documented in a compartmented report (Annex F).

C. Background

The environment within which the national spacelift mission is conducted involves a complex web of actors, objectives, responsibilities, and influences. National security, economic interest, commercial competitiveness, technology excellence, and international relations all drive as well as limit our space launch needs and options. To understand this environment, a broad review of current circumstances and forces is essential.

1. Policy

Past national space policies have emphasized the need for assured access to space. The current national policy context is dominated by the theme of improving the Nation's economy by investing in U.S. industrial competitiveness as well as by encouraging technology transfer from defense to U.S. commercial industry. As this study neared completion, OSTP was in the process of developing the Administration's space launch policy embodying this theme. While past and evolving national policy has included specific direction on modernizing the Nation's space launch capability, little progress has been made due in large part to widely differing views and interests in this area and the inability to maintain consensus within the Executive Branch. To tackle this problem, the Administration's new draft space launch policy addresses DOD and NASA roles and provides guidance for implementation.

2. Prior Studies

The Space Launch Modernization Plan drew extensively from prior launch studies. Highlights and key items from four prior launch studies are included for background.

a. <u>Report of the Advisory Committee on the Future of the U.S. Space Program (the Augustine Report).</u> Requested by NASA and completed in December 1990, this study advised the NASA Administrator on the overall approaches NASA management could use to implement a balanced U.S. space program in the future. The committee stated a number of general concerns affecting America's space program, including

- Lack of consensus
- Over commitment of financial and personnel resources
- Program turbulence because of unforeseen technical problems or unrealistic program goals
- Institutional aging and large bureaucracies

- Need to maintain a technically qualified work force
- Declining technology base whose scarce resources are often threatened by mission needs
- Limited resilience of the Space Shuttle.

Not surprisingly, the SLMP identifies some of the same issues today in relation to the U.S. space launch situation. The Augustine Committee recognized that access to space is "the most fundamental building block without which there can be no future space program" and recommended reducing dependence on the Space Shuttle, developing a new, unmanned (but potentially man-rateable) launch vehicle, and maintaining an advanced launch system technology program to enhance current and evolving capabilities and provide a basis for new and revolutionary launch systems.

b. **The Future of the U.S. Space Launch Capability (the Aldridge Study).** Chartered by the National Space Council and completed in November 1992, this study examined the Nation's spacelift needs and recommended proceeding immediately into the development of a new expendable launch system called Spacelifter--a medium lift vehicle in the 20,000 pounds to low-earth-orbit class with modular growth up to 50,000 pounds to accommodate heavy lift requirements. The report noted that technology efforts such as the National Aero-Space Plane (NASP) and the Single Stage Rocket Technology (SSRT) programs were essential to future generations of fully reusable space launch systems. The report recognized the high costs of the Space Shuttle and suggested that an eventual solution to its high cost must be found. Finally, the report recommended that a new management structure, to include a launch "czar," be created to provide more centralized planning, integration, and coordination for implementing the Nation's launch strategy.

c. **NASA Access to Space Study.** Completed in 1993 in response to tasking in the FY 93 Appropriations Conference Committee language, NASA's *Access to Space Study* examined the Nation's space launch needs. The agency studied three options: Option 1 maintained the Shuttle and current ELV fleet until 2030; Option 2 examined a new expendable launch system using state-of-the-art technology with a transition date of 2005; Option 3 developed a new advanced technology, next-generation reusable launch system with a technology demonstration program and an operational transition date of 2008. NASA recommended adoption of Option 3.

d. **DOD Bottom-Up Review.** The DOD Bottom-Up Review (BUR), completed in 1993, included a review of DOD's space launch program -- taking into consideration commercial concerns, the needs of the civil space sector, and impacts on the U.S. industrial base. The BUR examined three alternatives: Alternative 1, a life extension of the current expendable DOD fleet; Alternative 2, the development of a new launch system; and Alternative 3, the development of a "leapfrog" technology launch system. Alternative 3 was eventually eliminated as a viable alternative, but a reusable single-stage-to-orbit (SSTO) rocket was included in Alternative 2. The BUR acknowledged that spacelift modernization was a desirable national goal but concluded that DOD's requirements were being met with the current fleet of expendable boosters. So, Alternative 1 was selected as the most cost-effective option in the near term and as such provided the basis for the DOD space launch program in the FY 95 President's Budget.

3. Management

Four major sectors coexist in the national space community: defense, intelligence, civil, and commercial. Each sector has distinct space missions and to a significant degree has developed unique cultures and practices. However, spacelift is a mission that is common to all sectors. The first step in developing a modernization plan for space launch is to understand the needs and perspectives of the principal customers and suppliers of spacelift systems and services.

a. Defense Sector. The defense sector's principal objective is to have efficient and cost-effective space launch capabilities to carry out its warning, surveillance, communication, weather, and navigation missions from space. The evolving National Military Strategy places increased reliance on smaller, more mobile military forces to respond to crises and conflicts around the world. This requires highly capable space force and space launch capabilities with the operability, dependability, and responsiveness to meet operational needs. Because of the increasing costs of launch, the defense sector has generally been pursuing lighter satellites to meet future needs, resulting in a focus on medium lift capabilities.

b. Intelligence Sector. The intelligence sector provides critical information to national and military decision makers. Their payloads are generally large and expensive, so reliable, heavy lift capability is a top concern. The intelligence sector is also concerned about transition to any new launch vehicle because of experience with transitions from expendable launchers to the Space Shuttle and back to expendables after the Challenger accident. These changes required costly satellite modifications and caused long launch delays.

c. Civil Sector. Human spaceflight and the need to reduce the costs of Space Shuttle operations dominate NASA's needs. Accordingly, NASA's most important requirement is a more cost-effective reusable space launch system.

For the near term, NASA plans to meet its Space Station assembly and resupply requirements with the Space Shuttle and Russian Proton and Soyuz boosters. For its scientific, communications relay, and earth observation missions, NASA will rely on a limited number of medium lift expendable boosters.

d. Commercial Sector. Today's commercial space launch requirements are dominated by geosynchronous communications satellites. Both commercial satellite builders and launch service providers want low launch service prices and dependable launch schedules, creating a natural synergy between the needs of the defense and the commercial sectors. Although commercial competitiveness characterizes the dialogue in this sector, the Government is the predominant purchaser of launch products and services, and today there are limited opportunities to significantly expand the space launch market.

e. New Management Models. Many different management schemes have been proposed to deal with the new, more stringent environment. One of particular interest is a proposal to establish a quasi-public launch corporation similar to COMSAT. This corporation would be chartered by Congress to develop, operate, and sell spacelift services to U.S. public and private customers. Such a corporation would provide a national entity that operates on business principles and practices to provide space transportation. As a quasi-public entity, the corporation would deal directly with spacelift users such as NASA, the Air Force, NOAA, and commercial customers. The U.S. Government would invest in the corporation--about $3.5 billion over the first 5 to 7 years of the corporation's existence--and would include a continuing anchor tenancy agreement. While many questions remain concerning implementation, the fundamental concept appears to address many management problems that the Government has found intractable. On the other hand, discussions with a variety of industry leaders as well as those familiar with COMSAT-like activities led the Study Group to conclude that absent a major breakthrough in the commercialization of space, this very innovative approach is not required at this time, but should continue to be examined.

4. Economics

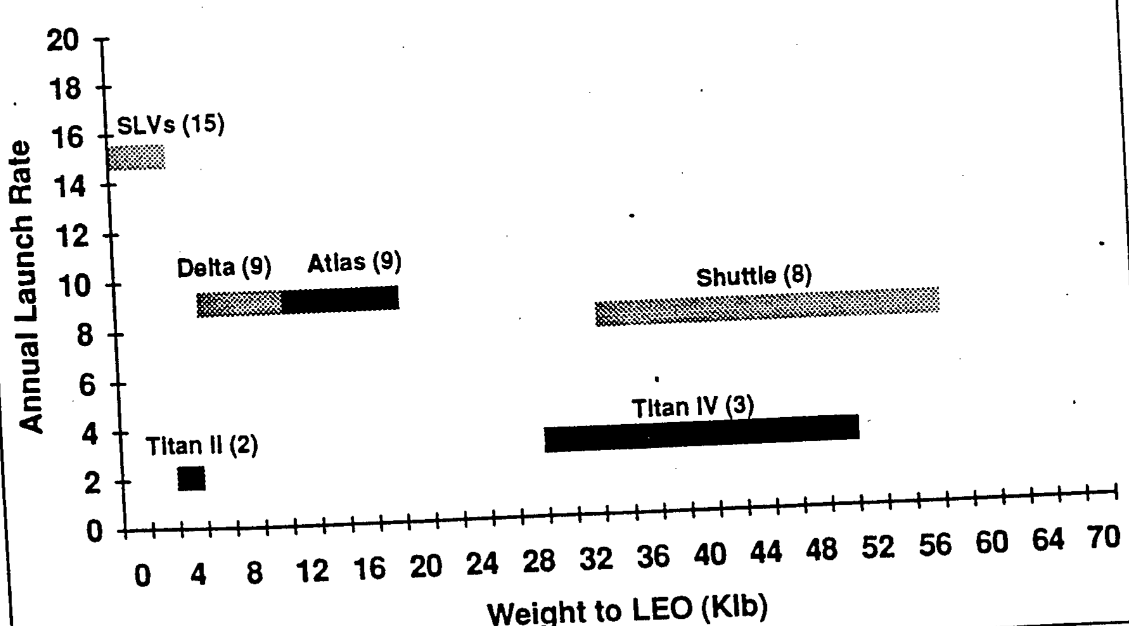
a. Space Economics. Roughly 6 percent of the DOD budget is spent on space, of which about 20 percent of this funding is spent on space launch--a figure roughly on the order of $2.5 billion in today's dollars. In contrast, space activities make up about 93 percent of NASA's budget, with aeronautical activities accounting for the remaining 7 percent. Launch costs account for about 31 percent of NASA's budget--about $4.3 billion in today's dollars.

b. Hardware Costs. Within defense, hardware costs in the medium (Delta II and Atlas II) and heavy (Titan IV) lift categories are increasing. Atlas costs have risen nearly 50 percent as new capabilities have been added; these are expected to increase again when new contracts are awarded in the late 1990s. Titan costs have been driven up almost 60 percent--approaching $325 million for a Titan IV Centaur. Inefficient production rates primarily account for the increase in Titan IV costs--Titan production was originally sized to support a production rate of 10 per year versus today's rate of 3 per year.

c. Failure Costs. Launch accidents are costly. The cost of expendable launch vehicles failures averages roughly $300 million per year and is growing. Failure to achieve predicted reliability and the high costs of boosters and satellites are the principal contributors. Achieving predicted reliability rates could reduce the cost of failure by half, but low launch rates make meeting these performance goals difficult.

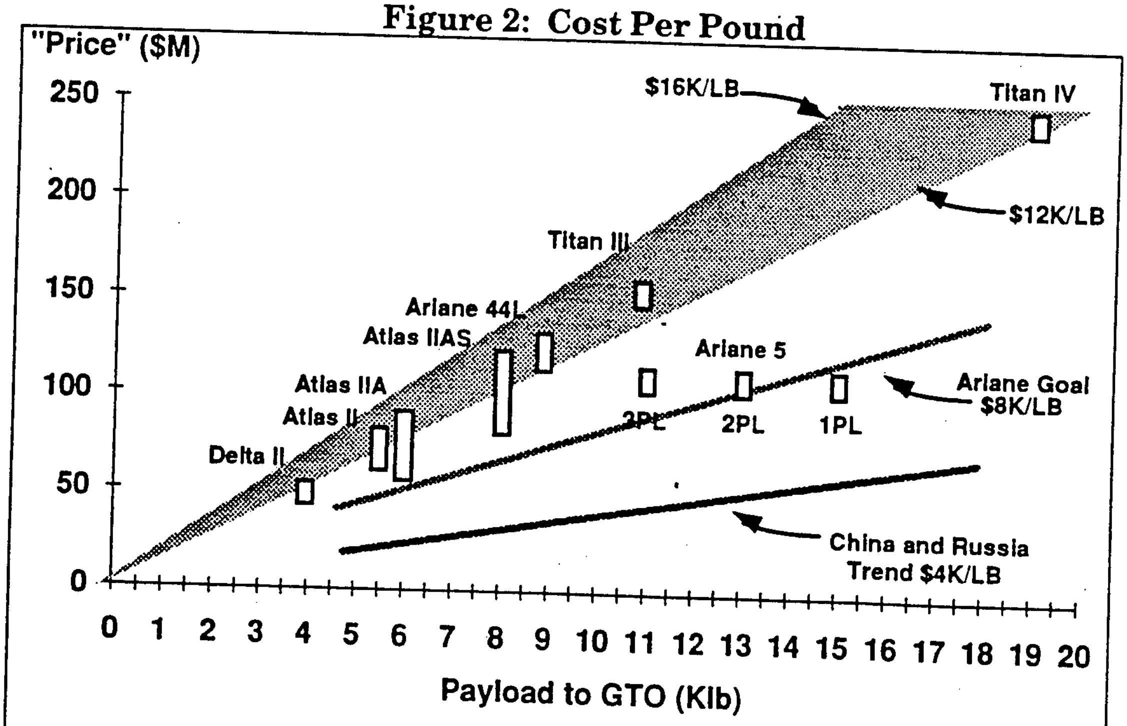
d. "Niche Markets." While the overall DOD launch demand is decreasing, the division of U.S. launch capability into "niches" with limited ranges of performance--small launchers, Titan II, Delta II, Atlas II, Titan IV and Shuttle--further contributes to the low launch rates. As depicted in Figure 1 below, no single heavy or medium launcher is projected to have a production or launch rate of more than nine per year.

Figure 1: Launch Vehicle "Niche Markets"



e. Competitiveness. The commercial competitiveness of the U.S. fleet has eroded over time. Figure 2 below shows cost per pound of payload to geo-transfer orbit for all launch vehicles. The chart suggests that U.S. systems, in particular Atlas, are generally price competitive with Ariane IV today. However, there is some evidence, anecdotal in nature, which suggests that subsidization may permit competitors to price somewhat lower than the curve shown in Figure 2. Besides pricing, it is clear that other factors are at play such as international politics, perceptions about U.S. launch systems reliability and schedule dependability, and marketing techniques that also contribute to the loss of U.S. market share. There was general consensus and concern that the U.S. will be even less price competitive with the advent of the new Ariane 5 system and the increasing use of the non-market economy launchers--China's Long March and Russia's Proton and Zenit. A relatively new commercial sector--the small communications satellite market--has the potential to drastically change the space launch landscape of all four sectors, but the actual size and viability of this new element of the commercial sector are still uncertain. A recent Department of Transportation, Office of Commercial Space Transportation (OCST) study estimated the size of this market for 1994-2005 at between 4 and 10 medium launches for constellation deployment and between 8 to 12 small launches for constellation sustainment, noting that this estimate is highly uncertain.

Figure 2: Cost Per Pound



Source: DOD Space Launch Systems Bottom Up Review

f. Launch Business. The medium/heavy launch market will continue to be dominated by Government launches for the foreseeable future. Launch demand has declined as a result of defense reductions, significantly increasing per flight costs. Future Government mission requirements will not likely increase, and the commercial launch market provides little potential for significant growth or economies. From these trends, the Study Group concluded the United States has too many space launch providers with too much production capacity.

All launch providers are wary of committing any large corporate resources to modernize their product lines and will remain cautious. These companies view the risks as high and the return on investment as low and uncertain. There are indications some private funding could be made available, given certain guarantees, investment underwriting, and/or anchor tenancy; optimistically, the total would probably be less than $1 billion. This amount would represent a significant downpayment but would not be sufficient to fund a major modernization effort.

5. International Factors

Foreign space launch competition has grown and has become more effective. The European Space Agency (ESA) will remain the principal competitor well into the future. Bilateral agreements limit the purchase of Russian medium/heavy launch services until 2000, while trade with China is limited until 1994 (with a renewal under consideration). Beyond 2000, the Russians and Chinese can be expected to be more competitive. Japan is entering the market with the H-2 booster, but its price and launch base limitations will constrain its market share.

In addition to the competitive landscape described above, the worldwide commercial launch market is influenced by other factors, such as economics and politics. For example, INTELSAT, an international consortium with close to 130 member nations, bases launcher selection primarily on cost but also considers the need to maintain competition among launch providers and the political interests of consortium members. Given the environment, analysis estimates that only 12 to 15 satellites per year are actually open for bid by all launch service providers. Consequently, it is believed that relatively little that can be done in the near term to recapture a significant portion of the market. Hence, the U.S. market share, roughly 30 percent since 1990, will not change significantly absent a modernization initiative.

While the competition for launch services is increasing, there are opportunities for increased cooperation in spacelift. For example, U.S. and

Russian cooperation in space endeavors is growing. Changes in foreign policy have encouraged and resulted in significant U.S.-Russian cooperation underscored by the Space Station agreement and trade with Russia in space-related products and technology. Russia possesses highly effective space launch systems and technologies that may provide attractive alternatives to domestic systems or technologies. However, the United States must also be cautious of creating unacceptable dependencies.

6. Technology

The Nation's space launch technology investment--Defense, NASA, and industry--has dropped dramatically in the last 2 years from $570 million in FY 92 to $351 million in FY 94, a decrease of nearly 40 percent. The drop in funding is due primarily to major program cancellations including the National Launch System (NLS) and the Space Nuclear Thermal Propulsion programs, which exposes a weakness in our technology strategy. Dependency on major programs for the technology base provides robust funding while the program is healthy, but the efforts are eliminated as programs are canceled.

Leaving out industry investment, the combined DOD/NASA space launch technology total for FY 94 is $312 million, with much of the funding earmarked for specific developments. Only 14 percent of the total, or $45 million, supports DOD core technology efforts. Without a change in priority, funding will decline in FY 95, leaving a total of about $31 million. These funding levels are insufficient to accomplish a meaningful core space launch technology program.

7. Operations

a. Launch Delays. As a result of system design choices made years ago and the primacy of performance requirements, U.S. launch systems do not have the desired operability characteristics. Delays adversely impact cost, DOD mission performance, and throughput for defense and commercial customers. Delta is the most operable U.S. expendable launch system today with average delays of 22 days. For Atlas, recent statistics show an 88-day average delay. Titan must be considered a system still in development with long on-pad processing times--the average Titan delay is 223 days. Hardware tends to dominate delay statistics, but evidence indicates a significant percentage of the delays are traceable to faulty instrumentation.

b. Manpower. U.S. launch system manufacturing and operations are manpower intensive. Current system designs fundamentally limit processing and operability improvements. U.S. manufacturing processes extend from the plant to the launch pad in increasing degrees from Delta to Titan IV. In contrast, Arianespace, with Ariane 4, has segregated manufacturing from operations. However, when assessed on an equivalent basis by labor category, the launch processing teams for Atlas and Delta are not disproportionately large and compare favorably with Ariane. In the case of Titan IV, the launch team is sized for substantially greater launch activity than is now planned. Misperceptions arise because U.S. *launch bases* are often compared with foreign *launch complexes*. A substantial amount of the activity at the U.S. ranges is not space launch related.

c. **Capability.** The current U.S. spacelift systems all meet their capability requirements, but often at the price of reduced operating and performance margins. Growth in payload mass typically necessitates expensive increases in space launch vehicle performance. An increase in launch rate would force expensive changes in the ground infrastructure, including launch pads, ranges, and supporting facilities. Without extensive redesign and requalification, virtually no room exists for future payload weight growth in the current fleet.

d. **Reliability.** Space launch vehicle reliability is inherently dependent on a number of factors including complexity, flight rate, and design stability. The Delta II has quite high reliability rates, while systems that include more stages, hardware, and flight events, such as Atlas and Titan IV, are not as reliable. Likewise, flight rate directly impacts reliability. Systems with high flight rates, such as Delta II, have had more opportunity to identify and correct problems than those with low flight rates, such as Titan IV. Flight rates are tied directly to production rates and the production learning curve and quality. Delta, in contrast to Titan IV, enjoys higher production rates, which help to increase system reliability.

e. **Responsiveness.** None of the current launch systems were built to be responsive, either in the vehicles or in their associated support launch complex. Small launch vehicles fare best by the very nature of their size. As system size and complexity increase, system responsiveness decreases. One measure is the flight rate for each system. On the Eastern Range, Delta II can launch up to 12 missions per year, if needed. Atlas is limited to eight per year. On the low end, Titan IV can launch four missions per year. Shuttle can launch up to eight missions per year, but at high cost and labor intensive operations. Of the current medium and heavy fleet, the only system with a true launch-on-need (LON) capability is Delta II.

D. Requirements

There are widely divergent views within the space community on how to define and characterize spacelift requirements. Traditionally, definition has focused on mission models and fundamental performance parameters. Early on, the Study Group concluded that a new method was needed to investigate requirements. Spacelift system requirements were analyzed using a Quality Function Deployment (QFD) process to define, develop, and rank system requirements. This methodology allowed participants of all four space sectors to develop a preliminary set of requirements that represent the "wants" of all the sectors.

Five top-level requirements were developed--capability, operability, economics, mission success, and responsiveness:

- Capability describes the system's ability to provide accurate, sufficient, predictable, and repeatable performance in operation. It covers access to multiple orbits, crew transport (currently a unique NASA requirement), launch rate, launch system performance, and payload accommodation.

- Operability describes the spacelift system's ability to accomplish the spacelift mission in a timely manner and to support customer needs. It includes supportability, maintainability, operable processes and designs, availability, and schedule dependability.

- Economics describes whether the system is efficient to develop, operate, and support. It addresses the entire spectrum of cost-effectiveness and competitiveness.

- Mission success describes the system's ability to satisfy spacelift requirements with a very low incidence of failure. It is characterized by system reliability, crew survival (currently a unique NASA requirement), payload survival, and effectiveness.

- Responsiveness describes the ability of the system to quickly and dependably respond to changing requirements. Responsiveness includes resiliency, ability to launch on need, and flexibility.

E. Current System Capabilities

Current U.S. spacelift systems share some common characteristics. The expendable systems are all derived, to one degree or another, from ballistic missile systems. All launch systems operate at or very near their maximum performance capability. In many cases, modifications have been made to extend performance capabilities that compromise flight margins, operability, and supportability. Figure 3 summarizes the current spacelift systems in terms of the above requirements.

Figure 3: Characteristics of Current U.S. Space Launch Systems

Payload Class	Spacelift System	Capability (Performance; Launch Rate)	Operability	Economics	Mission Success for Current Configuration	Responsive-ness
Small	Pegasus	Less than 1,000 lb to LEO (east or polar); 4 per year	Modern, operable design; maintainable; routine operations; contractor logistics support	$14 million per flight; only flight-proven commercial SLV; very producible	1.0 mission success rate	2-4 month call up; standard interface
Medium	Titan II	4,200 lb to LEO polar; 3 per year	Refurbished ICBM - no enhancements; contractor logistics support	$35 million per flight; hand-refurbished from ICBM	0.75 mission success rate; 1.0 launch success rate	90 day call up for DMSP; 66 days on pad
	Delta II	4,200 lb to GTO; 9 per year	Most dependable ELV; some AF logistics support	$40 million per flight; modern production line	1.0 mission success rate	98 day call up; 56 days on pad
	Atlas I, II, IIA, IIAS	4,970 lb to 8,450 lb to GTO; 4 per year	Contractor logistics support	$90 million per flight; modern production line	0.863 mission success rate for Atlas-Centaur system	No call up; 50 days time on pad
Heavy	Titan IV	Up to 10,000 lb to GEO, 49,000 lb to LEO; 4-5 per year (both coasts)	Contractor logistics support; not designed for operability	$250 million to $325 million per flight; very low production rates (3 per year)	0.857 mission success rate; still in development	180+ day call up; 110 days on pad
	Shuttle	Up to 53,500 lb to LEO; crewed; 8 per year	Contractor logistics support; some operability features	$375 million per flight at 8 per year	0.982 mission success rate (ops flights only)	12-33 month call up; 21 days on pad

F. Centers of Gravity

Of the many metrics that could be used to measure improvement in space launch, the Study Group identified five key leverage areas or "centers of gravity." Centers of gravity describe points or elements which when pushed on provide the highest leverage in achieving desired goals. These centers can be mutually independent or highly interdependent and can change in value over time. The centers of gravity for spacelift and the results of improvements in each center are as follows:

- *Production and launch rate and stability*--Reduce the high costs of launch; maintain production, processing, and operations continuity; and improve the ability to meet reliability goals.

- *Reliability*--Control the high costs of failure and thereby improve the availability of resources for investment.

- *Technology availability*--Provide a foundation for force modernization at reasonable cost, schedule, and technical risk.

- *Space launch management*--Achieve and maintain consensus, move from available technologies to fielded capability, and reverse technological and industrial drift and atrophy.

- *Funding commitment*--Move beyond the austere upgrades to current systems that limit the U.S. ability to perform its mission and compete effectively in the international marketplace.

The recommendations of the Study have been assessed using these centers of gravity to ensure that they work these high-leverage areas.

G. Options

The Study Group developed four options for modernizing U.S. space launch capabilities:

- Option 1: Sustain existing launch systems
- Option 2: Evolve current expendable launch systems
- Option 3: Develop a new expendable launch system
- Option 4: Develop a new reusable launch system

Collectively, they represent program "building blocks" from which separate roadmaps were developed. The options generally correlate with those in the *DOD Bottom-Up Review* and NASA's *Access to Space Study*. The individual options describe a range of approaches and costs, not point designs. They were based upon compilations of contractor or system program office estimates plus a management factor applied by the Study Group. Costs are presented to provide relative comparisons between options. In addition to developing the program options, the Study Group defined an enhanced core technology program and examined continued space launch infrastructure sustainment and modernization.

1. Core Technology

A key element of any program for space launch modernization is the "core" space launch technology investment. Currently, DOD core space launch technology is funded at roughly $45 million per year. A time-phased increase from that level to $120 million per year would allow DOD to pursue a coherent strategy for space launch technology development to support a wide range of future launch system and program options. This strategy should begin with an appropriate distribution of the FY 94 Advanced Research Projects Agency (ARPA) funding consistent with congressional direction. Areas for increased technology investment are shown in Figure 4.

2. Sustainment

Spacelift system sustainment covers the launch bases, space launch complexes (SLCs), and the ranges. The majority of sustainment is funded by the Air Force through the Space Launch Infrastructure Investment Plan (SLIIP), an investment strategy that includes both critical upgrades to SLCs and the Range Standardization and Automation (RSA) program. The Air Force's commitment to improving the infrastructure is commendable. SLC sustainment under the SLIIP addresses critical upgrades to launch pads and their associated complexes. When RSA is completed in 2003, it will have brought the ranges' 1950s equipment and methodologies up to the state of the art. Current range equipment and facilities must be sustained until the benefits of RSA are fully realized.

Figure 4: DOD Core Space Launch Technology

	Propulsion	Vehicle	Operations
Expendable Unique	Low Cost Engine Storable Propellants Clean Solid Propellants Hybrid Propulsion	Low Cost Booster	
Common	Upper Stage Propulsion Russian Engine Test Simple Pumps Chambers/Injectors Test Beds High Energy Fuels	Adaptive GN&C Al/Li Structures Composites Low Cost Mfg ManTech	Automated Processes Health Management Non Destructive Inspection Leak Free Joints Fault Isolation
Reusable Unique	Linear Aerospike Advanced Propulsion Preburner Turbopumps Tripropellants	Primary Structure Insulation Reliable Sensors CryoTanks Aerothermo	Recovery/Refurbishment

Total FYDP Unfunded Core Technology Investment $384M (CY94$)

94	95	96	97	98	99
$0M	$45M	$89M	$86M	$83M	$81M

3. Transition Windows

Transition costs for new launch systems include those for concurrent operation and maintenance of old and new boosters, infrastructure, and personnel until all payloads are being launched on the new system(s). One way to minimize this cost is to ensure new launch systems are available in time to influence designs for new satellites or planned satellite block changes. Each of the options has been structured to make maximum use of program phasing such that new launch systems are introduced in convenient transition windows.

- Medium lift: 2003-2005
- Heavy lift: 2005-2007, 2009, 2011-2013
- Space Shuttle: 2006-2010.

4. Option Descriptions

a. **Option 1: Sustain Existing Launch Systems.** Option 1 maintains the current fleet of launch systems--Delta, Atlas, Titan, and the Space Shuttle--for the foreseeable future. Funding, based on the FY 95 President's Budget, includes only "austere" upgrades to enable missions, improve reliability and safety, or to address obsolescence.

NASA plans to continue Space Shuttle operations through the early part of the next decade and to continue to use existing ELVs for science missions. The NASA budget funds a focused technology program for reusable launch vehicles accomplished in cooperation with planned DOD technology investments. Tentative plans include conducting flight demonstrations prior to the turn of the century. Such demonstrations could support a Space Shuttle replacement decision in 1999-2000 with credible cost and engineering data. At that point, NASA will either recommend a new start for a Space Shuttle replacement or will program additional safety and reliability upgrades to the existing Shuttle system and procure an additional orbiter.

The FY 95 President's Budget includes money for a competition for a medium class launch vehicle (MLV IV) in FY 96 to support operational Air Force launches. The Request for Proposals (RFP) for MLV IV may contain provisions for support to new DOD on-orbit capabilities: the ALARM early warning satellite and advanced EHF satellites.

Market-driven industry downsizing may reduce operating costs from current levels. Under Option 1, per flight costs are anticipated to be as follows. The range in costs are due to differences in booster type and configuration (w/ or w/o an upper stage).

- Medium lift: $50-$125 million per flight
- Heavy lift: $250-$320 million per flight
- Space Shuttle: $375 million per flight.

b. Option 2: Evolve Current Expendable Launch Systems. Key features of Option 2 include flying out current launch vehicles already on contract, evolving a family of launch vehicles from current systems by consolidating medium and heavy lift booster families, and fielding the evolved vehicles to meet payload transition windows. This option would cost between $1.0 billion and $2.5 billion in CY 94 dollars, but would significantly lower operations costs by increasing production rates. Private financing may be available for this option with suitable Government guarantees, such as anchor tenancy or low-interest loans.

As in Option 1, NASA will continue Shuttle operations through the early part of the next decade, continue to use existing ELVs for science missions, and fund a reusable technology program with coordinated DOD investments.

Option 2's acquisition approach includes a competitive procurement with the

Request for Proposals (RFP) structured to allow bidders to propose against various sets of payload weight and orbit requirements, launch rates, and operations concepts. Key RFP elements should include firm cost targets, performance-based Government specifications, and strong incentive structures. Recurring costs for this option are estimated at

- Medium lift: \$50-\$80 million per flight
- Heavy lift: \$100-\$150 million per flight
- Space Shuttle: \$375 million per flight.

c. Option 3: Develop a New Expendable Launch System. Option 3 would correct deficiencies in current expendable launchers by developing an entirely new launch vehicle family with significantly improved reliability, operability, and cost. This "clean sheet of paper" approach for a new expendable system would use a modular family composed of a common core vehicle and/or common major subsystems--strap-on stages, upper stage(s), payload fairings, and processing and launch facilities. There are two major paths a new expendable system development could follow: (a) replace only the current expendable systems, or (b) replace current ELVs and the Space Shuttle. Replacing the Space Shuttle would require significant additional investment for crew rating enhancements and personnel and cargo transport systems development.

The nonrecurring development cost for the basic new expendable vehicle is estimated to be in the \$5 billion to \$8 billion range. The crew-rated launcher and associated personnel/cargo vehicles would require an additional \$5-\$6 billion to develop. The recurring flight costs are estimated to be

- Medium lift: \$40-\$75 million per flight
- Heavy lift: \$80-\$140 million per flight
- Personnel launch: \$90-\$190 million per flight
- Cargo transport: \$130-\$230 million per flight.

d. Option 4: Develop a New Reusable Launch System. Option 4 would develop a fully reusable space launch system with the objective of substantially reducing flight costs while improving operability and responsiveness. Since a fully reusable system requires significant advances in technology and substantial engineering development, this option is based on a phased development.

The overall approach for Option 4 is to undertake a focused technology development and demonstration effort, followed by a decision as to whether to proceed with development of a prototype system and production of a fleet of operational vehicles. A parallel technology development and flight demonstrator program would be conducted to define technology and engineering feasibility and risks before committing to full-scale system development.

Because of the wide range of technologies, designs, and operating concepts among the various reusable concepts, the cost estimates for a new reusable launch system span a broad range. The technology development and demonstration would require $0.6 billion to $0.9 billion. The cost for engineering development ranges from $6 billion to $20+ billion. This wide range captures the most innovative industry approaches on one end and NASA's estimate from Option 3 of the *Access to Space Study* on the other end. The cost for procuring a four-vehicle fleet ranges from $2.5 billion to $10.5 billion spent beginning in the year 2004 and continuing through 2009. Although the nonrecurring development and procurement investment is relatively high, the annual operational cost of the fleet is estimated to be in the $0.5 billion to $1.5 billion range, compared with today's annual Space Shuttle and expendable launch costs of over $6 billion.

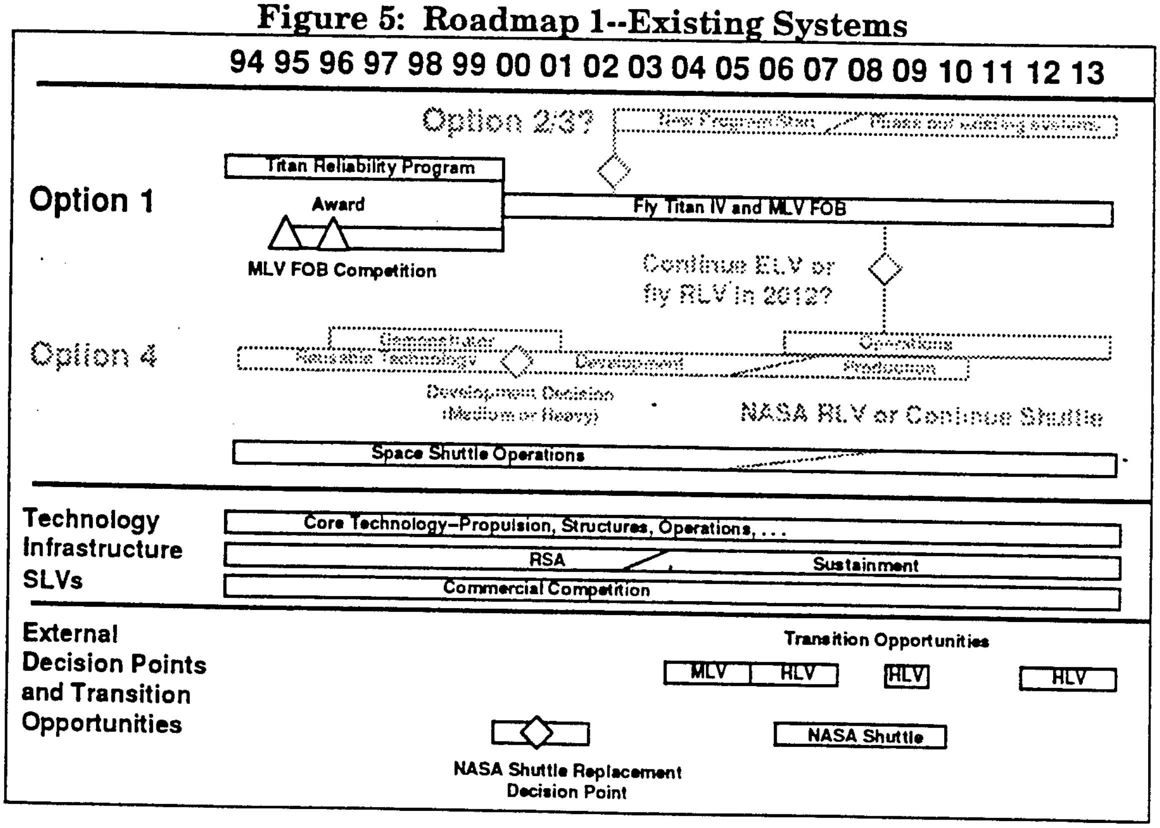
H. Roadmaps

The Study Group developed roadmaps from the system options described above. Each roadmap contains main elements from one or more options as well as common elements, such as core technology, infrastructure improvements, and transition opportunities. Each allows for technology maturation and changes in strategy by showing appropriate transition points between options. The roadmaps also include a focused technology segment that both supports the specific set of options displayed and maintains a healthy generic spacelift technology base to preserve future choices.

1. Roadmap 1: Existing Systems.

This roadmap, shown in Figure 5, focuses on retaining the current space launch systems through at least 2012 with appropriate service life extension programs. Service life extension is accomplished by the Titan IV Reliability Program and the Medium Launch Vehicle Follow-On Buy. Both of these programs involve a minimal set of critical upgrades to the current systems. This roadmap also shows potential transition points to all three of the other options. NASA would continue to fly the Shuttle for human spaceflight operations and Space Station resupply.

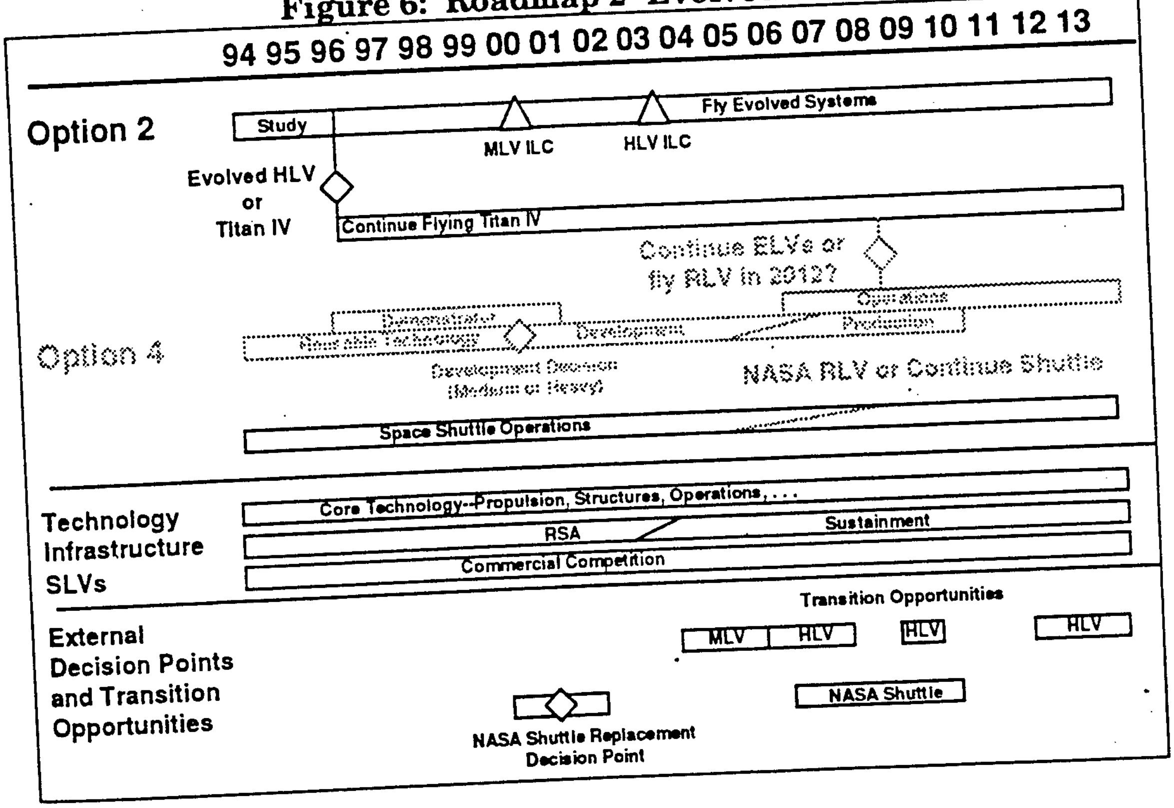
Figure 5: Roadmap 1--Existing Systems



2. Roadmap 2: Evolved Expendable Launch Vehicle.

This roadmap, shown in Figure 6, showcases Option 2, which envisions evolving one or more of the current space launch vehicles into one family of vehicles to meet the entire national mission model. There are two suboptions: either continue to fly Titan IV for all heavy payloads while evolving a medium launch vehicle (MLV), or consolidate the MLV and heavy launch vehicle (HLV) requirements into one system family. NASA continues to fly the Space Shuttle for human spaceflight missions and Space Station support. In parallel, the U.S. Government can choose to pursue an advanced technology demonstration and maturation program supporting a later decision to develop a reusable launch system (Option 4) with a decision point in 2008 whether or not to transition DOD payloads to the new system.

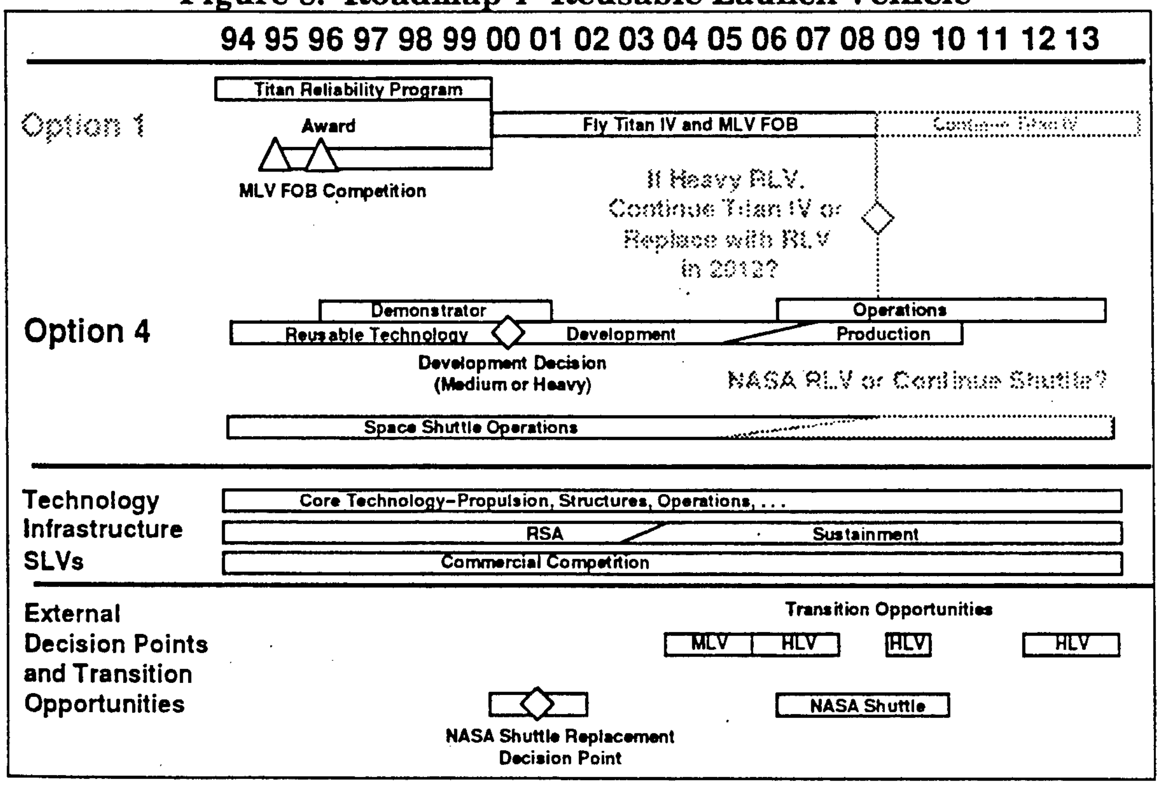
Figure 6: Roadmap 2--Evolved ELV



4. Roadmap 4: Reusable Launch Vehicle.

This roadmap, shown in Figure 8, highlights Option 4, which develops a new reusable launch vehicle. This roadmap includes an extensive, robust RLV technology maturation and demonstration program identical to that in Roadmap 1. The only difference is that this roadmap assumes the decision to implement Option 4 is made. A decision point for a heavy lift RLV is shown in 2008.

Figure 8: Roadmap 4--Reusable Launch Vehicle



I. Findings and Recommendations

The study developed 15 findings and recommendations divided into four groups:

- Fundamental drivers of the space launch industry
- Critical drivers of cost, capability, or operations
- Special focus areas
- Current operations enhancement areas.

1. Fundamental Drivers of the Space Launch Industry

Finding #1: Excess production and processing capacity exist within the space launch industry.

The space launch industry grew up in times of increasing budgets, strong national interest, increasing requirements, and a technology base that produced many satellites with limited lifetimes. The result was a high launch rate and a robust space launch industry. Today, we do more mission with fewer satellites, and the on-orbit lifetimes are very long. The net result is that the launch rate has decreased markedly, yet the industry still has multiple providers with several families of launch vehicles and a capacity to produce more than is needed. Different elements of the industry have developed niches of capability, each of which operates at low, inefficient rates, and none of which remain cost-effective.

Recommendation #1: A major objective of future modernization efforts should be to reduce industrial overhead through downsizing and reduction of niche markets.

Finding #2: Industry is unwilling to fund major space launch modernization alone, but private "up front" investment may be available given United States Government guarantees.

Because of high costs and decreasing demand, the space launch industry has little incentive to make the significant capital investment necessary to modernize its product lines. Several innovative funding concepts exist, some of which may require special legislation, that could enable the Government to become a partner with industry to encourage modernization, such as off-budget financing (e.g., loan guarantees, tax incentives, government indemnification), and anchor tenancy (guaranteed minimum launch rates and prices). Such guarantees would also encourage private investment to levels perhaps as high as $1 billion.

Recommendation #2: DOD should pursue innovative incentives to encourage private and industrial investment in space launch modernization.

Finding #3: Driven by user (DOD and National) requirements and current booster and spacecraft technology, heavy lift is required for the foreseeable future.

Any restructure of the space launch industry will require a solid understanding of the range of lift capability required. The number of launches of the Titan IV, today's HLV, has decreased substantially. Therefore, it has been suggested that the Nation could move all satellites to either medium launch vehicles or to the Space Shuttle, eliminating the need for a heavy lift vehicle. The Study Group examined in detail the user requirements that drive heavy lift and the technology potential for heavy satellite downsizing to MLV class payloads. These heavy lift requirements are principally intelligence related, including but not limited to military operational and science and technology (S&T) intelligence requirements. Intelligence needs and technology limit the potential to downsize intelligence satellites, and it is unlikely that any known technologies could enable similar mission success at MLV weights and sizes in the near term.

Recommendation #3A: In the near term, DOD must continue and improve heavy lift capability

Recommendation #3B: In the longer term, DOD should review and revalidate its intelligence requirements (both operational and S&T) that drive heavy lift. The NRO should continue to examine advanced spacecraft technologies that could provide major reductions in payload size and weight.

Finding #4: Opportunities for payload-booster transition are currently not fully coordinated to maximize the cost-benefit to the Government.

The introduction of new space launch capabilities must be timed properly to realize cost-effective transitions of spacecraft to the new capabilities. Redesigning satellites to fly on new boosters is extremely costly, delays the satellite program, and often does not improve satellite capability. The movement of payloads onto and then off the Space Shuttle is the case in point, where the payload transition costs were extraordinary. Based upon current plans for future new starts and/or block changes to satellite systems, windows of opportunity for transition of satellites to new launch vehicles occur for heavy lift in the years 2005-2007, 2009 and 2011-2012; for medium lift in 2003-2005; and for the Shuttle in 2006-2010. Any major changes in the industry structure should be timed such that the initial launch capability (ILC) of new spacelift systems occurs at the satellites' transition points.

Recommendation #4: If a new or evolved space launch system is pursued, the ILC should be planned to coincide with anticipated payload block changes and/or new starts.

2. Critical Drivers of Cost, Capability, or Operations

Finding #5: Increased cost of failure demands greater emphasis be placed improving reliability.

The cost of the vehicles (booster and spacecraft) destroyed in the August 1993 Titan IV failure exceeded $1 billion. Over the past 10 years, the average yearly cost of launch failures has exceeded $300 million and is rising. Such failures directly and substantially impact on-orbit mission capability. Additionally, however, post-accident standdowns for failure resolution create lost opportunity costs that are often hard to quantify. The Nation's fleet of launch vehicles is not as reliable as it should be. As the Nation moved onto the Shuttle, ELV launch rates dropped, production lines slowed, and engineering expertise eroded. Another contributing factor is the lack of sufficient fault tree and failure mode analysis, process control, and instrumentation in the launch system and infrastructure.

Recommendation #5: Support and sustain funding for launch system and infrastructure reliability improvements.

Finding #6: Operations costs per launch for Titan IV are significant and rising.

Although there have been eight Titan IV launches to date, it has not yet reached its full operational capability (FOC) and must be classified as in the development phase. Thus, operation of the system requires more time and people than for a mature system. In 1989, operations cost per launch was $34 million (CY 94 $); by 1994 it increased to $54 million; and by 1999 it is projected to be $72 million. As the launch bases conduct further Titan IV launches and the system approaches FOC, the on-pad time should shrink, and the number of personnel, particularly those involved in Titan RDT&E, should diminish. If the number of Titan IV launches per year remains very small, it would be appropriate to consider closing or putting into a backup mode one of the East Coast Titan IV launch pads.

Recommendation #6: Aggressively restructure and streamline Titan launch base operations to reduce current and future operations costs.

Finding #7: A cross-sector process to collect, coordinate, and consolidate space launch requirements does not exist.

The most fundamental driver of space launch capability is the set of space launch requirements, yet there are widely differing views and definitions of these throughout the four space sectors. No forum or mechanism has been available to coordinate intersector launch requirements, which has hampered the Executive Branch's ability to articulate needs and sustain support for spacelift modernization. A cross-sector process that balances performance, sustainability, reliability, and cost-effectiveness, such as the Quality Function Deployment used in this study, would greatly facilitate a national consensus on where this country should go in space launch. The results of the QFD process performed during the Study form the basis for follow-on work in this area.

Recommendation #7: Institutionalize a process to gain and sustain community agreement on requirements and associated metrics.

Finding #8: The DOD core space launch technology program is significantly underfunded and externally constrained, which has hindered opportunities for space launch modernization.

Future capability depends on the availability of technology, but space launch technology has suffered in terms of quality and quantity such that current modernization options are limited. Much of the technology work has been accomplished in major programs (ALS, NLS) that no longer exist. Other work is specifically directed such that it cannot be refocused on the most pressing technology issues. Overall space launch technology funding has decreased, and the amount available for core technology, such as engines and structures, is a small fraction of the total. While the emphasis in launch technology has traditionally been on performance, in the future, greater focus on technology to decrease cost is needed. Core technology needs to be increased in the near term; FY 94 ARPA funding should be used to enhance the core DOD launch technology program, consistent with congressional guidance. This includes completion of the Delta Clipper-Experimental (DC-X), investigation of Russian engine technology, and initial work on reusable launch system "long pole" technology and demonstrations, and low cost expendable boosters.

Recommendation #8: Increase funding for a core space launch technology program as an enabler for future investment.

Finding #9: Air Force launch base operations are constrained by antiquated and unsupportable ground systems and facilities.

A critical limit in launch operations is the ground equipment at the launch bases, particularly at the Eastern and Western Ranges, much of which is antiquated and unsupportable. Some range systems average three failures per mission. On 16 Delta missions between February 1992 and September 1993, Eastern Range equipment problems caused 22 delays. In light of those deficiencies, the Air Force has instituted and funded the Range Standardization and Automation (RSA) and launch base infrastructure improvement programs. The RSA program has been a very successful program to date; it requires continued advocacy and support.

Recommendation #9: Continue funding RSA and launch base infrastructure improvements.

3. Special Focus Areas

Finding #10: A detailed understanding of Russian engine technology can potentially lead to reduced cost for modernization.

The end of the Cold War and the demise of the Soviet Union create some significant opportunities for cooperation on space launch. Specifically, Russian rocket engines demonstrate high performance, robust margins, and proven ruggedness. Cooperation with Russia has foreign policy benefits; however, at the same time, reliance on Russian engine technology has potential national security implications from a dependency point of view. The prime Russian candidate for cooperation in this area is the RD-170 engine, which the Air Force, in cooperation with NASA and industry, should procure and test. RD-170 testing will give the U.S. Government and rocket engine industry significant insight into alternative design approaches and technical solutions that have apparently enhanced Russian rocket engine performance and durability. Similarly, NASA, with DOD and industry participation, may choose to investigate the use of Russian engine technology applicable to future reusable vehicles.

Recommendation #10: DOD should lead and fund a cooperative effort, with NASA and industry, to investigate the use of Russian engines and engine technology in future ELVs.

Finding #11: There exists general consensus on the potential benefits of a new reusable system; however, there are widely divergent views on timing, approach, cost, and risk.

A fully reusable launch system is an intriguing concept to all the space sectors and industry alike. It offers the potential benefits of responsiveness, reliability, operability, and very low cost per flight, which are universally agreed to be desirable. However, the feasibility of achieving those benefits is uncertain. Based on its needs to continue human spaceflight and provide options to replace the Shuttle, NASA should be assigned the lead for reusables with DOD maintaining a cooperative reusable program. On the other hand, DOD should lead in the ELV arena. Each agency should manage and fund efforts within their respective areas of responsibility. To prove the concept, sustain support, and enable lower risk entry into system development, the reusable technology program should include flight demonstrations.

Recommendation #11: Pursue a cooperative NASA/DOD technology maturation effort that includes experimental flight demonstrations.

Finding #12: DOD and NASA space launch program coordination needs to be improved.

While the civil and defense space programs are clearly separate and distinct, space launch is an area of common interest and interdependence that needs interagency coordination. In particular; organizational roles in launch vehicle technology need to be defined and coordinated to avoid confusion and overlap. The Aeronautics and Astronautics Coordination Board (AACB) has been used in the past for high-level DOD/NASA coordination, but in recent years the Board has been used infrequently. In addition to improved DOD/NASA oversight, coordination with other Executive departments is likewise important.

Recommendation #12A: Assign DOD the lead role in expendable launch vehicles and NASA the lead in reusables.

Recommendation #12B: Maintain top-level DOD/NASA oversight and coordination through a mechanism such as the AACB.

Finding #13: The small launch vehicle market is uncertain but could be a major growth area--the key is development of distributed communications and surveillance systems.

An exciting but uncertain trend in the space program is toward small satellites in distributed architectures. Emerging distributed low-earth-orbit constellation concepts for communications and the Brilliant Eyes concept for surveillance in DOD could revolutionize space missions and create a large, new, and different market for small launch vehicles. However, these concepts are not yet proven.

The Government is clearly making progress with its support of the U.S commercial launch industry and should continue to look for further improvements that would result in enhanced opportunities for commercial launch suppliers, such as improved access to launch facilities and user friendly range services. However, the Study concluded the Government should let commercial market forces function rather than taking a lead role at this time.

***Recommendation #13: DOD should continue to monitor development of the small* launch vehicle market but not take an active leading role.**

4. Current Operations Enhancement Areas

Finding #14: Substantial data on DOD launch operations exist, however, the information is difficult to access and use effectively.

The Air Force routinely collects, maintains, and analyzes operations and maintenance data on its aircraft systems to properly operate and manage its air operations. Similarly, a substantial amount of data is collected and maintained on launch vehicles, equipment, facilities, operations, and processes. This information, however, is scattered, poorly organized, and inconsistently collected and analyzed, which inhibits its use, raises costs, and often results in duplication. Systematic data collection and formatting would allow easier analysis and interpretation of the information to support operations and sustainment decisions.

Recommendation #14: Establish a standardized program for metrics,

data collection, and supporting analysis.

Finding #15: There is a lack of standardization within Air Force space launch systems and operations.

Standardization at the launch bases is lacking in areas beyond just data. The launch systems and operations themselves are different at Cape Canaveral Air Station than at Vandenberg Air Force Base. Each launch base developed its own procedures when launch was under R&D management. Notwithstanding the transfer of the launch bases to an operational command, the unique systems and operations remain. Air Force Space Command launch wings, system program offices, and NASA should work together to define and implement a common set of standards.

Recommendation #15: Develop a standard set of procedures, systems, interfaces, processes, and infrastructure across all the launch bases.

J. Concluding Remarks

While this study makes no recommendation for any one specific program option, or roadmap, 15 recommendations are offered that have common themes--how do we get the maximum payoff for our limited dollars, and how do we create options for the future? These recommendations focus on cheaper approaches, such as using foreign technology; on innovative funding where Government and industry share the risks and rewards; and on preserving future options by investing in enabling technology.

Although the Study Group members received widely differing views and recommendations on launch needs, technologies, programs, and management, one consistent theme pervaded the study. ***Space launch is the key enabling capability for the Nation to exploit and explore space.*** Serious deficiencies in space launch, if left uncorrected, will have profound impacts on the Nation's future space program. While resources to correct these problems will be limited, a long-term commitment to improve cost and operational effectiveness is essential. Whatever path is chosen must be done as part of a coordinated, time phased, integrated, long term plan. The consensus begun in this study can and should be used to foster Administration and congressional support. The Nation can accept the status quo or choose to establish a future vision and begin to take steps, however bold or measured, towards a more robust and capable space launch future. The choice remains open.

Appendix 1:

Public Law 103-160--Nov. 30, 1993
NATIONAL DEFENSE AUTHORIZATION ACT
FOR FISCAL YEAR 1994

PUBLIC LAW 103-160 - NOV. 30, 1993

NATIONAL DEFENSE AUTHORIZATION ACT FOR FISCAL YEAR 1994.

An Act

To authorize appropriations for fiscal year 1994 for military activities of the Department of Defense, for military construction, and for defense activities of the Department of Energy, to prescribe personnel strengths for such fiscal year for the Armed Forces, and for other purposes.

SECTION 213. SPACE LAUNCH MODERNIZATION PLAN.

(a) PLAN REQUIRED. - (1) The Secretary of Defense shall develop a plan that establishes and clearly defines priorities, goals, and milestones regarding modernization of space launch capabilities for the Department of Defense or, if appropriate, for the Government as a whole. The plan shall specify whether the Secretary intends to allocate funds for a new space launch vehicle or other major space launch development initiative in the next future-years defense program submitted pursuant to section 221 of title 10, United States Code.

(2) The plan shall be developed in consultation with the Director of the Office of Science and Technology Policy.

(3) The Secretary shall submit the plan to Congress at the same time in 1994 that the Secretary submits to Congress the next future-years defense program.

(b) ALLOCATION OF FUNDS. - Of the amount authorized to be appropriated in section 201, $35,000,000 shall be available through the Office of the Undersecretary of Defense for Acquisition and Technology for research, development, test, and evaluation of new non-manrated space launch systems and technologies. None of that amount may be obligated or expended for any operational United States space launch vehicle system in existence as of the date of the enactment of this Act. Of that amount -

(1) $17,000,000 shall be available for the single-stage rocket technology (SSRT) program, including -

(A) completion of phase one of the SSRT program begun in the Ballistic Missile Defense Office;

(B) concept studies for new reusable space launch vehicles;

(C) data base development on domestic and foreign launch systems to support design-to-cost, engine development, and reduced life-cycle costs; and

(D) examination of reusable engine thrust chamber component applications to achieve advanced producibility, cost, and durability information needed for improved designs; and

(2) $18,000,000 shall be available for similar tasks related to expendable launch vehicles, including -

(A) concept studies for new expendable space launch vehicles;

(B) data base development on domestic and foreign launch systems to support design-to-cost, engine development, and reduced life-cycle costs; and

(C) examination of expendable engine thrust chamber component applications to achieve advanced producibility, cost, and durability information needed for improved designs.

(c) REQUIREMENTS REGARDING DEVELOPMENT OF NEW LAUNCH VEHICLES. - If the space launch plan under subsection (a) identifies a new, non-man-rated expendable or reusable launch vehicle technology for development or acquisition, the Secretary shall explore innovative government-industry funding, management, and acquisition strategies to minimize the cost and time involved.

(d) COST REDUCTION REQUIREMENT. - The plan shall provide for a means of reducing the cost of producing existing launch vehicles at current and projected production rates below the current estimates of the costs for those production rates.

(e) STUDY OF DIFFERENCES BETWEEN UNITED STATES AND FOREIGN SPACE LAUNCH VEHICLES. - (1) The Secretary of Defense shall conduct a comprehensive study of the differences between existing United States and foreign expendable space launch vehicles in order-

(A) to identify specific differences in the design, manufacture, processing, and overall management and infrastructure of such space launch vehicles; and

(B) to determine the approximate effect of the differences on the relative cost, reliability, and operational efficiency of such space launch vehicles.

(2) The Secretary shall consult with the Administrator of the National Aeronautics and Space Administration and, as appropriate, the heads of other Federal agencies and appropriate personnel of United States industries and academic institutions in carrying out the study.

(3) The Secretary shall submit to Congress a report of the results of the study no later than October 1, 1994.

Appendix 2:
Terms of Reference for the Space Launch Modernization Plan

THE UNDER SECRETARY OF DEFENSE

WASHINGTON. DC 20301-3000

23 DEC 1993

:QUISITION

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (POLICY)
VICE CHAIRMAN JOINT CHIEFS OF STAFF
ASSISTANT SECRETARY OF THE ARMY (RESEARCH, DEVELOPMENT & ACQUISITION)
ASSISTANT SECRETARY OF THE NAVY (RESEARCH, DEVELOPMENT & ACQUISITION)
DIRECTOR ADVANCED RESEARCH PROJECTS AGENCY
DIRECTOR BALLISTIC MISSILE DEFENSE OFFICE
DIRECTOR NATIONAL RECONAISSANCE OFFICE

SUBJECT: Space Launch Modernization Plan

The Fiscal Year 1994 Defense Authorization Act tasks the Secretary of Defense to develop a plan to establish priorities, goals, and milestones for the modernization of space launch capabilities for the Department of Defense or, if appropriate, the Government as a whole. It also directs the Department of Defense to examine requirements for a new launch system, means of reducing production costs for current launch systems, and the differences between U.S. and foreign launch systems.

I have asked the Air Force to lead a study group under the chairmanship of Lt General Thomas S. Moorman Jr., Vice Commander of Air Force Space Command to produce this plan. The terms of reference for this activity is attached. Since this issue cuts across the Defense Department as well as other government agencies, it is essential the group be as representative as possible. To that end, I would like to ask for your support by providing a full time participant to the working group as well as representation on a Steering Group of senior executives. The study will commence in early January and will be completed no later than April 1, 1994.

The first meeting of the working group will be on Wednesday January 5, 1994, starting at 0900, at the Anser Corporation Complex, at the Crystal Gateway. Please provide the names of your representatives to SAF/AQS, Brig General Sebastian Coglitore at (703) 695-1904 (DSN 225-1904) and FAX (703) 697-5663. We look forward to your participation in this effort.

John M. Deutch

Attachment

TERMS OF REFERENCE FOR THE SPACE LAUNCH MODERNIZATION PLAN

I. INTRODUCTION

Spacelift systems are the enabling foundation for all military, intelligence, civil, and commercial activities in space. Over the past several years, a number of studies have examined and identified serious deficiencies in U.S. space launch capabilities and competitiveness. To date, there is no consensus on the appropriate course of action to remedy these deficiencies. Recognizing this, Congress has tasked the Department of Defense to build a Spacelift Modernization Plan.

II. PURPOSE

A Study Group will convene in early January to address the congressional tasking. The Study Group's task is to develop a plan to include priorities, goals, and milestones for modernization of space launch capabilities. Specifically, Congress directed the examination of (1) requirements for a new launch system, if the plan identifies a new system for development or acquisition, (2) means of reducing the costs of producing existing launch systems, and (3) a study of the differences between U.S. and foreign space launch systems.

III. ORGANIZATION

The Study Group will be led by the Air Force and chaired by Lieutenant General Thomas S. Moorman, Jr. The Study Group will include a Steering group, consisting of senior-level representatives (general offices, or equivalent) that will meet periodically to oversee the development of the study recommendations and findings. Additionally, a Working Group will be assigned on a dedicated basis for the duration of the review. Parent organizations will be responsible for any travel required by their representatives.

The Steering and Working Groups will include, but are not limited to, representatives of the following organizations:

<u>Department of Defense</u>
Office of the Undersecretary of Defense (Policy)
Office of the Undersecretary of Defense (Acquisition and Technology)
Ballistic Missile Defense Office
Advanced Research Projects Agency
Joint Chiefs of Staff
Secretary of the Air Force
Headquarters U.S. Air Force
Air Force Space Command

<u>Other Government Agencies</u>
National Aeronautics and Space Administration
Department of Commerce
Department of Transportation

IV. PRODUCTS

SPACE LAUNCH MODERNIZATION PLAN. The Study Group will recommend an executable plan for improving the Nation's spacelift capabilities. Building this plan will require examination of the following areas:

Spacelift System Requirements. The Study Group will conduct a comprehensive review of spacelift requirements for all national space sectors (military, intelligence, civil, and commercial) with the objective of examining and recommending whether the Department of Defense should allocate funds for a new expendable or reusable spacelift system, or improvements to the current fleet of expendable launch vehicles. The Study Group will evaluate a National Spacelift Requirements Process with the objective of developing national consensus on the approach for developing new spacelift systems.

Past Studies. The Study Group will conduct a comprehensive review of past studies highlighting the deficiencies of current spacelift systems and recommending improvements for future systems.

Reducing Production Costs for Current Spacelift Systems. With industry cooperation, the Study Group will examine means of reducing production costs for existing expendable launch vehicles at current and projected production rates below the current estimates of the costs for those production rates.

Spacelift Technology Development Efforts. The Study Group will conduct a comprehensive review of all ongoing spacelift technology development efforts currently under way in the United States.

New Spacelift System Development. If the Study Group recommends that the Department of Defense should fund development or acquisition of a new expendable or reusable spacelift system, then they will identify requirements for such a system.

Innovative Funding and Management. The Study Group will examine and recommend how to fund and mange development and acquisition of a new spacelift system through cooperation among DOD, national security, NASA, and commercial industry to minimize acquisition costs and development lead time.

COMPARISON WITH FOREIGN SYSTEMS. The Study Group will report on the differences between existing U.S. and foreign expendable launch vehicles in terms of design, manufacturing, processing, overall management, and infrastructure to assess the effects of each specific difference on cost, reliability, and operational effectiveness.

V. DURATION OF EFFORT

The Study Group will prepare the Spacelift Modernization Plan for approval by USD(A&T) within 90 days. The Study Group will prepare the report comparing U.S. and foreign space launch systems for approval by USD(A&T) by 1 October 1994.

Appendix 3: Study Membership/Support

Organization	Name
Study Chairman	Lt Gen Thomas Moorman, Jr.
Vice Chairman	Col William Files
AF	Maj Gen Richard Scofield Col S. Peter Worden Col Christopher Waln Lt Col Stephen Wojcicki MSgt Edward Fuller Mr. Jordan Katz
AFMC	Mr. Robert Steele Lt Col David Lewis Capt Heather Knight Lt Thad Summers
AFSPC	Lt Col Michael Hamel Lt Col Randall Joslin Lt Col Timothy Roberts Lt Col Robert Worley Maj Victor Villhard
ARPA	Lt Col Michael Francis
BMDO	Maj Jess Sponable Maj Larry Ortega
Joint Staff	Lt Col David Hyland Lt Col Douglas Nowak
NASA	Mr. Mike Lyons Mr. Ronald Harris Mr. Gary Krier Mr. Armis Worlund Mr. Joel Blum Ms. Barbara Fratzeky Mr. Joseph Hamaker Mr. Uwe Hueter Mr. Steve Richards
NAVSPACECOM	Mr. Eric Nichols
SAF	Col Charles Banta Col William Savage Lt Col Pat Beauchamp Lt Col Gary Siegel Maj Sidney Kimhan Maj Randy Turner Capt Scott Swanson Capt Patricia Wilkerson
USD(A&T)	Dr. Richard Weiss
USSPACECOM	Lt Col Michael Coyle Maj Todd Travas
Aerospace Corporation (Technical Support)	Mr. Allen Goldstein Dr. Peter Portanova
ANSER (Technical Support)	Mr. Mark Berube Ms. Debra Facktor Mr. Robert Usher

Appendix 4: Steering Group Membership

Organization	Name
Air Force	Mrs. Darlene Druyun
Army	Lt Gen Don Lionetti
ARPA	Dr. Gary Denman Mr. Ron Murphy
BMDO	Lt Gen Mal O'Neill
DOC	Mr. Keith Calhoun-Senghour
DOT	Mr. Frank Weaver
JCS	Brig Gen Tom Twomey
NASA	Mr. Jack Lee Mr. Arnie Aldrich
Navy	Mr. Peter Wilhelm
NRO	Mr. Jimmie Hill
USD(A&T)	Dr. George Schneiter
USD(P)	Mr. Gil Klinger
USSPACECOM	VAdm Dave Frost
OSTP (Observer)	Mr. Rich DalBello

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