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Report to the Chairman, Subcommittee
on Defense, Committee on
Appropriations, House of
Representatives

August 1994

NATIONAL SPACE ISSUES

Observations on Defense Space Programs and Activities





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The Honorable John P. Murtha
Chairman, Subcommittee on Defense
Committee on Appropriations
House of Representatives

Dear Mr. Chairman:

On September 17, 1993, you requested that we perform a broad review of Department of Defense (DOD) space programs and activities, including organization, launch vehicles, launch facilities, satellites, and ground control functions. As requested by your Subcommittee staff, we provided interim briefings. This report documents the information provided in our most recent presentation to your staff on July 28, 1994 (see apps.). We also briefed other congressional staff and representatives from DOD, National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), and Department of Transportation. This report does not make recommendations, but contains a number of observations about current issues.

Background

DOD plans to spend about \$70 billion during the next 5 years on military and intelligence space programs and activities. This represents 5.7 percent of DOD's total planned military budgets during this period. By comparison, NASA plans to spend about \$65 billion on the space portion of its mission during the next 5 years. In addition to intelligence, over 75 percent of DOD's military space dollars are planned for communications, surveillance, launch vehicles, launch facilities, and satellite control. The remaining amounts are planned for navigation, meteorology, supporting research and development, and general support. (See app. I.)

Results in Brief

Since 1989, despite numerous attempts, the government has been unable to acquire a new space launch system. Considering this experience, the administration's current draft policy on national space transportation strategy does not identify a means for implementing strong management at a high level within the Executive Office of the President. Such a means appears essential to address launch requirements for the national security, civil, and commercial space sectors; ensure interagency coordination, cooperation, and elimination of duplication; and maintain program and

funding stability while meeting the government's affordability challenge. (See app. II.)

Within DOD, space acquisition management responsibilities are fragmented among several organizations. Although a major portion of the military space budget is controlled by the Air Force, such predominance does not appear to be in the best interest of DOD's diverse set of space users. Decisions on space acquisitions may be better served by more central organizational management within the Office of the Secretary of Defense and by separate space appropriations that would include both the military and intelligence sectors. An integrated satellite control network and a consolidated space education and training program are additional steps that could be taken to exercise greater discipline within DOD's space mission. (See apps. III and IV.)

DOD lacks an adequate and validated set of requirements for a future launch system. Therefore, initiating major investments in, or evolving to, an improved launch capability would be premature until a quantifiable set of requirements are established. In addition, DOD's space launch infrastructure lacks central management, and although some infrastructure improvements are necessary, major investments would not be prudent unless they are compatible with any improved launch system that DOD may select. (See apps. V and VI.)

Our observations on the commercial space launch industry and three satellite efforts—convergence of military and civil meteorological satellites, early warning satellite replacement, and the Milstar program—are discussed in appendixes VII and VIII.

Scope and Methodology

Our scope of work encompassed the four U.S. space sectors—military, intelligence, civil, and commercial—with the primary emphasis on matters associated with national security. It included a review of national and DOD space policies; DOD space organizations and missions; plans, programs, and budgets associated with launch vehicles, launch infrastructure, satellites, and satellite control; and space-related issues in the commercial sector.

We analyzed budget information; program and system requirements; acquisition, modernization, and funding plans; agency and program directives; and supporting reports, studies, and briefings. We discussed space topics with representatives of the Executive Office of the President; Office of the Secretary of Defense; Joint Staff; Departments of the Air

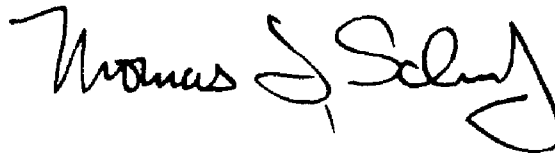
Force, Army, and Navy; and U.S. Space, Air Force Space, Naval Space, and Army Space Commands. We also interviewed NASA, NOAA, the Department of Transportation, and selected contractor representatives.

As requested, we did not obtain written agency comments. However, based on our briefing to agency representatives, we intend to obtain their comments and will provide them and our evaluation to your staff. Since we are continuing to review the issues contained in this report, we will also consider any agency comments in our ongoing work. We performed our review from September 1993 through July 1994 in accordance with generally accepted government auditing standards.

We are sending copies of this report to the Chairmen, House Armed Services Committee, Senate Subcommittee on Defense Appropriations, and Senate Armed Services Committee; the Secretary of Defense; the Director, Office of Management and Budget; and other interested congressional committees. We will also make copies available to others upon request.

The project director for this work is Homer H. Thomson. If you or your staff have any questions concerning this report, please contact me or Mr. Thomson at (202) 512-4841. Other major contributors to this report are listed in appendix IX.

Sincerely yours,



Thomas J. Schulz
Associate Director, Systems
Development and Production Issues

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Abbreviations

ALARM	Alert, Locate, and Report Missiles
DOD	Department of Defense
DSP	Defense Support Program
FEWS	Follow-on Early Warning System
NASA	National Aeronautics and Space Administration
NOAA	National Oceanic and Atmospheric Administration

Budget Overview

The Department of Defense (DOD) plans to spend about \$70.7 billion on military and intelligence space programs and activities during the next 5 years. Annually, the space budgets range from \$13.5 billion in fiscal year 1995 to \$15 billion in fiscal year 1999—a planned 11-percent increase. Relative to DOD's total military budgets, the annual space budgets are expected to represent an increasing share—from 5.4 percent to 5.9 percent as shown in table I.1.

Table I.1: DOD's Military and Space Budgets (dollars in billions)

DOD budgets	Fiscal year				
	1995	1996	1997	1998	1999
Total	\$252.2	\$243.4	\$240.2	\$246.7	\$253.0
Space	\$13.5	\$13.9	\$13.9	\$14.4	\$15.0
Space as a percent of total	5.4	5.7	5.8	5.8	5.9

For comparison purposes, the National Aeronautics and Space Administration (NASA) plans to spend about \$65.5 billion during the next 5 years on the space portion of its mission—\$5.2 billion less than DOD. NASA's annual budgets are divided between space and aeronautics as shown in table I.2.

Table I.2: NASA Budgets (dollars in billions)

NASA budgets	Fiscal year				
	1995	1996	1997	1998	1999
Space	\$13.0	\$13.1	\$13.1	\$13.1	\$13.2
Aeronautics	1.3	1.3	1.4	1.5	1.4
Total	\$14.3	\$14.4	\$14.5	\$14.6	\$14.6

During the next 5 years, DOD has allocated about 71 percent of its military (excluding intelligence) space dollars to the investment accounts (research, development, test and evaluation—38 percent; procurement—32 percent; and military construction—1 percent). The remaining approximate 29 percent is allocated to the operations and support accounts (operations and maintenance—22 percent and military personnel—7 percent). The ratio of investment to operations and support is about 2.5 to 1.

During the next 5 years, DOD plans to spend about 77 percent of its military (excluding intelligence) space dollars on communications, surveillance, launch vehicles, and ground support (launch facilities and satellite control). Other functional categories, including supporting research and

**Appendix I
Budget Overview**

development, navigation, meteorology, and general support account for the remaining approximate 23 percent.

National Policy and Management

In 1992, Vice President Quayle asked the National Space Council to review U.S. national space policies in light of the (1) end of the Cold War, (2) decline in defense spending and aerospace industry cutbacks, (3) impact of the federal budget deficits, (4) revolution in space-related technologies, and (5) recognition that space has become a critical element in America's war-fighting capability.

The policy review resulted in three studies ending with the "Fink" report on the future of the U.S. space industrial base, the "Aldridge" report on the future of the U.S. space launch capability, and the "Wilkening" report on a post-Cold War assessment of U.S. space policy. The Wilkening report stated that the four U.S. space sectors—military, intelligence, civil, and commercial—each have their own institutional culture that encourages overlap and discourages cooperation. Two major conclusions from these studies dealt with the need for (1) fundamental changes in the way government space activities are organized and managed and (2) a new, cost-effective space launch capability.

In a January 1993 final report to President Bush on the U.S. space program, the Vice President made a series of space policy recommendations to assist the Clinton administration. Two of the recommendations involved the need (1) for strong White House focus to implement organizational changes to encourage greater cooperation and synergism and less duplication among government space activities and (2) to phase over to a new launch capability by about the turn of the century when the next generation of several satellite systems will be ready for launch.

In April 1994, the Office of Science and Technology Policy, within the Executive Office of the President, published a draft national space transportation strategy directive intended to (1) supersede several existing directives and (2) establish national policy, guidelines, and implementing actions for the conduct of the national space transportation programs. The general guidelines called for (1) maintaining the existing mixed fleet of expendable launch vehicles and the space shuttle as the primary means of space transportation at least through the end of the decade and (2) DOD and NASA to plan for the transition of space programs to future launch systems in a manner that would ensure continuity of mission capability and accommodate transition costs.

The draft policy did not (1) address organizational changes to encourage cooperation and reduce duplication among government space activities or

(2) provide a basis for addressing known governmentwide funding issues associated with future launch vehicle programs. Instead, it directed DOD and NASA to cooperate, in pursuit of their individual responsibilities, to take advantage of the unique skills of each agency. DOD was to be the "lead agency for improvement and evolution of the current U.S. expendable launch fleet." NASA was to be the "lead agency for advanced technology development and demonstration to prove the technologies required for next generation reusable launch systems."

The draft policy does not address how the administration expects to provide effective management oversight for future space transportation evolution and development. This is critical because of the government's prior poor experience in this area. The Bush administration policy directed DOD and NASA to undertake the joint development of a new space launch system to meet civil and national security needs. However, this approach has essentially been judged a failure. Some references to this fact are as follows:

"The conferees are frustrated by the failure of the administration and Congress to come to grips with the future course of space launch systems . . . NASA does not appear to be able to afford to pay half the cost of the NLS (National Launch System) and DOD cannot afford to pay more than half . . . At the same time, study after study within the administration concludes that current U.S. space launch systems and practices are archaic and non-competitive, which could have adverse economic and military consequences in the future."¹

". . . joint programs have proven difficult to implement and have often become a source of conflict among agencies. Differing agency priorities have often resulted in budget mismatches. Another factor complicating joint programs is the need for support from several different congressional committees, each of which with its own priorities."²

"The conferees agree that the Administration must focus scarce resources to achieve any success at all . . . overall, NASA and the Department of Defense have demonstrated a remarkable inability to work together. Across the government, a debilitating culture favors complexity, fragility, and accommodation to unique payload demands. To date, neither the government nor industry has attempted to approach space launch as they do cargo

¹National Defense Authorization Act for Fiscal Year 1993, Conference Report 102-966, October 1, 1992, p. 617.

²A Post Cold War Assessment of U.S. Space Policy, Vice President's Space Policy Advisory Board, December 1992, p. 23.

transport by truck, rail, ships, or aircraft. In these areas, standardization, rugged design, performance margins, low cost, and responsiveness are of overriding importance."³

"... NASA, together with the Defense Department and the aerospace industry, had spent nearly a decade defining and advocating a new launch vehicle program (which culminated in the proposed National Launch System), without being able to reach consensus with the Congress that it should be developed."⁴

"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... The most fundamental driver of space launch capability is a set of space launch requirements, yet there are widely differing views and definitions of these throughout the four space sectors... 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."⁵

Observations

The Clinton administration's draft space transportation policy does not identify a mechanism to implement strong management at a high level within the Executive Office of the President. Past experience indicates that such a mechanism is essential so that the executive branch and the various congressional committees responsible for space launch can better cooperate in making cost-effective decisions on the future of national space transportation.

Specifically, there appears to be a need for the policy to address (1) military, intelligence, civil, and commercial space launch requirements to achieve greater standardization across these sectors; (2) a process for centralizing oversight and decision-making to ensure interagency coordination and cooperation and elimination of duplication; and (3) a funding mechanism to maintain program stability and meet the government's affordability challenge.

³National Defense Authorization Act for Fiscal Year 1994, Conference Report 103-357, November 10, 1993, p. 602.

⁴NASA's Access to Space Study, November 21, 1993, p. 1.

⁵Space Launch Modernization Plan (referred to as the "Moorman report") Executive Summary, Department of Defense, April 1994, pp. 3, 27, and 29.

DOD Organization and Management

In 1993, the Air Force reported that multiple space acquisition organizations—Air Force, Army, Navy, Ballistic Missile Defense Organization, Advanced Research Projects Agency, and National Reconnaissance Office—have resulted in (1) fragmented responsibilities; (2) duplicate facilities, staffs, and infrastructures; (3) deficiencies in achieving economies of scale, optimizing existing capabilities, and focusing on validated operational requirements; and (4) less effective forces because several organizations are developing space hardware that are not interoperable, thus complicating joint military operations.

DOD's space programs and activities are primarily concentrated within the Air Force. For example, in fiscal year 1993, the Air Force controlled 73 percent of the military space budget. For fiscal year 1995, its control increased to 80 percent, and by fiscal year 1999, its control is projected to increase to 84 percent. In descending order, the Army, the Navy, and the Ballistic Missile Defense Office have the next largest space budgets. The Advanced Research Project Agency and the Defense Information Systems Agency have the smallest space budgets.

From an operational perspective, the Air Force Space Command has about 95 percent of the personnel to perform DOD space operations, as shown in table III.1.

Table III.1: Number of DOD Space Personnel

	Number of personnel		
	Military	Civilian	Total
U.S. Space Command	443	128	571
Air Force Space Command ^a	12,303	16,111	28,414
Naval Space Command	249	245	494
Army Space Command	401	89	490
Total	13,396	16,573	29,969

^aIn addition, approximately 10,400 military and 1,300 civilian personnel are assigned to support the U.S. Strategic Command's Minuteman and Peacekeeper programs.

Despite this Air Force predominance, DOD space systems primarily provide capabilities to a wide variety of users for joint military operations and national purposes. For example, DOD's total military satellite communication requirements for 1997 (measured in millions of bits per second of throughput) are divided by users as shown in table III.2.

**Table III.2: Percentage of DOD's 1997
Military Satellite Communication
Requirements by User Categories**

	Percent
National authorities and commanders in chief	50
DOD agencies	31
Military services	12
Non-DOD agencies	7
Total	100

In October 1992, the House and Senate conference committee report on the fiscal year 1993 defense authorization bill (p. 569) noted that the declining defense budget would inevitably increase pressure to constrain or reduce spending on space programs. As a result, they directed the Secretary of Defense to develop a comprehensive acquisition strategy for developing, fielding, and operating DOD space programs. The strategy was (1) to be aimed at reducing costs and increasing efficiencies and (2) to address policy, requirements, programs, and funding. A report on the strategy was due in April 1993, but was indefinitely delayed due to DOD's Bottom-Up Review of major defense programs, which was completed in October 1993. Since April 1994, disagreement within DOD has prevented the completion of the acquisition strategy report.

In 1993, the House Appropriations Committee's report accompanying the fiscal year 1994 defense appropriations bill noted a lack of a coherent management structure associated with national security space programs. It directed the Secretary of Defense to provide a detailed 5-year plan for implementing organization and management changes in the areas of acquisitions, appropriation accounting, operational and war-fighting responsibilities, and requirements and policy. The plan was to be completed by February 1994, but was delayed due to the complexity of the changes and its relationship to two ongoing efforts—the space launch modernization study and the Commission on Roles and Missions study. A DOD representative expected the organization and management plan to be completed in August 1994.

Several ideas have come to our attention on how to better manage space acquisition programs. They are summarized as follows:

- An Air Force approach is to place acquisition responsibility entirely with the Air Force.
- A U.S. Space Command approach is to place acquisition responsibility within the Air Force, but through joint program offices.

- A suggestion surfaced within the Navy is to create a space system procurement executive office within the Office of the Secretary of Defense, supported by each service.
- A suggestion surfaced within the Air Force is to create a space corps within the Air Force to separately acquire and operate space systems.
- An alternative possibly being considered within the Office of the Secretary of Defense is to create a defense space agency to acquire and manage space systems.

Observations

The effects of organizational fragmentation can be a waste of resources as well as detrimental to the effectiveness of joint war-fighting forces. Because of the size of DOD's annual space budgets—in excess of \$13 billion and over 5 percent of DOD's total military budgets—consolidating selected space functions and centralizing management may be warranted.

The Air Force controls about 80 percent of the military space budget, which competes on an annual basis with other Air Force requirements, including aircraft and missiles. Such single service predominance does not appear to be in the best interest of the diverse set of space users because these users' needs could be detrimentally effected by Air Force budget decisions.

There are opportunities to address these matters through ongoing studies to (1) develop a comprehensive space acquisition strategy aimed at reducing costs and increasing efficiencies, as directed by the committee of conference for the fiscal year 1993 defense authorization bill; (2) provide a plan for implementing space organization and management changes, as directed by the House Appropriations Committee in its report accompanying the fiscal year 1994 defense appropriations bill; and (3) review roles, missions, and functions of the armed forces, as required in sections 951-960 of the National Defense Authorization Act for Fiscal Year 1994.

An overall approach would be to combine all military space system acquisitions under a separate appropriation, managed by a single organization within the Office of the Secretary of Defense that is headed by a civilian and supported by the military services. Consideration should also be given to merging requirements and program management functions of the National Reconnaissance Office into this single organization to ensure adequate support to the joint war-fighting forces.

Other DOD Management Issues

Satellite Control

The Air Force Space Command manages about 90 satellites through its satellite control network at two primary locations—Falcon Air Force Base, Colorado, and Onizuka Air Force Base, California. The Naval Space Command manages about 19 satellites through its satellite control network at Point Mugu, California. The Naval Research Laboratory also manages satellites through its satellite control network at Blossom Point Test Facility in Maryland.

The Air Force Space Command has stated that its satellite control network (1) is manually intensive, requiring a large number of highly skilled personnel, and is therefore costly to operate and (2) uses a centralized computer system that is limited in data processing capacity and lacks standardization and interoperability among several satellite systems. The Air Force plans incremental upgrades to the network during the next 10 years, but has neither a detailed cost estimate for the upgrades nor an architecture on which to base its upgrades. A newly designed advance satellite control system could be an alternative, but a formal cost estimate is also lacking. Further study is essential in this area because the Air Force plans to spend over \$3 billion during the next 5 years to operate, maintain, sustain, and upgrade the satellite control network.

The Naval Space Command's satellite control network is a more modern design than the Air Force network. However, its use will decline by 1997 because the navigational satellites (called Transit) it controls are scheduled to be phased out, and only one satellite (called Geosat Follow-on) is scheduled to be added in the near future. However, according to a Navy official, the Navy plans to upgrade its network to control those Navy satellites that are currently being controlled by the Air Force. This upgrade will allow the Navy to use Air Force satellite control assets, such as antennas.

The Naval Research Laboratory's satellite control network is also a more modern design than the Air Force network. For example, (1) operators do not need to be as highly skilled to perform satellite control, due to a simplified user interface; (2) the number of simultaneous satellite contacts is not constrained by the network's design; and (3) satellite commands are automated, thereby limiting the need for manual real-time control of the satellite and reducing the chance for introducing errors.

A January 1994 U.S. Space Command report recommended merging Air Force and Navy satellite bus operations into a common satellite control network to achieve improvements in efficiency and effectiveness. The

Command is now studying the sharing of satellite control assets between the Air Force and the Navy. However, the primary focus of ongoing Air Force plans to upgrade its network does not address consolidation. In addition, the Command is performing a more detailed study to identify near-term savings and determine how the military services and other agencies, such as the National Reconnaissance Office, NASA, and the National Oceanic and Atmospheric Administration (NOAA), involved in satellite control, can work together. The results of this detailed study are expected during the summer of 1994.

Observations

DOD should be able to achieve greater satellite control efficiencies by moving toward an integrated satellite control network. In doing so, the U.S. Space Command needs joint requirements, a system architecture, an implementation plan, and a cost and operational effectiveness analysis of plausible alternatives that would include the existing Navy designs. The Air Force should cease its upgrade plans until the U.S. Space Command has completed these efforts and then be guided by the results. We have recommended in our briefings to House and Senate Armed Services Committees and Defense Appropriations Subcommittees that \$48 million requested by the Air Force in fiscal year 1995 for satellite control upgrades be denied.

Education and Training

According to the Air Force, space support was largely provided on an ad hoc basis during Operations Desert Shield and Desert Storm, with no single organization assigned the responsibility to provide space expertise to the theater commander. Although it was the primary operator of space systems, the Air Force stated that in many instances, direct communication to the United States was required to obtain the needed support, resulting in multiple requests for similar information that produced conflicts and prioritization difficulties. The Air Force recommended better structures and mechanisms for providing space support to joint forces.

DOD expects joint military operations to be the primary means of organizing a response to future regional conflicts. In February 1993, the Chairman of the Joint Chiefs of Staff stated that the new post-Cold War national military strategy required that U.S. forces be trained to operate jointly, not just for occasional exercises, but as a way of life. This meant that military leaders must have knowledge of the capabilities and limitations of land, sea, air, space, and special operations. As a result, the

U.S. Atlantic Command was assigned the responsibility for joint training, force packaging, and facilitating deployment of U.S.-based forces to support all unified commands. Based on the growing importance of space capabilities to the national military strategy, the Joint Chiefs of Staff assigned the U.S. Space Command the responsibility for drafting joint doctrine for military space operations.

Space education and training is performed in a disjointed manner. It is performed by the individual space commands and is not guided by a common curricula or by approved joint doctrine and procedures, although these are in development. For example, the Army has had a Space Applications Demonstration and Exploitation Program since 1987. The purpose is to demonstrate and exploit new technologies for making space information available to Army components. The Navy established Space Contact Teams (now known as Space Support Teams) in 1991 after Operation Desert Storm. The purpose is to provide 1- to-2-hour briefings to Navy personnel on space systems capabilities and limitations prior to a training cruise or deployment. In 1993, the Air Force established Forward Space Support Teams to provide training, guidance, and support to Air Force components primarily during exercises and a Space Warfare Center to provide analysis and simulation capabilities using the computer and network facilities at the National Test Facility. Also in 1993, the U.S. Space Command established Theater Support Teams to address lessons learned from Desert Storm. These teams provide training, guidance, and support to other commanders primarily during joint exercises and as requested.

Observations

There is potential for consolidating space education and training if the U.S. Space Command were to develop core curricula on space applications, drawing on the strengths of the service space components' programs. The curricula should be based on the space support needs of war-fighting forces. Considering that military space systems are primarily used for joint purposes, the curricula should be coordinated with, and could be incorporated into, the U.S. Atlantic Command's joint task force training.

Launch Vehicles

Based on DOD's existing vehicle contracts, as of early July 1994, the industrial base will remain active at least through this decade. Specific information on Titan II, Delta II, Atlas II (medium-lift vehicles), and Titan IV (heavy lift vehicle) is shown in table V.1. In addition, up to six Atlas IIs are scheduled for procurement in fiscal year 1995 for a classified user, and a follow-on Titan IV procurement is expected in fiscal year 1997.

Table V.1: Launch Vehicles Still on Contract

Vehicle	Number of vehicles to be procured on existing contracts	Year of launch for last procured vehicle
Titan II	7 ^a	2000
Delta II	30	2002
Atlas II	5	2000
Titan IV	32	2004

^aTwo additional Titan IIs are not currently assigned to any particular satellite, thus, the launch dates of these satellites could extend beyond 2000.

Source: DOD's existing vehicle contracts (as of July 1994).

According to the April 1994 Moorman report, the expendable launch vehicle industry grew during times of increasing requirements and budgets. The report stated that today, fewer satellites, with longer lives, perform more work, which has resulted in decreased launch rates and excess launch vehicle production and processing capacity. The accompanying negative effect is low, inefficient production rates that raise unit costs. In addition, a contributing factor to high vehicle costs is the frequent perturbations in launch schedules. For example, Atlas II and Titan IV program schedules have been stretched out 3 and 9 years, respectively. According to a Titan IV program representative, the program's stretched schedule increased development and procurement cost estimates by about \$8.5 billion in then-year dollars.

During the past several years, the government's attempts to develop an improved launch vehicle has been based on deficiencies in existing vehicles that various reports have identified. For example, as reported by the Defense Science Board, the near-term goal of the Advanced Launch System program, which began in fiscal year 1987, was to improve the expendable launch vehicle family to reduce cost, increase reliability, and improve responsiveness.¹ In addition, DOD's October 1993 report on the Bottom-Up Review stated that (1) U.S. military space launch capabilities

¹National Space Launch Strategy, Defense Science Board Summer Study, March 1990, p. 14.

are characterized by high cost and serious operational limitations and (2) performance and flexibility of launch operations is inadequate and system responsiveness in crises or emergencies is limited. Finally, the April 1994 Moorman report stated that the current launch systems are not built to be responsive, are not as reliable as they should be, and do not have the desired operability characteristics.

DOD has upgraded its existing vehicles and plans to continue the effort as set forth in the 1993 Bottom-Up Review. This decision is to maintain the current launch fleet and employ an austere life-extension program by making only the most necessary improvements. According to DOD, this approach was selected primarily because it was the least expensive option in the near term. However, the approach (1) fails to satisfy the flexibility requirement or meet improved reliability goals and (2) offers little potential for reducing the high operating costs of the existing systems. In addition, the Air Force plans to begin acquiring another medium-lift vehicle in fiscal year 1995 that could be evolved into a heavy-lift vehicle.

The results of two DOD studies issued within 6 months of each other—the October 1993 Bottom-Up Review and the April 1994 Moorman report—indicate that DOD is faced with a predicament. A sizeable investment is required in the near term to reduce costs in the long term, but the needed near-term funding is not considered affordable. Thus, the desired long-term cost reduction may not be possible. The options contained in these studies are summarized in table V.2, which compares and contrasts the assessment results associated with critical decision-making elements.

**Appendix V
Launch Vehicles**

Table V.2: Options and Critical Decision-Making Elements in Two DOD Studies on Launch Vehicle Improvements

Options	Is it affordable in future year defense program?	Can it reduce life-cycle costs?	Will it improve proposed launch capabilities?	What is the cost, schedule, and technical risk?
Sustain vehicle fleet (Bottom-Up Review 1A and Moorman plan 1)	Yes	No	No	Low
Evolve existing vehicle into a family of vehicles (Moorman plan 2)	Maybe	Yes	Some	Low to medium
Develop new expendable vehicle (Bottom-Up Review 2 and Moorman plan 3)	No	Yes	Yes	Low to medium
Develop new reusable vehicle (Bottom-Up Review 2 and 3 and Moorman plan 4)	No	Yes	Yes	Medium to high

DOD stated in its Bottom-Up Review report that there are two types of space launch requirements: (1) performance—the ability to deliver a satellite reliably to a specific orbit and (2) operational flexibility—the capability to perform rapid and adaptive payload integration, servicing, substitution, and launch. Despite this statement, DOD does not currently have an approved or validated set of requirements. In support of DOD's Bottom-Up Review, the Institute for Defense Analyses discussed nine different launch system "attributes" in a May 1993 paper. Some of these attributes were based on the validated Advanced Launch System and Tactical Space System mission needs statements of 1988 and 1990, respectively. However, the Institute observed that (1) regardless of validity, currently identified military requirements are not sufficiently specified to drive development of alternative launch strategies and (2) additional analyses or statements of requirements with a greater degree of specification and quantification are needed. The Air Force Space Command has drafted a Mission Need Statement, identifying needed spacelift capabilities for the future, but the statement has not been validated.

The Moorman report found that (1) the most fundamental driver of space launch capability is requirements and (2) views differ widely within the space community on how to define and characterize spacelift requirements. The report stated that (1) traditionally, definition has focused on mission models and fundamental performance parameters and (2) 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. The report concluded that a new method was needed to investigate requirements. With the use of a different methodology, the study group developed a preliminary set of requirements representing the "wants" of all the space sectors. The report recommended institutionalizing a process to gain and sustain space community agreement on requirements.

DOD, NASA, and commercial companies generally agree that Russian launch vehicles and processes represent an untapped resource that could be beneficial to the United States. For example, the Moorman report stated that Russia possesses highly effective space launch systems and technologies that may provide attractive alternatives to domestic systems or technologies. The Russians have developed new launch vehicles; the Proton and Zenit medium-lift vehicles and the Energia heavy-lift vehicle are the latest. Russian engine technology is of particular interest to the United States because of efficiency, reliability, and an ability to vary the thrust. The Moorman report found that a detailed understanding of such technology could potentially lead to reduced cost for modernization. Although this technology sounds promising, it should be noted that the U.S. industrial technology base could be negatively affected by introducing Russian systems.

The administration's draft policy on national space transportation strategy addresses the use of foreign launch systems and hardware. Although the policy prohibits the government from purchasing space launch services from foreign providers, with some exceptions, it does not inhibit the use of foreign components or technologies in upgrading or developing launch systems, except as required by national security, foreign policy, public safety, or law. The policy also states that the government will seek to take advantage of foreign technologies.

Observations

The U.S. industrial base should be available to support development of an improved launch vehicle because existing launch vehicle contracts continue into the next decade. In addition, DOD plans to continue with some upgrades to the existing vehicle fleet. Despite these efforts, DOD does not have an adequate and validated set of requirements for a future launch system. Because the most fundamental driver of space launch capability is requirements, initiating major investments in, or evolving to, an improved capability would be premature until a quantifiable set of requirements are established.

**Appendix V
Launch Vehicles**

Although DOD desires to improve and evolve the existing expendable launch vehicle fleet, it has not established an approach for acquiring and evaluating Russian launch vehicle components and technologies to incorporate into future designs. Considering the potential cost and performance benefits associated with the use of such items, it appears that the administration's final space policy would require development of a consistent approach for DOD and civil agencies.

Launch Infrastructure

In 1992, based on the 1991 National Space Policy Directive 4 entitled National Space Launch Strategy, the Deputy Secretary of Defense approved the Secretary of the Air Force's long-term investment plan for improvements to the existing space launch infrastructure. The plan consisted of four elements—launch ranges, facilities, bases, and vehicles—and three priority categories—maintaining current operations, increasing reliability and efficiency, and product improvements. According to the plan, the ranges element, consisting of communications and other equipment for safe launch operations, required fixes because of old technology and designs, resulting in obsolescence and supportability and reliability problems. The facilities element, consisting of the launch pads and other facilities to store, process, assemble, and test vehicles and payloads, required constant maintenance because they are located in high corrosion areas. The bases element, consisting of real property and equipment that directly supported launch activities such as roads, water and sewer, electrical power, and air cargo handling facilities, was in need of repair because of natural decay and technical obsolescence. The vehicles element, involving Titan II, Delta II, Atlas II, and Titan IV and related upper stages, were of concern because of the lack of system confidence, lengthened processing times, and decreased flexibility to meet short notice launch demands. As a result, the required investment was estimated to cost about \$2.5 billion through fiscal year 2004; however, \$1.1 billion (over 40 percent) was unfunded.

DOD's fiscal year 1994 budget request reflected the requirements in its investment plan. In July 1993, the House Armed Services Committee directed the Secretary of the Air Force to submit a report on space launch facilities infrastructure that reflected changing requirements and budget reductions. In addition, in September 1993, the House Appropriations Committee directed DOD to provide a plan to modernize and manage DOD's space infrastructure, including launch facilities and range and tracking stations. In April 1994, the Air Force submitted an updated plan to Congress. The estimated cost through fiscal year 2004 was about \$1.4 billion—\$1.1 billion less than the 1992 estimate. However, this updated plan did not fully disclose the Air Force's intentions because our discussions with Air Force representatives indicated that there was no significant reduction in the scope of work. We were informed that some of the originally planned activities were delayed to later years, no unfunded items were reported as they were in the 1992 plan, and the vehicle element was totally eliminated as part of the plan. A summary of the cost differences between the 1992 and 1994 space investment plans for the four infrastructure elements is shown in table VI.1.

Table VI.1: Estimated Costs of Space Launch Investment Infrastructure (dollars in millions)

	1992 plan	1994 plan
Ranges	\$1,270	\$975
Facilities	407	137
Bases	316	318
Vehicles	486	0
Total	\$2,479	\$1,430

The space launch infrastructure investment plans appear to lack a central program management focus for controlling projects and costs and measuring progress. In addition, there was no indication that such a plan would be maintained on a recurring basis or that it would require a periodic assessment relative to established goals. For example, the 1992 plan stated that some support facilities had deficiencies so severe that they were in imminent danger of failing and could have caused an unacceptable impact to operations. However, the 1994 report did not show the status of these, or other, deficiencies, which could have detrimentally affected operations or caused economic loss. Instead, the plans consist of a series of individual projects managed by a combination of individual system program offices under the Air Force Materiel Command and other offices under the Air Force Space Command.

This is similar to other criticism of fragmented management in the space launch area. For example, a December 1993 study by the Air Force Space Command alluded to confusion within the space community concerning organizational roles and responsibilities. It stated that the Materiel Command's program offices award the spacelift contracts and exercise authority over research and development mission launches, the Space Command is the launch deployment authority for DOD operational missions, and the national community has launch deployment authority over vehicles that carry its payloads. The study stated that too many organizations, with their own specific agendas, are going in separate directions and that no one organization has the entire "big picture."

Observations

There are indications that (1) significantly greater investment is required in space launch infrastructure than the most recent report to Congress disclosed and (2) the planned infrastructure investment lacks central management oversight and reporting mechanisms in establishing and monitoring requirements, determining needed resources and annual spending priorities, and measuring the progress of the investment. Infrastructure investments should be compatible with any improved

**Appendix VI
Launch Infrastructure**

launch system that DOD chooses. Decisions on such matters would likely be more effectively made by more central and less fragmented management.

Commercial Sector

The U.S. government is concerned about the commercial launch industry losing market share because the result may be higher overall launch costs. A European company called Ariespace is considered the major competitor to the U.S. launch industry and, according to the Wilkening Report, launches 60 percent of all commercial space launches. Ariespace's success has been attributed primarily to the inability of the U.S. industry to compete because of outdated launch systems that are expensive and inefficient. The government says a new launch vehicle is needed for the United States to regain its competitiveness and to keep overall launch costs down. The 1992 Aldridge report said:

“... a decision by the Administration or the Congress not to fund a new, reliable, low-cost operational space launch capability is a de facto policy decision to forgo U.S. competition in the international space launch marketplace, a mandate that the U.S. government will continue to pay higher prices than necessary to meet future government launch requirements...”

Although the United States no longer dominates the commercial launch market, the absolute number of commercial satellites being launched by the United States is about the same as it was before Ariespace began operations in the early 1980s. Specifically, from 1977 to 1979, prior to Ariespace, the U.S. launch industry averaged eight commercial satellites per year. During the ensuing 6-year period after Ariespace began operations, 1980-85, the United States averaged almost nine commercial satellites per year. Following the failure of several U.S. launches, including the Challenger in 1986, the number of U.S. commercial launches decreased significantly for about 4 years and Ariespace's share of the international launch market increased significantly. By 1990, however, the United States had nearly regained its previous commercial launch rate and will average about eight per year through 1994. Table VII.1 compares U.S. and Ariespace commercial satellite launches and shows the number of U.S. government satellite launches. It also shows the loss of nearly all European commercial satellites to Ariespace beginning in 1980. These losses are as likely to be due as much to political reasons as economic reasons.

Appendix VII
Commercial Sector

Table VII.1: Numbers of Commercial and U.S. Government Satellite Launches

Year	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94 ^a
Commercial satellites launched by United States and Arianespace																		
Total U.S. commercial	12	9	3	2	6	10	10	11	14	1	1	0	2	11	6	8	5	10
U.S. launch of European satellites	6	3	1	•	1	•	1	2	•	•	•	•	1	4	3	3	1	•
U.S. launch of others	6	6	2	2	5	10	9	9	14	1	1	•	1	7	3	5	4	10
Total by Ariane	0	0	0	2	3	2	3	6	7	5	3	13	10	16	15	13	17	14
Ariane launch of European satellites	•	•	•	2	2	2	2	4	3	3	2	6	6	7	10	5	6	3
Ariane launch of others	•	•	•	•	1	•	1	2	4	2	1	7	4	9	5	8	11	11
U.S. government satellites launched																		
Total gov't	19	30	15	15	13	8	12	18	13	11	12	13	19	25	25	16	16	^b

^aScheduled.

^bClassified.

Industry representatives gave various reasons for choosing Arianespace over U.S. launchers. Price was given as an important consideration, but U.S. launchers were considered competitive in this area. Also, the Moorman report said that U.S. launch vehicles, particularly Atlas, are generally price competitive with Arianespace today. Other factors, such as the long success rate of the Ariane vehicle and the aggressive and innovative marketing techniques of Arianespace have been cited as primary reasons for choosing the launch company. One U.S. manufacturer's representative said his company chose Arianespace because of its success rate—the European company had already completed a number of successful launches—and not price. He stated that the Delta vehicle was too small for the intended payload and the Atlas II vehicle was just getting established when the decision was made. Marketing techniques that Arianespace uses, such as charging only for the actual weight of the satellite instead of the maximum allowable weight, were also cited.

The potential for additional commercial launches is limited and a new launch vehicle is not warranted solely for commercial reasons. A 1994 Commercial Space Transportation Advisory Committee report estimates that only about 17 commercial payloads per year will be available from

1993 to 2010 and the Moorman report stated that the commercial launch market provides little potential for significant growth or economies. A U.S. space launch contractor believes that the potential commercial market is too small to recoup an investment in a new launch vehicle in a reasonable period.

Commercial payloads make up the smaller portion of the total U.S. requirement for launch capability. Government satellites have accounted for over 60 percent of all satellites launched from U.S. facilities for the past 4 years. Thus, government requirements should be the driver behind the development of a new launch vehicle.

Observations

The commercial launch industry is price competitive with foreign launchers and the future commercial launch market appears limited. Using requirements of the U.S. commercial launch industry as justification for developing a new launch vehicle does not appear to be warranted. If, however, a valid set of government requirements are established, commercial requirements should also be considered to take advantage of the widest possible user base in reducing costs and risks and increasing reliability and safety.

Satellites

Convergence of Meteorological Satellites

Since 1972, eight studies have been performed on convergence of DOD and NOAA polar-orbiting meteorological satellite programs. Although unique agency missions and requirements were claimed to have precluded full program convergence, changing world political conditions and declining agency budgets have now made reexamination of satellite convergence a priority. Last year, this subject was examined under the Vice President's National Performance Review. The review recommended convergence of the two satellite programs based on estimates of substantial cost savings. In May 1994, the President signed a directive endorsing an implementation plan that had been developed by a tri-agency study team.

The anticipation of substantial cost savings has been a principal reason to converge DOD's and NOAA's meteorological satellites. The National Performance Review identified up to \$300 million in cost savings through 1999 for the converged program. However, we were informed that no firm data exist to support the estimated savings. During these periods, substantial research and development funding will be needed to design new and potentially complex sensors capable of meeting both civilian and military requirements. In addition, both DOD and NOAA are still procuring a large number of existing satellites that have yet to be deployed, and the first converged satellite will not be needed until 2004. Long-term savings are more likely because the overall constellation size and satellite replacement rate are expected to be reduced, but there are still uncertainties associated with these potential savings.

A single integrated requirements document is critical to the development of a converged satellite system. Such a document is being drafted by a tri-agency team and is to be submitted to the agencies for comment, with final approval planned for October 1994. However, this may be optimistic, given the broad base of internal customers each agency has and the challenges associated with reconciling diverse requirements. The requirements will be reviewed and validated using a new and untested process.

Under the convergence implementation plan, an integrated program office is to be responsible for acquisition, operation, and management of the converged system. The plan adopted a multi-agency funding approach whereby the program office would prepare a single budget. However, funding for the converged program will actually be requested by the individual agencies from several different congressional authorization and appropriation committees. As a result, such joint funding efforts may present significant challenges, as demonstrated by previous unsuccessful

government efforts to fund joint programs. A joint funding mechanism that equitably divides program costs and ensures congressional support will be essential for program success.

European participation in the converged program is contingent upon an agreement (1) to a set of U.S. requirements that will include the ability to deny data to adversaries during wartime and (2) to the maintenance of a backup satellite in the event of a satellite failure. In addition, European participation is contingent upon the U.S. government's plan for long-term cost savings. We understand that the Europeans have recently raised objections to the data denial requirements, raising concerns that their participation could be more difficult to achieve than originally anticipated. Also, European agreement to a backup satellite for a launch-on-need policy is uncertain. Finally, the United States will buy sensors to be integrated on European satellites, but it would need to maintain a backup satellite capability in the event that European participation declines. Given the need to ensure a backup capability, significant cost savings are not obvious, and will need to be demonstrated.

Currently, DOD has nine, and NOAA has six, meteorological satellites that are either built or are being procured. This imbalance prevents an easy synchronization of U.S. satellite programs. Assuming that all issues regarding European participation can be resolved, two European satellites could provide "pre-convergence" satellites to facilitate the convergence plan. This would be in lieu of DOD transferring two satellites to NOAA or NOAA buying additional satellites. Such synchronization is required to achieve the first converged satellite delivery planned for 2004. This is based on an assessment of the projected satellite life expectancies and probable failure rates of existing meteorological satellites. Also, based on historical experience, the tri-agency study team believes that the development and production of the first converged satellite will take 10 years, and therefore, must begin shortly to meet the 2004 delivery date.

Early Warning Satellite Replacement

DOD is planning to replace the existing Defense Support Program (DSP) with the Alert, Locate, and Report Missiles (ALARM) program to provide early warning and detection of ballistic missiles. ALARM is to be designed to provide warning of theater ballistic missile launches to a greater degree than DSP. Revised requirements for this new purpose is essential to initiate program development. DOD's efforts to do so may be delayed by the ongoing architecture review of space-based early warning being led by the Office of the Secretary of Defense for Command, Control,

Communications, and Intelligence. The Air Force is planning to have users comment on the desired performance characteristics of the new system and has tasked the Air Force Space Command to complete the requirements development by the end of fiscal year 1994.

Air Force documents show that ALARM is almost as expensive as the previous Follow-on Early Warning System (FEWS). Early life-cycle cost estimates identified the total cost of ALARM at about \$11.3 billion, and that of FEWS at about \$11.7 billion. However, ALARM was selected following the termination of FEWS because it was deemed to be significantly cheaper than FEWS in the future years defense program. The ALARM yearly funding profile was kept at levels significantly lower than those for FEWS to make the program affordable by sacrificing short-term capability. In this regard, DOD proposes to build a series of Block I satellites to form the first ALARM constellation before upgrading the design with additional capabilities. We were subsequently informed that DOD used a FEWS cost model to estimate ALARM life-cycle costs, suggesting that this could be a reason for the nearly equivalent ALARM costs. To date, we have not identified any better ALARM cost estimates, with and without planned block upgrades.

The Air Force has stated that ALARM can be accelerated by 2 years from 2004 to 2002 without significant risks. However, the additional costs associated with acceleration may put DOD in a similar unaffordable position when it rejected the FEWS program. The program office has tentatively identified an additional \$434 million that would be needed during fiscal years 1995 through 2001. More firm cost data may not be available until the program progresses beyond the generation of requirements.

Accelerating ALARM has advantages and possibly a few disadvantages that should be further analyzed. Accelerating ALARM could obviate the need to procure an additional DSP satellite (number 24), its launcher (Titan IV), and an inertial upper stage. If DSP satellites can last for about 6 years, as indicated in a study (by the Everett Panel) on space-based early warning, DSP 23 would not have to be launched until 2001 or 2002. In that case, the first ALARM satellite may not have to be launched until the year 2002 or 2003, and DOD may not need DSP 24. This could save as much as \$700 million dollars in acquisition costs. However, accelerating the program could create program risks by (1) shortening the demonstration and validation phase of the acquisition process by 10 months—from 28 months to 18 months and (2) performing the critical design review a full year ahead of the original schedule. Air Force representatives claim,

however, that previous engineering efforts on earlier programs (the Boost Surveillance and Tracking System, the Advanced Warning System, and FEWS) provide enough experience to offset this risk.

DOD maintains that it has identified a majority of critical technologies required for capabilities specified for ALARM. However, there are areas that require additional funding and continuing development. To date, the two most important elements are an infrared focal plane array and radiation-hardened electronics. Our discussion with Air Force representatives reveals that these two technology development efforts are critical to ALARM. However, program officials tell us that funds to develop these technologies are "frozen." A team of contractors informed us that these technologies would have to be funded by the government because of the unique applications. Two contractors stated that no private sector funds would be available for the above technologies because there are no returns on the investment.

Milstar Acquisition and Advanced Replacement

During the past 12 years, the Milstar program has gone through a number of changes. In 1990, congressional leaders considered Milstar's cost to be too high and its support for tactical forces inadequate. The National Defense Authorization Act for Fiscal Year 1991 directed DOD to either restructure Milstar or develop an alternative. DOD chose to restructure the Milstar program and reduced the number of satellites in the planned constellation to six. In October 1992, based on guidance from the conference committee on the fiscal year 1993 defense authorization bill, DOD further reduced the constellation size to a total of four satellites.

In October of 1993, the Bottom-Up Review established a new acquisition strategy for the Milstar program. DOD opted to limit the total acquisition to six satellites—the first two satellites, referred to as Milstar I, with only a low-data rate capability, and the next four satellites, referred to as Milstar II, with both low- and medium-data rate capabilities. To reduce long-term costs, DOD plans to replace the Milstar II design with a smaller advanced satellite design that will use a smaller, less expensive launch vehicle. The first launch of the advanced satellite is scheduled for 2006.

In two recent GAO testimonies,¹ we proposed canceling the fifth and sixth Milstar satellites (the third and fourth Milstar II), and accelerating development and launch of an advanced Milstar design to 2003. This

¹Military Space Programs: Opportunities to Reduce Missile Warning and Communication Satellites' Costs (GAO/T-NSIAD-94-108, Feb. 2, 1994) and Military Space Programs: Comprehensive Analysis Needed and Cost Savings Available (GAO/T-NSIAD-94-164, Apr. 14, 1994).

proposal would delay deployment of a complete constellation of four Milstar II satellites by 2 years, from 2002 to 2004. We estimated that this proposal could save between \$1.4 and \$2.1 billion dollars over the next few years. We testified that this proposal offers a logical breaking point for the program. A contract has not been awarded for the last 2 Milstars, and the associated Titan IV launch vehicles for these 2 satellites are not part of the current contract for 41 vehicles. Technical experts supporting the Bottom-Up Review unanimously agreed that a 2003 launch date was feasible. Some of these experts even believed a first launch would be possible as early as 2000, using technology already developed or under development. We also said DOD should compare the benefits of these significant cost savings to the operational risk of delaying deployment of the full Milstar constellation.

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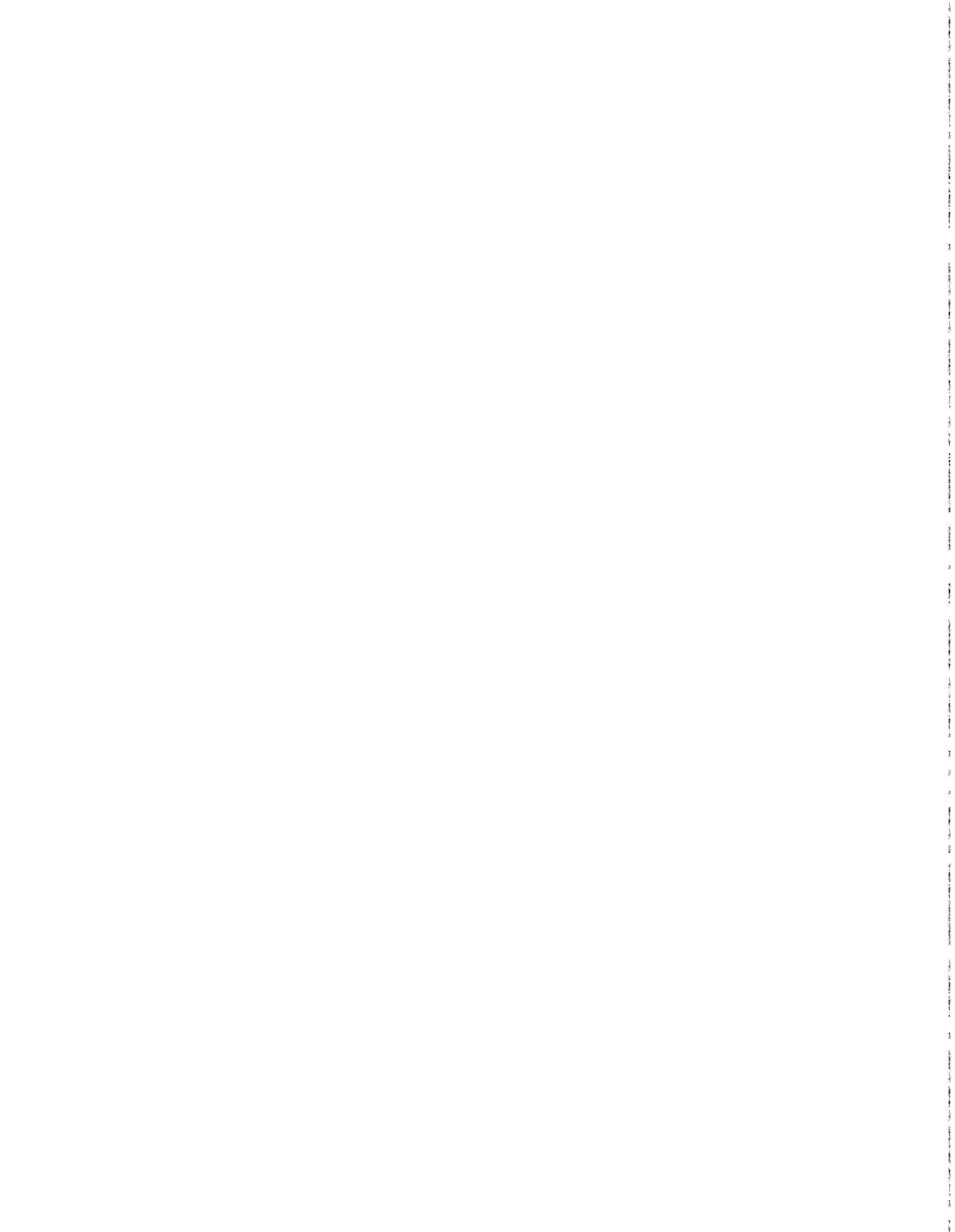
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