United States General Accounting Office

GAO

Report to the Chairman, Legislation and National Security Subcommittee, Committee on Government Operations, House of Representatives

July 1993

MILITARY SATELLITE COMMUNICATIONS

Opportunity to Save Billions of Dollars

149623

GAO/NSIAD-93-216

GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-253632

July 9, 1993

The Honorable John Conyers, Jr.
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

As you requested, we have reviewed certain aspects of the Department of Defense's (DOD) plans for military communication satellites. Specifically, we have reviewed DOD's (1) alternatives contained in its 1991 military satellite communications architecture study, (2) efforts to develop low-cost technologies for future satellite systems, and (3) plans for making decisions to implement follow-on satellite acquisitions.

Background

During the past several years, the Congress has been critical of DOD's management of satellite communications—a primary concern being high costs. In August 1989, the House Appropriations Committee expressed concern that DOD's satellite communications architecture was in a state of disarray. It directed DOD to provide a comprehensive plan, defining all satellite communications requirements and potential solutions to meet the requirements within realistic resource levels. In October 1990, during deliberations on the fiscal year 1991 defense appropriations bill, the conference committee expressed dissatisfaction with the plan that DOD had provided in March 1990. The committee was concerned about the lack of a comprehensive architecture and directed DOD to submit a "clear and affordable plan" with the fiscal year 1992 defense budget request.

In addition to the appropriations committees' concerns, the National Defense Authorization Act for Fiscal Year 1991, enacted on November 5, 1990, directed the Secretary of Defense to develop and carry out a plan for either a restructured Milstar communication satellite program or an alternative advanced communications satellite program, with specific goals of reducing costs and better supporting tactical forces. (Milstar is a major part of DOD's satellite communications architecture.) In January 1991, the Secretary reported DOD's plans to restructure the Milstar program rather than develop an alternative advanced system. One of the key changes that had the effect of substantially lowering costs was to reduce the planned constellation size from eight to six satellites. The

Congress responded favorably by fully funding DOD's Milstar budget request for fiscal year 1992.

In November 1991, DOD published its military satellite communications architecture study—the plan that the Congress had directed DOD to submit with its fiscal year 1992 budget request. The study identified 12 alternatives that outlined various communication approaches that ranged from using all commercial to all military satellite systems. The estimated life-cycle costs[1] of these alternatives ranged from $16 billion for the all-commercial approach to $58 billion for the most expensive all-military approach. From among the 12 alternatives, DOD selected an all-military approach consisting of existing systems, which it called the baseline architecture. This alternative had an estimated life-cycle cost of about $55 billion.

In October 1992, the conference committee report on the fiscal year 1993 defense authorization bill expressed additional concern about DOD's space investment strategy. It noted that (1) the declining defense budget will inevitably increase pressure to constrain or reduce spending on space programs and (2) increased efficiency and decreased costs will likely be necessary to sustain current systems and capabilities and will certainly be required to afford new systems. Accordingly, the conferees directed the Secretary of Defense to develop a comprehensive acquisition strategy, aimed at reducing costs and increasing efficiencies for developing, fielding, and operating DOD space programs.

Congressional concern over the need for cost reductions and greater efficiencies may become even more important because DOD projects that its satellite communications capacity requirements will increase by 50 percent between 1992 and 1997. These requirements are measured in terms of throughput—the number of bits of information that can be passed through the satellites per second. In 1992, DOD's total requirements were about 1 billion bits per second, whereas by 1997 its requirements are projected to be about 1.5 billion bits per second.

Considering the conflicting relationship between declining defense budgets and increasing satellite communication requirements, DOD must decide what level of satellite communications is affordable. DOD is developing new cost estimates and alternatives for military communication satellites as part of the Secretary of Defense's ongoing

[1]Life-cycle costs are defined as the total cost of acquisition and ownership over a system's useful life. In this case, the life cycle is the 20-year period from 1991 through 2010.

"bottom-up" review of major defense programs. The review is to be completed by the end of July 1993 and is to provide guidance for upcoming acquisition decisions.

Results in Brief

There are acceptable alternatives to DOD's baseline architecture that could save billions of dollars, but DOD's plan for taking advantage of modern technology, which is intended to consider such savings, has failed to materialize. Although it recognized in 1991 that there was a need to reduce costs as soon as technologically feasible, DOD does not have a coordinated process within the military satellite communications technology and acquisition communities for technology insertion. Unless such a process is established, planned program management decisions associated with the baseline architecture may commit DOD to continued acquisition of existing, costly, customized military satellites.

DOD developed alternative satellite architectures based on common bus designs—standard satellite platforms capable of carrying various payloads—that were intended to satisfy DOD's communications requirements at substantially less long-term cost. Although DOD did not select these alternatives, one of them, called the dual common bus—containing two different platform sizes—provided a better way to demonstrate advanced technologies. It also had the most flexibility in terms of augmentation and surge capabilities, and now offers a potential for satisfying polar requirements—at lower estimated costs.

DOD has opportunities to insert modern technology into its existing communication satellite systems. For example, by revising the Defense Satellite Communications System (DSCS) launch schedules to avoid an excessive number of satellites in orbit, DOD would have time to insert modern technology. In addition, DOD has the opportunity to address cost and affordability concerns of the Milstar communications satellite program, as well as reduce the costs of other satellite systems, through such technology insertion.

DOD Selected Baseline Architecture

DOD's military satellite communication architecture study identified 12 alternatives—7 that made use of existing military satellite systems with either enhanced or reduced capabilities, 3 with new advanced technology proposals, and 2 with extensive use of commercial satellite capabilities. It compared and ranked these alternatives using costs, capabilities, risk, and policy as criteria and included funding availability as a critical decision-making factor. The study then narrowed the choices to five alternatives that satisfied the requirements, with estimated life-cycle costs ranging from $36 billion to $58 billion.[2] It stated that the final architecture should include communication capabilities in all radio frequency ranges that are currently used or planned to be used by military satellites.

DOD selected the second-highest-cost alternative, calling it the baseline architecture of currently approved and ongoing systems. The study stated that the baseline was the best alternative for the 1990s primarily because of high mission supportability and low to moderate programmatic and system transition risk. The baseline architecture consists of major ongoing programs, including Milstar, DSCS, and the Ultrahigh Frequency Follow-On (UFO) system. It also consists of (1) plans for technology insertion to upgrade or replace these satellite systems at the end of their operational lives and (2) continued leasing of commercial satellite communication services to satisfy requirements that are unmet by military systems, including plans to increase the use of commercial systems for general purpose communications.

Milstar is DOD's most recent communications satellite program and is designed to operate in the extremely high frequency range, providing tactical and strategic forces with high resistance to electronic jamming. The first Milstar satellite is scheduled to be launched in 1993. DSCS operates in the super high frequency range, providing moderate electronic jamming protection for the bulk of DOD communication users that require high-volume, voice and data services. DSCS has been in service for more than 20 years. The UFO system is a replacement for the existing Fleet Satellite and Leased Satellite communications systems. It operates in the ultrahigh frequency range and primarily supports communications that do not require protection from electronic jamming.

Less Costly Alternatives Could Satisfy Requirements

The architecture study presented alternatives to the baseline—specifically, common bus designs (standard platforms)—that could satisfy DOD's communications requirements at significantly less cost. According to the study, either a dual or single common bus approach, with advanced communication capabilities, were acceptable solutions.

DOD's Advanced Research Projects Agency (ARPA) proposed a dual common bus design with an estimated cost of $38 billion—$17 billion less

[2]One of the five alternatives was rejected because of high costs. Another one became obsolete when DOD restructured the Milstar program.

than the baseline, or a cost avoidance in excess of 30 percent. The Air Force proposed a single common bus design at an estimated cost of $46 billion—$9 billion less than the baseline, or a cost avoidance of about 16 percent. Although the greatest dollar-saving categories of both designs were associated with the spacecraft, the launch category offered from 30 percent to 40 percent in savings. (See table 1.) Today, the savings estimates are likely to be somewhat less because of the 2-year lapse in time and DOD's continued acquisition of the more expensive baseline architecture. However, the estimates do show significant relative differences and magnitudes associated with the alternatives.

Table 1: Estimated Costs of Baseline Versus Acceptable Alternative Architectures for Fiscal Years 1991 Through 2010

Cost categories	Baseline	Single common bus	Dual common bus
Spacecraft	$26.5	$21.8	$15.9
Mission control	1.2	1.5	0.7
Launch	6.9	4.7	4.1
User terminals	20.9	18.3	17.2
Total	**$55.5**	**$46.3**	**$37.9**
Savings over baseline	N/A	$9.2	$17.6

Source: DOD Military Satellite Communications Cost Study, 1991.

Dual Common Bus

The dual common bus alternative included designing two sizes of satellites—one weighing about 600 pounds, with an estimated operational life of 3 to 5 years, and the other weighing about 2,000 pounds, with an estimated operational life of about 10 years.[3] The 2,000-pound satellites were intended to be the primary means of communications within the dual common bus architecture, providing capabilities comparable to, or better than, existing systems. The plan for the 600-pound satellites was to (1) demonstrate advanced technologies that could be incorporated into the 2,000-pound satellites; (2) augment the capabilities of the 2,000-pound satellites, when needed; and (3) provide surge capabilities at low, medium, or high orbits, when needed.

The dual common bus alternative included two related efforts—development of a standard bus and an advanced communications payload—under ARPA's sponsorship and with service participation. The bus was to contain the necessary telemetry, tracking, and command functions

[3]According to ARPA, the two satellite designs could grow in weight to about 800 pounds and 2,500 pounds, respectively.

to control the satellite in orbit. The payload was to perform the communications mission in the extremely high frequency range. To demonstrate the technologies for the dual common bus and advanced communications payloads, ARPA's plans called for first launching a 600-pound satellite and demonstrating its capabilities for about 1 year, before developing the 2,000-pound satellites.

During the last few years, DOD research and development laboratories and contractors spent about $144 million to develop components related to the 600-pound common bus satellite that would demonstrate and promote a standardized, rather than a customized, system. ARPA representatives and contractors stated that the design and manufacture of existing customized satellites is a lengthy process because the payload and bus require greater integration and testing than a common bus design. ARPA representatives stated that the dual common bus concept required the bus and payload to be built separately and integrated through a "bolt-on" industry standard interface.[4] The representatives told us that the bolt-on method is central to the dual common bus design because it (1) provides a simple mechanical, power, and data interface and (2) allows for independent and parallel development, testing, and manufacturing of the bus and payload, thus saving time and reducing costs. Additionally, cost savings could be expected from economies of scale due to mass production of a class of common buses.

The architecture study estimated that the dual common bus risks ranged from low to high depending on the specific risk being assessed; the high-risk portion was associated with the standard bolt-on interface between the bus and payload. However, ARPA and contractor representatives stated that industry standards for interfaces exist and were not considered high risk.

Small Satellite Potential for Satisfying Polar Requirements

When the Secretary of Defense decided to restructure the Milstar program in 1991 and establish a six-satellite constellation, DOD planned to position four of the satellites in a low-inclined orbit above the equator. The planned positioning was to provide mid-latitude earth coverage. The remaining two satellites were to be in a high-inclined orbit that would provide polar, or high-latitude, coverage.

[4]DOD defines interface as a boundary or point common to two or more similar or dissimilar systems at which necessary information flow takes place. For example, the interface between the bus and payload would specify the functional, electrical, and physical characteristics needed to allow for exchange of information and performance of the various support functions.

In late October 1992, to lower costs, the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence approved reducing Milstar's constellation size from six to four. This decision eliminated the two satellites planned for polar coverage. Now, a separate program may be required to satisfy the polar communication requirements. Such a lack of polar coverage reduces the high mission supportability aspect of the architecture study's justification for the baseline architecture. The Air Force is studying various alternatives to prevent a potential gap in coverage, which could occur near the year 2000. Air Force representatives stated that alternatives being considered range from payloads hosted on existing satellite systems that would cost several hundred millions of dollars to two Milstar satellites that would cost billions of dollars.

Responding to a DOD tasking, an ARPA analysis shows that the 600-pound common bus satellite could satisfy most of DOD's stated polar requirements, and ARPA representatives indicated that modifications could be made to satisfy all the requirements. Based on research and development already performed by DOD laboratories and contractors, ARPA representatives believe that the 600-pound common bus design could provide the basis for an initial operational polar communications capability by about 2000 if a common bus program were initiated in fiscal year 1994 to mitigate risks. According to DOD representatives, a cost and operational effectiveness analysis of alternatives will be performed before a decision is made on a polar satellite system in late fiscal year 1994.

Single Common Bus

The single common bus alternative included satellites weighing about 3,000 pounds. Although this alternative was conceptual and not based on an ongoing demonstration program, DOD has extensive experience with satellites in this weight class—for example, DSCS. The architecture study estimated the risks to range from low to moderate—the same risks as the baseline architecture. The study did not indicate that an industry standard interface would be part of the single bus design. Instead, the payload would be integrated into the bus rather than being physically independent from the bus.

Additionally, the single common bus design would not provide (1) the augmentation or surge capabilities or (2) the ability to demonstrate advanced technologies, which the 600-pound satellite associated with the dual common bus design would provide. The smaller, less expensive, 600-pound satellite is expected to limit the risk in providing such capabilities and demonstrating such technologies.

Coordinated Process to Implement Modern Technology Is Lacking

A major recommendation in DOD's architecture study was to reduce the cost of military satellite communication systems as soon as technologically feasible while maintaining operational effectiveness. The study stated that modernization should be pursued under a coordinated program that (1) develops and demonstrates key technologies using small satellites and (2) transfers the technologies to higher capability spacecraft.

An October 27, 1992, decision memorandum on the military satellite communications architecture from the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence made programmed technology insertion a keynote of architecture modernization. According to the decision memorandum, a policy memorandum was to be prepared that would establish a coordinated process within the military satellite communications technology and acquisition communities. This process would then be the means of implementing modernization plans. The policy memorandum was to (1) endorse early identification and review of candidate programs by technology providers, service staffs, and program executive officers and (2) be approved by the Under Secretary of Defense for Acquisition; Director, Defense Research and Engineering; and Assistant Secretary of Defense for Command, Control, Communications, and Intelligence. It was considered an essential element in maintaining DOD-wide support and advocacy for such technology programs.

However, DOD never finalized the policy memorandum to establish the coordinated process. Despite this lack of policy, DOD requested funds for fiscal year 1993 to continue development of an advanced standard satellite bus and initiate development of an extremely high frequency communications payload for the bus. Although DOD referred to these projects as technology insertion efforts under the baseline architecture, no formal agreement had been established among the technology and acquisition communities within DOD to support such funding. As a result, the Congress denied the fiscal year 1993 request on the basis that the projects had not been justified. In addition, the Senate Appropriations Committee expressed concern that (1) the payload project was premature because it was intended to demonstrate a complement or follow-on system to Milstar, which had yet to be deployed and (2) there was no agreement within DOD as to the ultimate size of the Milstar constellation and its earth coverage capabilities, making an agreement necessary before beginning such a payload project.[5] In the fiscal year 1994 defense budget, DOD requested $30.2 million in research and development funds for ARPA's

[5]The Assistant Secretary of Defense for Command, Control, Communications, and Intelligence approved the Milstar constellation size and configuration in late October 1992 after the defense appropriations committees published their reports.

advanced space technology program. According to ARPA representatives, $11 million of this amount is specifically designated for the initial development of the 600-pound common bus and accompanying communication payload. Although DOD may still intend to establish a coordinated process to insert modern technology into its architecture, further action on this matter is not likely until the Secretary of Defense makes a decision on the ongoing bottom-up review. Without such a coordinated process, DOD could be making commitments to continued acquisition of costly, customized military satellites.

Opportunities for Introducing Dual Common Bus Capability

DOD has opportunities to introduce modern technology into the program plans for existing satellite communication systems. The Assistant Secretary's October 27, 1992, decision memorandum established plans for making program management decisions on the existing systems in the baseline architecture. The decisions to be made were divided into two categories: (1) architecture decisions, focusing on replenishment of existing systems or transition to other capabilities and (2) acquisition decisions, focusing on funding amounts and availability for system replenishment or transition.

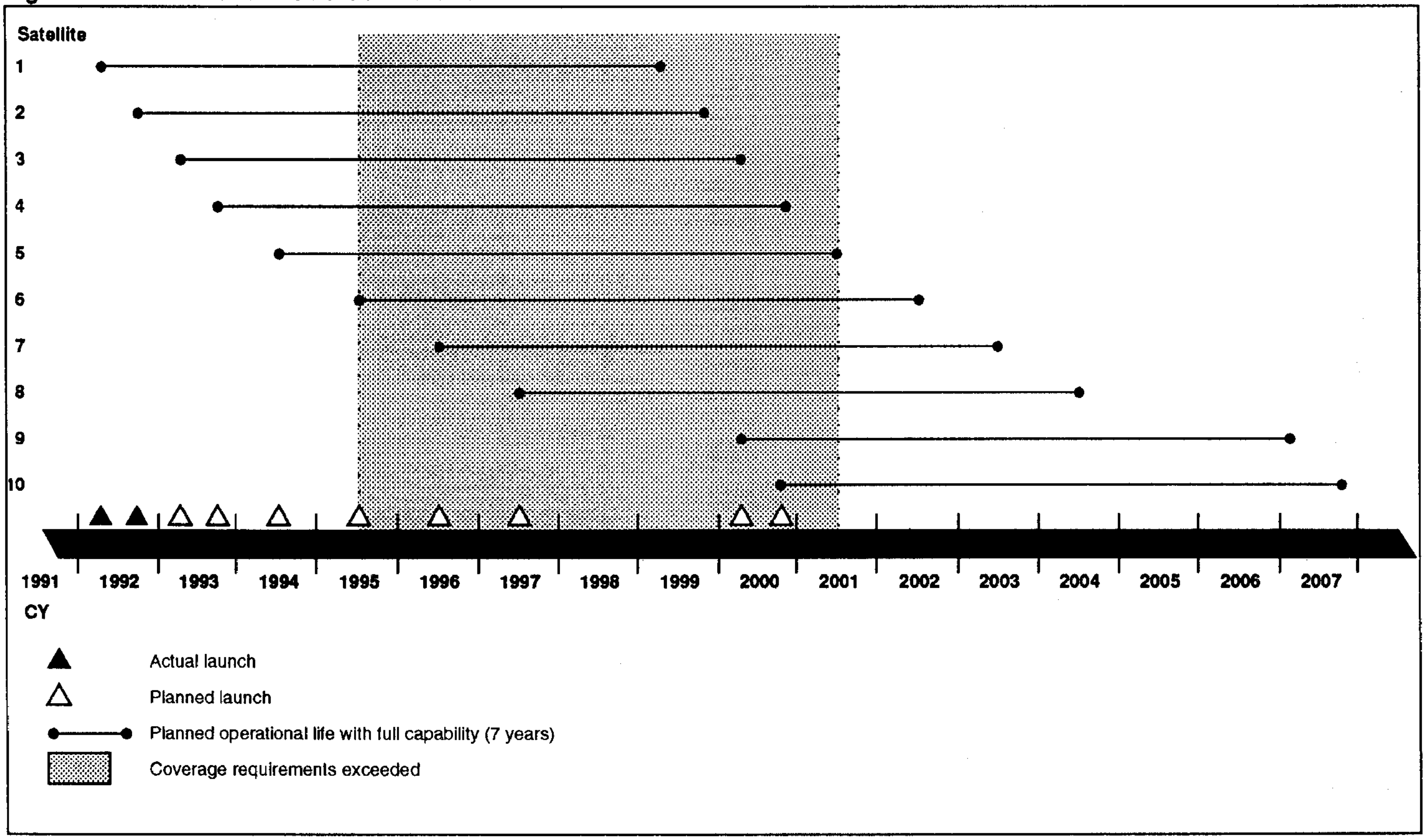
Our discussions with DOD representatives and analysis of DOD documents show that among the common bus alternatives, the dual common bus and accompanying payload technologies are at a more advanced stage of initial development than the single common bus. ARPA representatives informed us that a dual common bus capability could be provided in about 9 years, or by approximately 2003, assuming a technology program to develop and build advanced communications payloads and satellites based on the 600-pound and scaled-up 2,000-pound buses were initiated in fiscal year 1994. The expectation is that it could take about 4 years to develop, launch, and demonstrate the technology in a 600-pound satellite and another 5 years to produce and launch the first 2,000-pound operational satellite.

Decision on DSCS Program Has Priority

DOD's next major decisions are associated with DSCS—an architecture decision on replenishment or transition is planned for 1994, an acquisition decision is planned for 1995, and the first launch date is to be in 2002. However, there is time to institute a dual common bus capability if some of the scheduled DSCS launches are delayed. Several of the launch dates for satellites already in storage appear premature and, if retained, would result in an excessive number of satellites in orbit for a 6-year period between 1995 and 2001. DOD representatives told us that they intended to maintain a flexible launch schedule to ensure continuity of the DSCS constellation.

Figure 1 shows (1) DOD's actual and planned launch dates; (2) the planned period of time that each satellite would be operational—7 years; (3) the period of excessive satellites in orbit—shaded area; and (4) when replenishment or replacement would be needed—about 2002, when satellite 6 would likely expire. The information is based on DOD's constellation requirements for DSCS, which consists of 5 fully capable operational satellites at all times, plus the use of residual operational satellites that have partial capabilities.

Figure 1: DOD Plans for DSCS Constellation

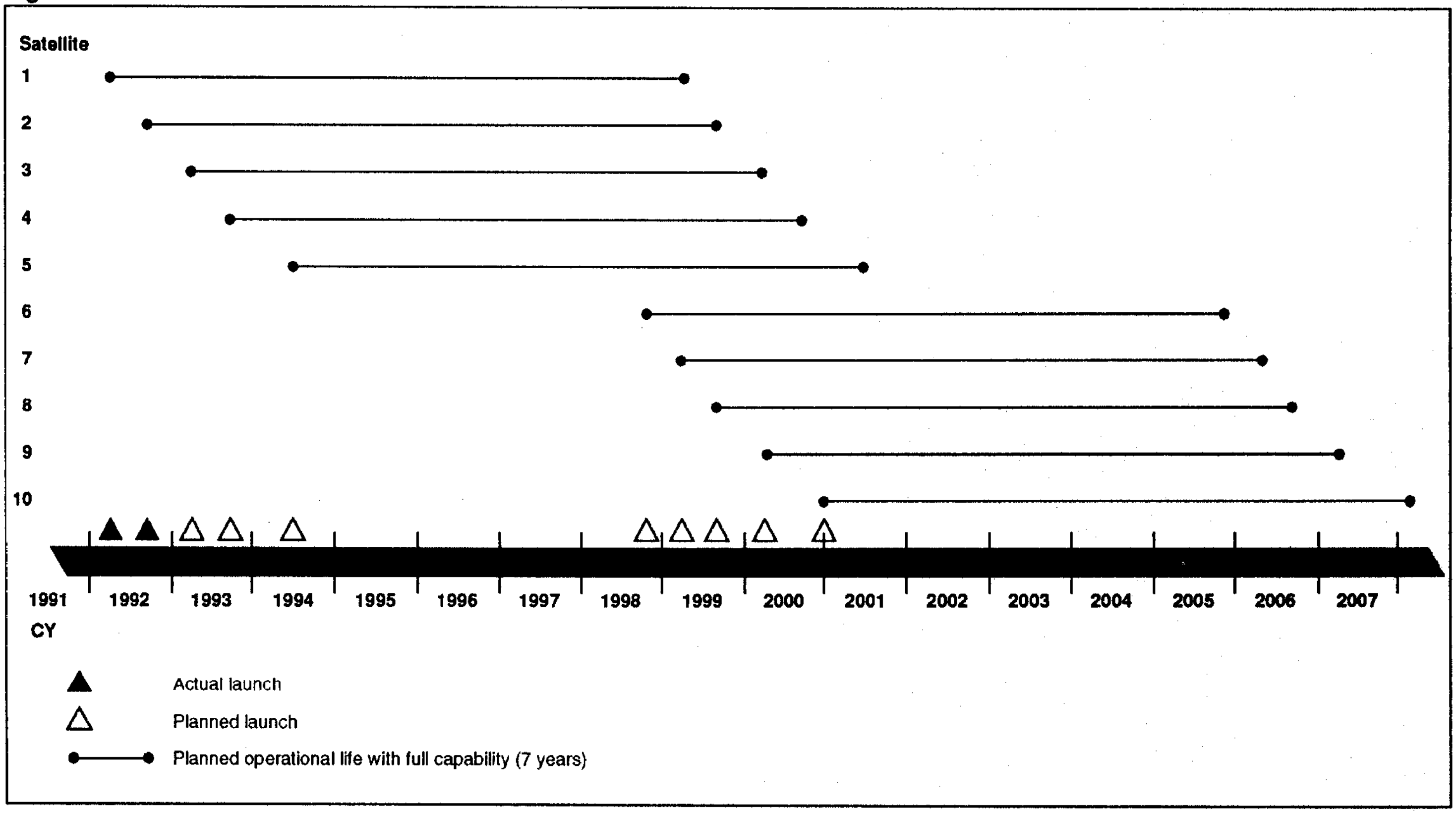


Source: Department of Defense.

Our analysis showed that if the DSCS launch dates were revised to avoid an excessive number of satellites in orbit, satellite number 6 would not have to be launched until 1998 to replace satellite number 1. The remaining satellites (7 through 10) would be launched successively to ensure that the required constellation size was maintained. The result would be a 3-year extension of the constellation life from 2002 to 2005. This would allow DOD time to provide dual common bus satellites by 2003, or shortly thereafter, instead of continuing with the customized DSCS.

Figure 2 shows (1) our revised planned launch dates for satellites 6 through 10; (2) the planned period of time that each satellite would be operational—7 years; and (3) when replenishment or replacement would be needed—about 2005, when satellite 6 would likely expire.

Figure 2: Revisions to DSCS Planned Constellation



Source: GAO.

Potential to Modify Milstar Program

In a June 1992 report,[6] we recommended that the Secretary of Defense ensure that a cost and operational effectiveness analysis be performed to determine whether Milstar was the best alternative for satisfying its satellite communication requirements. This recommendation was based on information contained in DOD's 1991 military satellite communication architecture study. In its May 1993 response to our report, DOD stated that the cost and operational effectiveness of Milstar is being examined as part of the 1993 DOD review of major defense programs. According to DOD representatives, this review is considering a range of options for a more affordable extremely high frequency program and is expected to be completed by the end of July 1993.

Prior to DOD's ongoing review of Milstar, an architecture decision on replenishment or transition was planned for 1997, with the first launch in 2007. However, considering (1) congressional concerns regarding the high cost of Milstar and (2) the timeframe in which a dual common bus capability could be made available, DOD has an opportunity to transition to a lower-cost alternative sooner than it originally intended to decide on Milstar replenishment or transition.

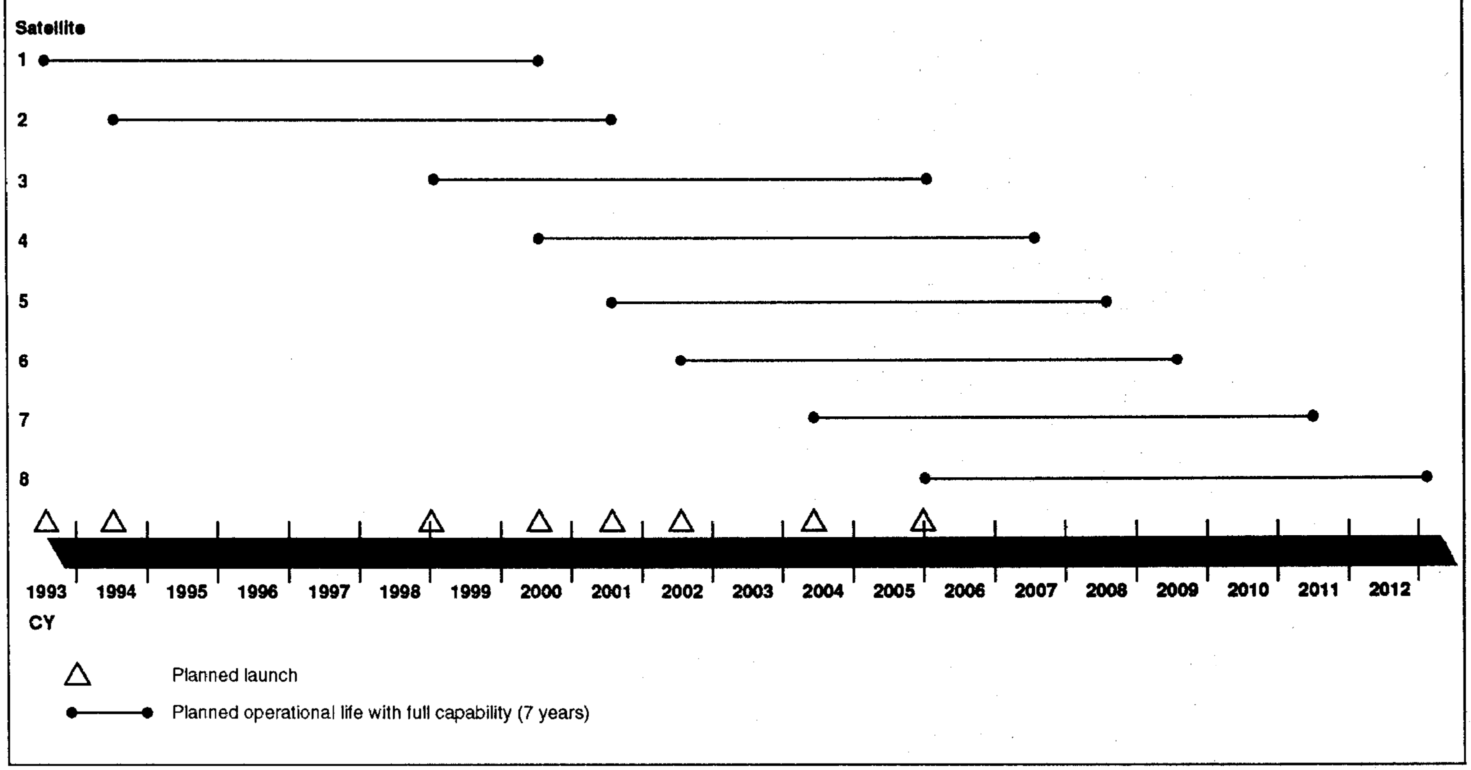
It may be practical to replace Milstar with the dual common bus design after launching the first six satellites. If this were done, replacement of the satellite constellation would have to begin by 2005. This would be compatible with the view that a dual common bus capability could be available by 2003. This would also be a logical break point in the program because (1) DOD has already made a substantial investment in the first two satellites—called Milstar I—which are based on the original design and (2) DOD's decision to restructure the program beginning with the third satellite—Milstar II—and its decision to have a four-satellite constellation, would provide the capabilities that are intended to better support tactical forces. Satellites 3 through 6 would make up the constellation, and introducing the dual common bus design would preclude the need for satellites 7 and 8. As with DSCS, using the dual common bus design would eliminate the customized Milstar design. DOD officials informed us that it may also be feasible to replace Milstar with a smaller common bus design after the first two satellites and not continue with Milstar II.

Figure 3 shows (1) DOD's planned launch dates; (2) the planned period of time that each satellite would be operational—7 years; and (3) when

[6]Military Satellite Communications: Milstar Program Issues and Cost-Saving Opportunities (GAO/NSIAD-92-121, June 26, 1992).

replenishment or replacement would be needed to maintain a four-satellite constellation—about 2005, when satellite 3 would likely expire.

Figure 3: DOD Plans for Milstar Constellation



Source: Department of Defense.

Recommendations

In view of opportunities to reduce long-term costs of military satellite communications, we recommend that the Secretary of Defense (1) not make any decisions regarding replenishment of existing military satellite communication systems until a coordinated process is established to insert modern technology into the architecture and (2) reassess the dual common bus alternative as a means of inserting modern technology, in addition to other alternatives being assessed in the bottom-up review, to preclude continuation of customized satellites.

Agency Comments

As requested, we did not obtain official agency comments. However, we discussed the contents of this report with DOD officials and have incorporated their comments where appropriate.

These officials generally agreed with the findings and the thrust of the report's message. They stated that although DOD's process for upgrading existing systems is not broken, DOD does not have a final plan to effectively incorporate significant technological changes into its systems such as those discussed in our report. They stated that DOD needs to articulate more clearly the value and the applicability of technology investment in ongoing military satellite communication programs.

The officials also stated that there are significant benefits in reducing the size and weight of satellites without reducing required capabilities. They indicated that the dual common bus design (1) was one of several alternatives that could achieve such benefits and (2) was being considered by the Secretary of Defense in the bottom-up review.

Scope and Methodology

We reviewed information associated with DOD's military satellite communications, including the 1991 architecture study, program management and budget documents, requirements data, acquisition plans and schedules, and correspondence. In addition, we interviewed several DOD representatives responsible for military satellite communications. We performed our work at the Office of the Secretary of Defense; Joint Staff; Departments of the Air Force, the Army, and the Navy; Defense Information Systems Agency; and ARPA. We also contacted representatives at selected DOD research and development laboratories and contractors' plants.

We performed our review from October 1992 to June 1993 in accordance with generally accepted government auditing standards.

Unless you publicly announce the contents of this report earlier, we plan no further distribution until 15 days from the date of this letter. We will then send copies of this report to the Secretaries of Defense, Air Force, Navy, and Army; the Director, Office of Management and Budget; and interested congressional committees. We will also make copies available to others upon request.

This report was prepared under the direction of Louis J. Rodrigues, Director, Systems Development and Production Issues, who may be reached on (202) 512-4841 if you have any questions about this report. Other major contributors to this report are Thomas J. Schulz, Associate Director; Homer H. Thomson, Assistant Director; Rahul Gupta, Evaluator-in-Charge; and Richard R. Irving, Evaluator.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Ordering Information

The first copy of each GAO report and testimony is free. Additional copies are $2 each. Orders should be sent to the following address, accompanied by a check or money order made out to the Superintendent of Documents, when necessary. Orders for 100 or more copies to be mailed to a single address are discounted 25 percent.

Orders by mail:

U.S. General Accounting Office
P.O. Box 6015
Gaithersburg, MD 20884-6015

or visit:

Room 1000
700 4th St. NW (corner of 4th and G Sts. NW)
U.S. General Accounting Office
Washington, DC

Orders may also be placed by calling (202) 512-6000 or by using fax number (301) 258-4066.

United States
General Accounting Office
Washington, D.C. 20548

Official Business
Penalty for Private Use $300

First-Class Mail
Postage & Fees Paid
GAO
Permit No. G100