United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Strategic Forces and Nuclear Deterrence, Committee on Armed Services, U.S. Senate

August 1988

SPACE SHUTTLE

The Future of the Vandenberg Launch Site Needs to Be Determined

GAO/NSIAD-88-158

GAO

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

National Security and
International Affairs Division

B-225026

August 3, 1988

The Honorable J. James Exon
Chairman, Subcommittee on Strategic
Forces and Nuclear Deterrence
Committee on Armed Services
United States Senate

Dear Mr. Chairman:

This report discusses Air Force activities and plans to deactivate, maintain, and reactivate the Vandenberg Launch Site. It contains a recommendation to the Secretary of Defense to develop a cost-effective reactivation schedule for the site, if it is to be preserved for future shuttle use.

We are sending copies of this report to the Secretaries of Defense and the Air Force; the Administrator, National Aeronautics and Space Administration; the Director, Office of Management and Budget; and other interested parties.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

Executive Summary

Purpose

Through fiscal year 1987, the Air Force spent about $3.1 billion to plan and construct a space shuttle launch site at Vandenberg Air Force Base, California. However, before the facility was ever used, the Challenger accident occurred, and with the subsequent changes to shuttle missions and launch dates and significantly reduced shuttle lift capability, the Air Force decided to deactivate the site and place it in a low maintenance status.

GAO examined the Air Force's deactivation efforts and its plans for maintaining and reactivating Vandenberg because of the facility's potential use in the U.S. space program, the influence such plans will have on the capability to reactivate the facility, if required, and the significant financial investment in Vandenberg.

Background

In 1972, the National Aeronautics and Space Administration (NASA) and the Department of Defense (DOD) determined that the space shuttle program needed two launch sites to be fully operational. NASA and DOD selected the Kennedy Space Center in Florida as the east coast launch site and Vandenberg as the west coast launch site. Vandenberg was chosen because it provides access into polar orbits without passing over populated areas.

After the Challenger accident in January 1986, NASA grounded the shuttle fleet, and the Air Force, after examining Vandenberg's options, eventually placed the launch site in a low maintenance status.

Results in Brief

After the cancellation of the shuttle's 1992 Vandenberg launch, placing the shuttle launch site in a low maintenance status appears to be a reasonable decision. However, low maintenance status presents high reactivation risk, with the risk and cost of reactivation increasing each year the site remains nonoperational. In addition, the shuttle launch site's future role is unclear because the lift capability of the shuttle, when launched from Vandenberg to a polar orbit, is currently well below the required level. Also, another launch system—the Titan IV—is expected to provide the required lift in the future before improvements to the shuttle will enable it to do so.

Given such circumstances, the launch site's future needs to be decided and that decision should not be permitted to languish principally because its facilities, equipment, and systems will become increasingly more difficult and expensive to recapture from other users and update

in line with current launch requirements. The cost to reactivate the site for shuttle use could be extremely expensive, if not prohibitive, in just a few years. On the other hand, if the site is not to be preserved for future shuttle use, an assessment and selection of an appropriate alternative use should be made.

Principal Findings

Reactivation Costs Unknown

The launch site was placed in low maintenance status because of limited funding and the lack of a launch schedule for the shuttle. Little reactivation planning has been done because the emphasis has been on deactivation, which is virtually complete. The Air Force does not know how much it will cost to reactivate the site for shuttle use from its low maintenance status. However, such costs will increase each year it remains nonoperational. (See chs. 2 and 3.)

High Schedule and Technical Risk

Reactivating the shuttle's Vandenberg launch site from its current low maintenance level has high schedule and technical risk because the Air Force does not know how long the site's nonoperational period will last and the Air Force will have to

- recapture facilities, equipment, and systems loaned to others and ensure they are in an acceptable condition for the shuttle program;
- implement thousands of configuration changes to updated the site's facilities, equipment, and systems for a shuttle launch;
- implement a major safety-related construction project;
- hire and train over 2,000 personnel because the vast majority of personnel have left Vandenberg; and
- implement a new launch computer system. (See ch. 3.)

Unknown Future Shuttle Lift Capability

To carry out certain missions, DOD and the Air Force require the shuttle, when launched from Vandenberg, to be capable of lifting a 32,000-pound payload to a specific polar orbit. However, there is no available launch system with that capability, and, after the Challenger accident, the estimated lift capability was only 12,300 pounds. DOD, Air Force, and NASA officials stated that this limited lift capability was a primary reason for deactivating the site. Neither DOD nor the Air Force plan to use the shuttle from Vandenberg until NASA demonstrates it has a funded

program to increase the shuttle's capability to the required 32,000 pounds.

By 1994 NASA plans to increase the shuttle's capability by making changes, such as using an advanced solid rocket motor and obtaining more power from the shuttle's main engines. After such changes, NASA estimates the maximum shuttle lift capability will be 30,600 pounds to the desired orbit. Although this will still not meet the 32,000-pound requirement, the estimate does not include 4,500 pounds of potential lift capability that NASA withholds as a management reserve to offset potential shuttle weight growth. Shuttle lift capability could achieve the 32,000-pound level if 1,400 pounds of this management reserve is not needed for shuttle weight growth. NASA officials also said that other systems upgrades could increase the lift capability, although there are no current plans to fund these efforts.

Alternative Uses

The main potential alternative uses for Vandenberg in light of the uncertainties surrounding its use for the shuttle include the shuttle-C, an unmanned shuttle-derived heavy lift vehicle, in the early to mid-1990s; the Advanced Launch System, another type of heavy lift vehicle, in the late 1990s; and/or the Titan IV expendable launch vehicle. The Titan IV is expected to exceed the 32,000-pound requirement in fiscal year 1991.

Using Vandenberg for the shuttle-derived vehicle would most likely also allow shuttle launches; however, using it for the Advanced Launch System or Titan IV could preclude its use for any other system. (See ch. 4.)

Recommendation

In its May 1988 report on the fiscal year 1989 defense authorization bill, the Senate Committee on Armed Services asked for an assessment of the performance and availability of the shuttle for DOD payloads and of alternatives for the disposition of the Vandenberg site. In July 1988 the conference committee on the fiscal year 1989 defense authorization bill endorsed this requirement. Such an assessment should satisfy the need for timely consideration of the site's future and for identifying and selecting an appropriate alternative use if the site is not to be preserved for shuttle use. Therefore, GAO is not making any recommendations on these matters. However, if the site is to be preserved for shuttle use, a cost-effective reactivation schedule would still need to be developed. Consequently, GAO recommends that the Secretary of Defense direct the Air Force to develop a cost-effective reactivation schedule for the Vandenberg site if it is to be preserved for shuttle use.

Agency Comments

GAO discussed the matters addressed in this report with DOD, Air Force, and NASA officials, and their comments were considered in preparing it. At the Subcommittee's request, GAO did not obtain official agency comments on a draft of this report.

Contents

Figure

Abbreviations

DOD	Department of Defense
GAO	General Accounting Office
KSC	Kennedy Space Center
MFCS	minimum facility caretaker status
NASA	National Aeronautics and Space Administration
VLS	Vandenberg Launch Site

Introduction

In 1972 the Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) determined that the space shuttle program needed two launch sites to be fully operational. They selected the Kennedy Space Center (KSC) in Florida as the east coast launch site and Vandenberg Air Force Base, a missile and space-oriented facility which covers almost 100,000 acres on the Pacific coast of California, as the west coast launch site. The shuttle facilities, equipment, and systems are known as the Vandenberg Launch Site (VLS). The VLS is part of the National Space Transportation System. DOD is responsible for space-related national security policy, which the Air Force implements as DOD's executive agent. The Air Force Systems Command's Space Division acquires and manages DOD space systems, including VLS.

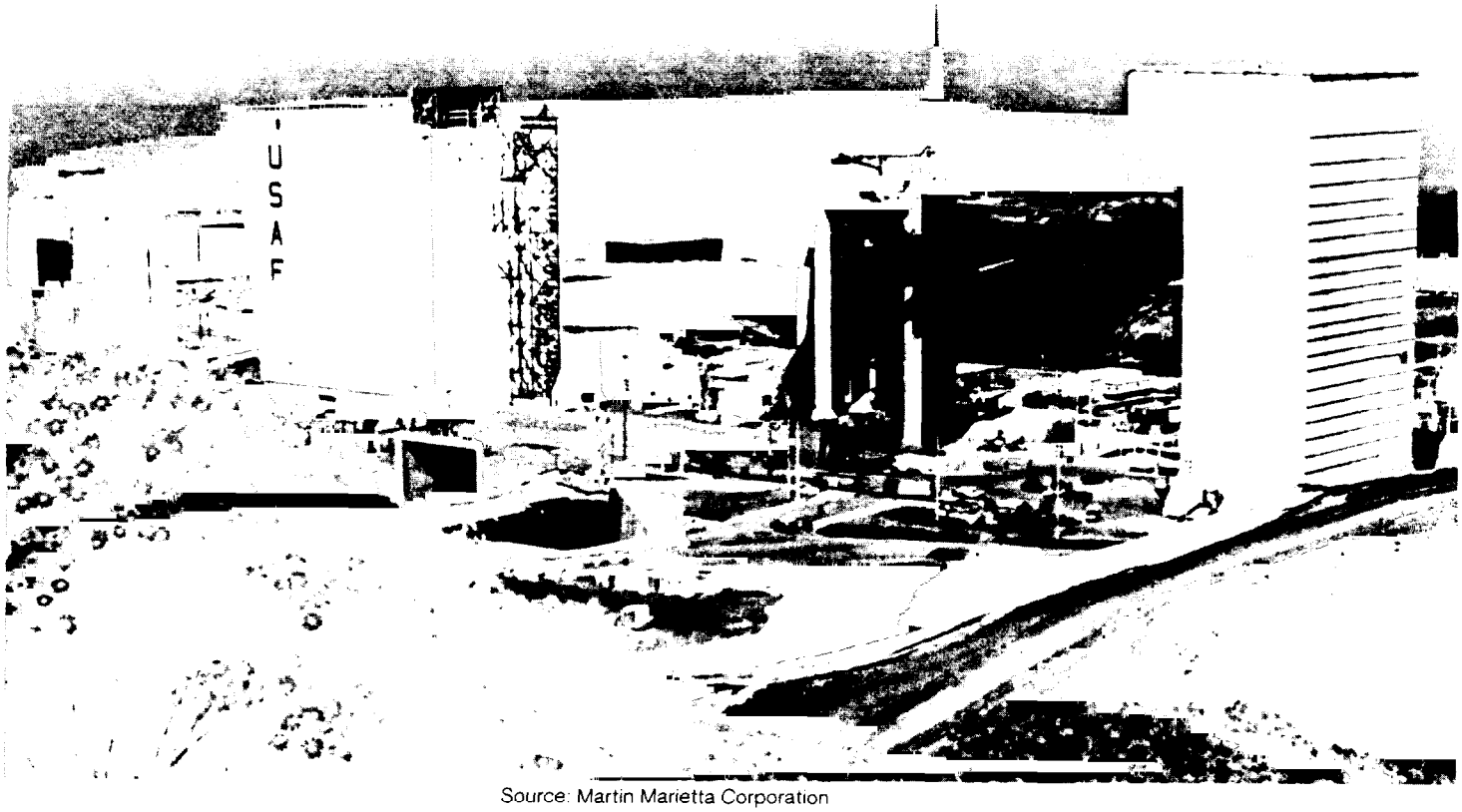
Vandenberg was selected as the west coast site because it provides access to polar orbits without endangering inhabited areas, and launch and support facilities for expendable launch vehicles[1] were already there. The Air Force funded, constructed, activated, and currently maintains VLS. VLS consists of about 53 facilities, 1-1/2 million square feet of space, 8,900 controlled pieces of equipment, 75,500 line items of uncontrolled equipment, and 245 systems, such as communications and fuels, located at Vandenberg Air Force Base and at Port Hueneme, which is also in California. The actual launch site, Space Launch Complex 6, has 21 facilities and 46 systems that cover 125 acres (see fig.1.1). At its peak in 1986, the VLS work force totaled about 4,000 persons.

In 1977 the Air Force initially estimated that VLS would cost $830 million. However, through fiscal year 1987, the Air Force spent about $3.1 billion to activate VLS. In addition, $400 million has been spent to maintain and deactivate it. According to VLS officials, the $2.3 billion activation cost increase was primarily due to cost overruns, schedule delays, and design changes, often driven by changes in space shuttle flight hardware and launch processing requirements. The Air Force originally scheduled the VLS initial operational capability for late 1982, but subsequently slipped the date to June 1983 because of Air Force budget problems and a NASA delay in the delivery date of the shuttle vehicle. Initial operational capability was achieved in October 1985, and the first launch was scheduled for July 1986.

In January 1986 the space shuttle Challenger exploded shortly after launch from KSC. As a result, the Air Force and NASA began post-Challenger reviews to identify changes to improve safety. The Air Force and

[1] Expendable launch vehicles are unmanned, nonreusable rockets such as the Titan.

Figure 1.1: VLS Space Launch Complex 6



Source: Martin Marietta Corporation

NASA also began reevaluating planned shuttle missions and launch dates, which led to various changes, which included shifting some VLS missions to KSC, shifting some missions to expendable launch vehicles, and delaying some missions.

After the Challenger accident, the Air Force also began to assess the status of VLS mainly because (1) NASA had grounded the shuttle fleet, (2) shuttle lift capability at VLS was significantly reduced, and (3) hundreds of millions of dollars could be saved annually by reducing VLS' operational level. By June 1986 Air Force officials had developed five options for operating and maintaining VLS. (See table 1.1.)

Table 1.1: Air Force Options for VLS as of June 1986

Dollars in millions

Operational/maintenance level	Contract cost per year	Contractor personnel required[a]	Months to reactivate
4 Launches per year	$416.6	2,100[b]	Not applicable
1 Launch per year	261.0	1,200[b]	Not applicable
Operational caretaker	200.0	1,200	18
Facility caretaker	150.1	750	At least 36
Mothball	25.9	150	At least 48

[a]These numbers are for the shuttle processing contract only.

[b]These personnel numbers do not include government personnel or the 600-person shared processing team from KSC required for the first launch. The shared processing team would not be needed after the first few launches for the 4 launches per year level, but would be needed indefinitely for the 1 launch per year level.

Of the maintenance levels, operational caretaker status would have retained a critical core of personnel and allowed VLS to remain compatible with the KSC launch facility. Facility caretaker status would have eliminated many critical positions, involved only essential maintenance on basic facilities, and not allowed VLS to remain compatible with the KSC launch facility, although, according to DOD officials, configuration control would have been maintained and they would have been aware of the requirements to bring VLS on line. Mothball status would have placed VLS in a long-term preservation mode and not kept VLS compatible with the KSC launch facility.

In July 1986 the Air Force selected the operational caretaker option, and VLS officials began planning to deactivate, maintain, and then reactivate VLS for a scheduled 1992 first launch. However, about 3 months later, the Air Force Systems Command directed VLS officials to brief Air Force Headquarters on the lowest level in which VLS could be placed that would be commensurate with (1) available funding, (2) launch requirements, and (3) prudent VLS preservation. On December 9, 1986, VLS officials briefed the Air Force on these issues and recommended that the Air Force put VLS into facility caretaker status, if the Air Force could not afford operational caretaker status.

On December 19, 1986, the Air Force decided to reduce the VLS status from operational caretaker to an unspecified lower status. Also in December 1986, the Air Force canceled the 1992 VLS launch, and, in February 1987, it directed that VLS be put into minimum facility caretaker status (MFCS). The Air Force switched from operational caretaker status to MFCS in response to direction from DOD's Defense Resources Board that

VLS funding be limited to $50 million per year. MFCS was not one of the original three maintenance options, but it is similar to mothball status. (See table 1.2.)

Table 1.2: Comparison of Original Maintenance Options to MFCS

Dollars in millions

Maintenance options	Estimated cost per year		Contractor personnel required[a]		Months to reactivate		Reactivation risk[b]
	June 1986	December 1986	June 1986	December 1986	June 1986	December 1986	
Operational caretaker	$200.0	$175.0	1,200	850	18	At least 36	Moderate
Facility caretaker	150.1	Did not revise	750	520	At least 36	At least 42	Moderate to high
MFCS[c]		50.0		350		At least 48	High
Mothball	25.9	40.0[d]	150	260[d]	At least 48	At least 48	High

[a]These numbers are for the shuttle processing contract only.

[b]Reactivation risk was not originally reported.

[c]MFCS was not developed until after December 1986; thus, no June 1986 data exist.

[d]According to VLS officials, these data reflect transition into mothball status. The cost and personnel needed to sustain mothball will not be known until the assigning of facilities and equipment to alternate users is completed. DOD officials estimate that $8 million to $9 million will be needed to maintain VLS.

VLS officials initially defined MFCS as mothball status plus limited engineering analyses of changes to the configurations of facilities, equipment, and systems.[2] The Air Force directed VLS officials to establish MFCS by the end of fiscal year 1987 and to maintain VLS at this level until shuttle recovery is complete and national requirements dictate reactivation.

In December 1987 the Congress reduced VLS' fiscal year 1988 funding to $40 million and directed the Air Force to allocate useful facilities to other programs or agencies, such as the Advanced Launch System, Titan or NASA, and to mothball those facilities serving no useful alternative purpose in the foreseeable future. After the allocation is complete, DOD officials expect to need only $8 million to $9 million annually to maintain the facility for possible future use. DOD was requested to report by June 1, 1988, on the uses for VLS facilities. When we finalized this report in the middle of June 1988, the DOD report was not yet issued.

[2]Such changes are required by post-Challenger reviews and the replacement/modification of existing shuttle systems.

Objectives, Scope, and Methodology

This review was performed to follow up on our previous report[3] because of VLS potential use in the U.S. space program, the impact the Air Force's plans will have on the capability to reactivate the shuttle launch site if and when directed to do so, and the significant financial investment in VLS. Our objectives were to describe the Air Force's deactivation efforts and its plans for maintaining and reactivating VLS and to identify factors affecting its future role.

Our review was performed at the Office of the Secretary of Defense, Air Force Headquarters, and NASA Headquarters in Washington, D.C.; the Air Force Systems Command's Space Division, Los Angeles, California; and the VLS program office, Vandenberg Air Force Base, California.

We obtained and analyzed various DOD, Air Force, NASA, and contractor documents, studies, briefings, contracts, cost and schedule estimates, budget data, deactivation and maintenance plans, reactivation guidelines, official messages, and strategy and policy documents. We interviewed DOD, Air Force, NASA, and contractor personnel who were responsible for the space shuttle program and/or for planning for deactivating, maintaining, and reactivating VLS. We also interviewed DOD and Air Force personnel responsible for developing, interpreting, and implementing DOD space policy. As requested, we did not obtain official agency comments. We discussed the issues in our review with DOD and NASA officials and considered their comments as we prepared our report.

Our review was performed from June 1987 to May 1988 in accordance with generally accepted government auditing standards.

[3]Space Shuttle: Issues Associated With the Vandenberg Launch Site (GAO/NSIAD-87-32BR, October 31, 1986).

Air Force Activities at VLS

VLS was virtually deactivated by the end of fiscal year 1987, and the few remaining deactivation tasks will be completed during fiscal years 1988 and 1989. VLS was placed in a low maintenance status because of limited funding and the lack of a launch schedule for the shuttle. VLS officials will not begin to make thousands of configuration changes to facilities, equipment, and systems until directed to reactivate VLS for a shuttle launch.

Deactivation Efforts

VLS officials had virtually completed deactivation by the end of fiscal year 1987, as directed by the Air Force. Although some deactivation tasks will not be completed until fiscal years 1988 and 1989, VLS officials already have sufficient funding available to complete the remaining tasks. In fiscal year 1987, the Air Force had more VLS funding available than needed, and used the excess for other Air Force programs.

VLS Almost Fully Deactivated

Although VLS officials did not complete deactivation by the end of fiscal year 1987, they told us that 95 percent of the tasks had been completed, despite contractor personnel leaving VLS more quickly than anticipated, and that they had completed the primary deactivation task of removing the fuels from the launch pad. Other important completed deactivation tasks were disassembling the shuttle's solid rocket boosters and identifying VLS systems that must be kept operational during the maintenance years. VLS officials stated these deactivation tasks were scheduled and completed first because they involved safety and had the highest costs, requiring the highest skilled personnel and the most time to complete.

VLS officials did not complete about 5 percent of the deactivation efforts, representing about $5 million of scheduled work. The primary residual tasks are to ensure the facilities, equipment, and systems match their design drawings; identify safety problems to be resolved during the maintenance years; and identify problems that could affect flight operations.

VLS officials had sufficient funding to complete all the deactivation tasks by the end of fiscal year 1987, but they decided to defer certain tasks that would not adversely affect the deactivation process because these tasks would have cost more than $5 million to complete on time. The officials stated that they have adequate funding to complete these tasks, and they plan to do so in fiscal years 1988 and 1989.

Excess VLS Funds Used for Other Programs

VLS officials had excess funds available in fiscal year 1987 for several reasons, including

- VLS was placed in a lower maintenance status than previously planned;
- an integrated test of facilities, equipment, and system and a major safety-related construction project to resolve a potential hydrogen entrapment problem at the launch pad were deferred until reactivation;
- VLS contractor personnel were lost faster than expected during deactivation; and
- deactivation costs were lower than expected.

As a result, the Air Force reduced the VLS fiscal year 1987 budget from $332.1 million to $88 million. The Air Force used all of the $244.1 million in fiscal year 1987 VLS excess funds for its other programs. (See table 2.1.)

Table 2.1: VLS Fiscal Year 1987 Funds Used for Other Purposes

Dollars in millions

	Amount
To Space Division for its	
Titan expendable launch vehicle program	$133.9
Defense Meteorological Satellite program	7.1
Other programs	3.9
Subtotal	**144.9**
To Air Force Systems Command	99.2
Total	**$244.1**

Maintenance Plans

In February 1987 the Air Force directed that VLS be put into MFCS. Under MFCS, VLS officials would have identified, but not made, thousands of configuration changes during the maintenance years. These changes were to have been accumulated and made when VLS is reactivated.

Maintenance at MFCS

On February 20, 1987, the Air Force directed VLS officials to maintain VLS in MFCS at $50 million per year, starting with fiscal year 1988, until shuttle recovery is complete and launch requirements dictate reactivation. Air Force officials said that the decision to go to MFCS was made after the 1992 launch was canceled in December 1986. VLS officials said maintaining VLS in a higher maintenance status than MFCS would have been difficult to justify without the 1992 launch date.

The fiscal year 1988 funding level was not based on an evaluation of the costs and risks associated with various maintenance level options. According to VLS officials, they were told to do the best they could with $50 million funding level because that was all the Air Force could afford. VLS officials developed a financial plan detailing their maintenance plans for fiscal year 1988. As of February 1988, the plan included 8 line items for $50 million and 7 line items for the $40 million level subsequently directed by the Congress. (See table 2.2.)

Table 2.2: VLS Financial Plan for Maintenance in Fiscal Year 1988

Dollars in millions

	Original plan	Revised plan[a]
Ground support system	$2.3	$2.2
Shuttle processing contract[b]	28.8	22.2
Electronic security services	0.9	0.0
Technical support	2.1	2.3
NASA reimbursements	1.7	1.7
Range support reimbursements	4.0	3.6
Management support	2.3	1.9
Facilities support	7.9	5.9
Total	**$50.0**	**$39.8[c]**

[a]According to VLS officials, these data reflect the cost to transition into mothball status. The cost to sustain mothball status is estimated by DOD officials at $8 million to $9 million annually, pending the completion of assigning facilities and systems to alternate users, as discussed in chapter 3.

[b]This includes most of the personnel costs to maintain VLS.

[c]As of December 31, 1987, about $39.6 million of this amount has been obligated.

MFCS is similar to mothball status. For example, VLS officials originally estimated that mothball status would cost $25.9 million per year. However, VLS officials subsequently revised this estimate to $40 million per year and briefed the Air Force on the revision in December 1986, before the decision to go to MFCS.

No one has ever deactivated, maintained, and reactivated a facility like VLS before, according to Air Force and DOD officials. Under MFCS, VLS officials planned to do 13,000 routine maintenance and corrosion control actions each year, the cost of which can be reasonably estimated. However, they also estimated an additional 3,250 to 6,500 unscheduled maintenance actions as a result of finding unexpected things that need to be done. The number of routine and unexpected maintenance actions which will be needed each year after VLS completes its efforts to lend its facilities, equipment, and systems to other users will be considerably

less, since many facilities, equipment items, and systems will be under the control of other users.

Many VLS Configuration Changes Will Await Reactivation

VLS officials will not keep VLS current with KSC shuttle launch facilities because its low funding level will not allow them to make thousands of configuration changes during the maintenance years. Although as originally defined MFCS did not involve making configuration changes, VLS officials subsequently planned to make the configuration changes that (1) NASA recommended that they make, (2) would enhance the safety of the maintenance work force and save money during the maintenance years, and (3) could be done under available funding. However, VLS officials will accumulate most of the configuration changes until directed to reactivate VLS for a shuttle launch.

Three NASA facilities can send potential configuration changes to VLS—KSC, Johnson Space Center, and Marshall Space Flight Center. Also, VLS officials will identify potential configuration changes. The VLS contractor expects to deal with a total of over 1,700 potential changes for each maintenance year, over 1,000 of which will apply to VLS. Under MFCS, the contractor estimated that it would have made over 400 of these changes each year. (See table 2.3.)

Table 2.3: Estimated Potential and Actual Changes Per Year at VLS Under MFCS

	Estimated annual configuration changes		
Facility	Total potential changes	Changes applicable to VLS	Changes to be made at VLS during maintenance years
KSC	300	300	0
Johnson Space Center[a]	1,200	480	240
VLS	240	240	190
Total	**1,740**	**1,020**	**430**

[a]According to VLS officials, the Johnson Space Center numbers include those from Marshall Space Flight Center.

Consequently, almost 600 configuration changes would have accumulated each year. Even more will accumulate now, since many VLS facilities, equipment items, and systems will be under the control of other users and VLS officials will have no opportunity to change them until they are returned to VLS control.

Furthermore, VLS officials have already accumulated configuration changes that must be made based on post-Challenger reviews. The reviews resulted in 10,536 action items as of November 1987. An action item needs further analysis to determine if it will require a VLS configuration change. Of the 10,536 action items, the VLS contractor estimates that it will have to make between 3,200 and 4,300 configuration changes.

Reactivation Plans

In February 1987 the Air Force directed VLS officials to be able to reactivate VLS within 4 years. VLS officials stated that they have not done any detailed reactivation planning because they have primarily focused on deactivating and maintaining VLS and because funding is limited. Chapter 3 discusses the reactivation issue in more detail.

Reactivation Has Many Unknowns and High Risks

The Air Force has not estimated the time or the cost to reactivate VLS, and reactivating VLS carries high schedule and technical risks, including those associated with (1) the ability to hire, train, and support over 2,000 skilled personnel during reactivation, (2) the effect of not implementing thousands of configuration changes until reactivation, and (3) the ability to recover, in a timely manner, VLS facilities, equipment, and systems on loan to other programs.

The specific examples of reactivation risk discussed in this chapter focus on MFCS. However, all nonoperational levels present reactivation risk—it is only a matter of degree. The most costly ones, which would keep VLS extensively staffed and fully updated on configuration changes, have the least risk. Generally, the lower the maintenance level, the higher the risk, since lower funding supports fewer personnel who can only do so much work to properly maintain the facility and keep it updated in line with its intended purpose. Also, if reactivation is directed, relatively greater numbers of new people who are unfamiliar with the site and its systems would need to be hired and trained. However, with no scheduled launch date, it seemed reasonable for the Air Force to accept high reactivation risk. When VLS' future use is clarified and a potential launch date is known, the Air Force can adjust its management of VLS to fit these new circumstances, as we note in chapter 5.

Reactivation Cost Not Yet Known

VLS officials prepared reactivation cost estimates in June 1986 for the three original maintenance options, but have not updated them since that time. (See table 3.1.)

Table 3.1: Air Force Reactivation Cost Estimates in June 1986

Dollars in millions

	Amount
Operational caretaker	$114
Facility caretaker	268
Mothball	657

These were understated estimates because they (1) did not include full funding for items and activities such as fixing the hydrogen entrapment problem or the new launch computer system which are discussed later, and (2) for the operational and facility caretaker options, were based on the now-canceled 1992 first launch.

VLS officials said that estimating the reactivation cost depends on many unknowns, such as

- the length of time VLS will be nonoperational, which affects VLS' condition and degree of obsolescence;
- the number and types of configuration changes that will have to be made during reactivation;
- the cost to hire, train, and support over 2,000 skilled personnel during reactivation;
- the additional cost that may result if VLS officials must accelerate reactivation efforts in order to meet the 4-year schedule; and
- the future funding that will be available.

According to VLS and contractor officials, a detailed reactivation cost estimate cannot be made until they know when reactivation will begin. However, the reactivation date is unknown because the first VLS launch date is unknown. Also, the longer VLS is nonoperational, the higher the reactivation cost will be. DOD and Air Force officials believe they will have to decide what to do with VLS by the end of fiscal year 1989 because reactivation costs could increase significantly after then.

Reactivation Has High Schedule and Technical Risks

Reactivating VLS from a low maintenance status has high schedule and technical risks. VLS officials who originally developed the 4-year schedule for the mothball option told Air Force Headquarters that reactivating from MFCS would take at least 4 years also. Consequently, the Air Force directed VLS officials to meet the 4-year reactivation schedule for MFCS. However, this direction carries high schedule and technical risk, and VLS officials believe that reactivation from MFCS would take at least 5 years.

Schedule Risk

VLS officials originally developed reactivation schedules for the three original maintenance options about July 1986. By December 1986, they had revised the schedules. The original and revised reactivation schedules are shown in table 3.2.

Table 3.2: Original and Revised Reactivation Schedules

	July 1986 estimate	December 1986 estimate
Operational caretaker	At least 18 months	36 months
Facility caretaker	At least 36 months	At least 42 months
Mothball	At least 48 months	At least 48 months

VLS officials believe that VLS reactivation will take about 5 years altogether—at least 4 years of reactivation work plus up to 1 year to get budget authority to reactivate, contract to reactivate, and accomplish other administrative tasks. According to VLS officials, they informed Air Force Headquarters that the 4-year reactivation direction has high schedule risk, but the Air Force has not revised its direction. The officials we interviewed from VLS, the Air Force, and DOD were not aware of any critical reason for requiring reactivation within 4 years.

According to VLS officials, they will not know the actual time it will take to reactivate until completing 1 to 2 years of reactivation work. Therefore, if the Air Force directed reactivation to begin in fiscal year 1988, it would be sometime during fiscal year 1990 or 1991 before Air Force officials would know if they could reactivate VLS by fiscal year 1993.

Technical Risk

Reactivating VLS has high technical risk due to circumstances such as the following.

- The actual number of configuration changes that will have to be made during reactivation is unknown, as is their magnitude and complexity. VLS officials said a few of them could be extremely difficult and require significant funds, time, and effort to make; others could be relatively simple.
- The Air Force will fix the hydrogen entrapment problem during reactivation. Air Force analysis indicated that hydrogen gas could be trapped in the launch pad's enclosed exhaust duct for the orbiter's main engines and could explode and damage the orbiter. To resolve the potential problem, the Air Force originally planned to design and implement a steam inerting system during 1987. Subsequently, the Air Force deferred the fix, which was estimated to cost about $32 million and take 32 months to complete, until reactivation.
- VLS officials will have to acquire, install, and test a new launch computer system during reactivation. A shuttle processing contract official said NASA is planning to replace the current launch computer system at KSC in the early 1990s. This official estimated that acquiring, installing, and testing the new system at VLS will cost about $100 million, including the software, and will take about 2-1/2 to 3 years to complete.
- VLS officials will have to recapture loaned facilities, equipment, and systems and make sure they are in an acceptable condition.
- VLS and the flight hardware have not been fully tested. Specifically, VLS officials did not do the NASA-required flight readiness firing or any flight readiness processing with a flight-ready orbiter because, according to

DOD officials, no orbiter was available. VLS has only completed about 4 of the planned 10 months of flight hardware processing.

Each year that VLS is nonoperational the technical risk of reactivation increases because more configuration changes will accumulate; deterioration and obsolescence of VLS' facilities, equipment, and systems will increase; and the facilities, equipment, and systems loaned to other agencies and programs may be increasingly difficult to recapture and use for VLS launches.

Loss of VLS Personnel Is a Major Risk Factor

VLS officials' ability to hire and train over 2,000 personnel when needed during reactivation will be a major schedule and technical risk factor. Various types of personnel—many of whom will be needed for highly skilled engineering and technical work--would fill these positions. Air Force and VLS officials stated that they are concerned about hiring and training over 2,000 skilled personnel during reactivation because almost all VLS launch personnel have left VLS; the pool of available personnel from which to hire during reactivation is unknown; and reactivation will require that VLS officials consistently hire and train about 67 people per month for over 2 years. VLS officials said the most they ever hired per month during activation was an average of 70 people, but for only a few months.

VLS officials said that maintaining the continuity of VLS engineering is very important in reducing reactivation risk. However, most of the engineers have left, and VLS officials have lost most of their corporate engineering memory, much of which may never be regained. Also, according to DOD officials, most Air Force expertise has been lost.

To help mitigate the risk associated with less experienced personnel, Air Force plans for launching the VLS shuttle included using about 600 KSC personnel for a few months before and during the first few VLS launches. These personnel are called the "shared processing team" and would return to KSC after the launch. VLS officials said the KSC personnel would act primarily in an advisory or consulting role to VLS personnel. They said that although VLS personnel could launch the shuttle without the KSC personnel, having them reduces launch risk. According to VLS officials, NASA wants the team at VLS to ensure the flight hardware is properly handled, although NASA officials stated that the temporary loss of the team could impair KSC's launch rate capability. DOD officials also noted that having the KSC team at VLS would facilitate the resolution of any anomalies that would develop.

Loaned Facilities, Equipment, and Systems Are Major Risk Factors

NASA, the Navy, and other Air Force programs have borrowed some VLS facilities, equipment, and systems. VLS officials are controlling the loaned items by requiring the users to sign 21 memorandums of agreement—8 for facilities and 13 for equipment—from January 1987 to February 1988. VLS officials received 204 requests from potential users of VLS equipment, and they loaned 18,169 components of equipment and 12 facilities as of February 1988. Also, since December 1987 the Air Force has been under congressional direction to expeditiously allocate all useful VLS facilities to other programs. NASA made most of the equipment requests. The agreement for equipment allows the user to continually request VLS equipment for the term of the agreement.

Memorandums of agreement for loaned facilities will remain in effect for 6 years or until the Air Force reactivates VLS and requires VLS officials to prepare for a shuttle flight, VLS officials eliminate the requirement for the loaned facility, or the parties mutually consent to terminate the agreement.

The facilities agreements are to be reviewed annually for appropriateness and to determine if they should be continued. NASA, the Navy, and other Air Force programs are using the following VLS facilities as of February 1988.

- NASA is using the External Tank Processing and Storage Facility and is sharing the Solid Rocket Booster Refurbishment and Subassembly Facility with an Air Force program.
- The Navy is using the Solid Rocket Booster Retrieval and Disassembly Facility and the retrieval ship Independence.
- Other Air Force programs are using the Orbiter Maintenance and Checkout Facility and Central Supply Facility.

VLS officials also had facilities agreements in process for other Air Force programs to share the Flight Crew Systems Facility and Orbiter Maintenance and Checkout Facility.

VLS officials are to approve all changes to loaned items, and, if VLS officials approve temporary modifications, the user will have to return these items to their original configurations before transferring them back to VLS officials. According to VLS officials, the loaning of facilities, equipment, and systems is adequately safeguarded under the agreements. However, in April 1987, the Surveys and Investigations Staff of the House Committee on Appropriations reported that

"Most officials agreed that in the months after caretaker status is implemented, the VLS facilities and equipment will be "cannibalized" by the Air Force, Rockwell International, NASA, and perhaps others...(which) will make the estimated 4- to 6-year VLS revamping capability even more remote."

According to VLS officials, Air Force, VLS, and Johnson Space Center officials subsequently revised their memorandums of agreement. The revised agreements clarified Air Force and NASA roles and renewed the commitment to return or replace loaned items for reactivation, or within 6 months of a request from the Air Force.

As a further control over loaned items, a 1987 VLS operating instruction states that VLS and Vandenberg Air Force Base officials may perform periodic audits and inspections to ensure compliance with the agreements. VLS officials said the VLS contractor will be primarily responsible for monitoring the loaned facilities, equipment, and systems by doing periodic physical inspections. However, a VLS contractor official disagreed with this and told us that the contractor was not responsible for the physical inspections. This difference of opinion was not resolved as of February 1988.

VLS officials inform other organizations of available VLS facilities, equipment, and systems but the potential users must determine if they can use them. According to VLS officials, some facilities, equipment, and systems are still available for use by other organizations.

VLS Role Is Uncertain

Some important missions require polar orbits, which can be most safely achieved from Vandenberg Air Force Base. However, the need to launch the shuttle from VLS is uncertain because (1) it currently has limited lift capability and may also be limited in the future and (2) the Air Force has increased funding and production of expendable launch vehicles with planned lift capacity sufficient to meet the largest class of missions more than 2 years earlier than the shuttle from VLS could. In light of the uncertainties surrounding the shuttle at VLS, the Air Force and NASA are considering alternative uses for VLS.

Unknown Future Shuttle Lift Capability From VLS

To carry out certain missions, DOD and the Air Force require that the shuttle, when launched from VLS, be capable of lifting 32,000 pounds to a specific polar orbit. However, the currently estimated shuttle lift capability to this orbit is only 12,300 pounds, and neither DOD nor the Air Force plan to launch the shuttle until NASA has a funded program to increase its lift capability to 32,000 pounds. By 1994 NASA plans to increase the shuttle lift capability close to this level by making three changes, namely, using an advanced solid rocket motor, a different shuttle ascent profile, and improved main engines operated at 109-percent thrust. NASA estimates that these changes will increase the maximum shuttle lift capability from 12,300 to 30,600 pounds—a total increase of 18,300—to the desired orbit. (See table 4.1.)

Table 4.1: Planned NASA Changes to Increase Shuttle Lift Capability

Numbers in pounds

	Added capability
Advanced solid rocket motor	12,000
Different shuttle ascent profile	2,300
Improving shuttle main engines and operating them at 109-percent thrust	5,000
Projected orbiter weight growth for the mid-1990s	−1,000
Total	**18,300**

According to NASA officials, the advanced solid rocket motor should be available in 1994 if NASA receives the fiscal year 1989 development funds it has requested. If not, NASA would reinstitute the filament wound solid rocket booster casing program, which NASA did not fund in fiscal year 1988, to increase shuttle lift capability, although not to the same extent.

Since 1977, DOD and the Air Force have stated the requirement that the shuttle launched from VLS deliver a 32,000-pound payload to a 150-nautical mile circular orbit at a final inclination of 98 degrees. Before the Challenger accident, NASA estimated that the shuttle could lift 24,800 pounds to this orbit from VLS using filament wound solid rocket booster casings and 104-percent main engine thrust.[1] Without the filament wound casings, the shuttle could have lifted 20,000 pounds from VLS before the Challenger accident, according to NASA officials. NASA now estimates the shuttle's lift capability from VLS is down to 12,300 pounds to this orbit, primarily as a result of post-Challenger review changes. DOD, Air Force, and NASA officials stated that this limited lift capability was a primary reason for deactivating VLS.

NASA's manager of the Space Transportation System said that NASA has reported to DOD that the estimated maximum lift capability for the shuttle to be launched from VLS is 30,600 pounds to a 150-nautical mile orbit, even after NASA makes all the presently planned improvements. This official also said that NASA cannot tell DOD if or when to reactivate VLS because it is an Air Force facility. According to DOD and Air Force officials, it would not be cost effective to operate VLS if the shuttle could not meet the 32,000-pound class missions.

NASA may be able to meet DOD's 32,000-pound requirement eventually, since the estimated maximum lift capability of 30,600 pounds does not include 4,500 pounds that NASA has withheld as a management reserve to offset additional potential shuttle weight growth. According to a NASA official, shuttle weight growth usually reduces the management reserve right up until launch. Assigning the entire management reserve to lift capability would give an estimated maximum lift capability for the shuttle from VLS of 35,100 pounds. Shuttle weight growth could use up to 3,100 pounds of the management reserve, and the shuttle from VLS could still meet the 32,000-pound requirement. However, should further shuttle weight growth projections exceed 3,100 pounds, NASA officials told us there are potential lift upgrades available through system improvements, but there are no current plans to fund these efforts.

[1]The current solid rocket boosters are encased in steel. Filament wound solid rocket boosters are encased in a lighter-weight material, which is more flexible than the steel casings. Normal main engine thrust is 104 percent.

Air Force and NASA Are Considering Alternative Uses of VLS

The Air Force and NASA are considering potential alternative uses for VLS in view of the many uncertainties surrounding the use for the shuttle. The main alternatives being considered include using VLS to launch the shuttle-C, an unmanned shuttle-derived heavy lift vehicle, in the early to mid-1990s; the Advanced Launch System, another type of heavy lift vehicle, by the late 1990s; or the Titan IV expendable launch vehicle. Using VLS for a shuttle-derived vehicle would most likely still allow shuttle launches from VLS also. However, using VLS for the Advanced Launch System or the Titan IV could preclude its use for any other system.

NASA is studying the shuttle-C, which would use shuttle facilities, equipment, and systems and would be expected to lift about 60,000 pounds from Vandenberg into low earth orbit. NASA plans to have the shuttle-C available in the early to mid-1990s at a development cost of about $1.5 billion, according to NASA officials. The shuttle-C's design would most likely allow both shuttle-C and shuttle launches from VLS.

In July 1986 the Air Force contracted with 7 contractors, with each contract valued at $5 million, for concept definition studies of the Advanced Launch System. NASA and the Strategic Defense Initiative Organization are also participating in the Advanced Launch System program. The Advanced Launch System could use unmanned expendable launch vehicles for lifting 60,000 to 90,000 pounds from Vandenberg into a 150-nautical mile, 98-degree inclination polar orbit. The Air Force plans to have the Advanced Launch System available by 1998 to (1) meet future requirements as projected in the Space Transportation Architecture Study, which is a joint study by the Air Force and NASA; (2) reduce launch costs to low earth orbit by 90 percent of the cost of current space boosters, or to about $300 to $500 per pound; and (3) provide flexible, robust, and reliable operations.

According to a Space Division official, using VLS for the Advanced Launch System could preclude shuttle launches. The official said that the contractors are also studying other locations for Advanced Launch System launches to polar, as well as equatorial, orbits. The official added that the contractors planned to deliver the first system designs by the summer of 1988. At that time the Air Force would know whether any of the contractors proposed to use VLS for the Advanced Launch System.

If VLS is proposed as part of the Advanced Launch System, Space Division officials will request Air Force direction on what changes can be

made to VLS. The official also said Space Division will need the direction by the summer of 1988 when the program is scheduled to enter a phase requiring detailed launch pad designs. According to the official, Space Division will not have a cost estimate to develop the Advanced Launch System until that time.

Air Force Space Division officials have also studied using VLS for the Air Force's Titan IV which is planned to have greater lift capability than the shuttle. To date, the Air Force has contracted for 23 Titan IVs and has requested 20 more, according to DOD officials. The Titan IV is expected to have capacity to launch 29,000 pounds from Vandenburg to the required orbit starting in January 1990. The Titan IV will use an upgraded solid rocket motor in fiscal year 1991, which will increase its total estimated lift capability to 36,250 pounds. Therefore, a launch vehicle capable of meeting DOD's 32,000-pound requirement at Vandenberg is scheduled to be available more than 2 years earlier than the upgraded shuttle with an estimated lift capability slightly less than the 32,000-pound requirement.

The Air Force plans to modify an existing launch pad and to construct a new Titan IV launch pad at Vandenberg. Preliminary analyses by the Titan IV contractor show that it is technically feasible, with low technical risk, to convert the VLS launch pad to a Titan IV launch site. The analyses show that converting the VLS launch pad into a Titan IV launch site would cost approximately $390 million and take about 38 months to complete, whereas constructing a new Titan IV launch site would cost about $726 million and take about 6 years to complete. OSD officials told us that the estimates for converting VLS to Titan IV and for constructing a new Titan IV launch site were $441 million and $565 million, respectively, as of April 1988. The Air Force plans to begin constructing the new Titan IV launch complex in fiscal year 1989, with the initial launch in 1994. A Space Division official stated that converting the VLS launch pad to a Titan IV launch site could preclude launching the Advanced Launch System from that site.

Recent Congressional Action, Conclusions, and Recommendation

Recent Congressional Action and Conclusions

The decision to place VLS in low-level maintenance seemed reasonable after the cancellation of the 1992 shuttle launch from VLS, since there is no scheduled use of the facility by the shuttle for the foreseeable future. However, the cost and technical and schedule risk of reactivating VLS for a shuttle launch will continue to grow throughout the time VLS remains nonoperational. In addition, VLS' future role as a shuttle launch facility is unclear because of (1) the actual and potential limits to the shuttle's current and future lift capability at VLS and (2) the Air Force's increased planned use of expendable launch vehicles at Vandenberg, including an upgraded Titan IV with the required lift.

VLS' future needs to be decided, and that decision should not be permitted to languish. Timely consideration is necessary because VLS' facilities, equipment, and systems will become increasingly more difficult and expensive to recapture and update to current launch requirements, and the cost to reactivate VLS for the shuttle could be extremely expensive, if not prohibitive, in just a few years.

If VLS is not to be preserved for future shuttle use, an assessment and selection of an appropriate alternative should be made. On the other hand, if VLS is to be preserved for shuttle use, a cost-effective reactivation schedule should be developed. Its development should include a reassessment of the Air Force's direction that VLS be reactivated within 4 years. This direction has high schedule and technical risks, and pressing to meet the time frame, even though there are currently no VLS shuttle launch requirements that dictate a 4-year reactivation, could increase costs and/or safety problems.

In its May 4, 1988, report on the fiscal year 1989 defense authorization bill, the Senate Committee on Armed Services said there is the need for a thorough review of the prospects for future use of the shuttle by DOD before any actions are taken that would preclude DOD's use of the shuttle from either coast after 1995. Consequently, the Committee directed the Secretary of Defense to request the Defense Science Board to review DOD space launch requirements in the mid- to late 1990s to determine whether the shuttle should be included in the array of space launch vehicles for DOD. The Committee noted that the Board's review should include assessments of (1) performance and availability of the shuttle for DOD payloads and (2) alternatives for disposition of VLS. In July 1988 the conference committee on the fiscal year 1989 authorization bill endorsed this requirement.

By properly implementing this requirement, DOD should satisfy the need for timely consideration of VLS' future, and for a thorough assessment of alternatives if it is not to be preserved for shuttle use. Therefore, we are not making any recommendations on these matters. However, if it is decided that VLS will be preserved for the shuttle, DOD would still need to establish a cost-effective reactivation schedule based on its new initial launch date.

Recommendation

We recommend that the Secretary of Defense direct the Air Force to develop a cost-effective reactivation schedule if VLS is to be preserved for shuttle use.

*U.S. G.P.O. 1988-201-749:80207

Requests for copies of GAO reports should be sent to:

U.S. General Accounting Office
Post Office Box 6015
Gaithersburg, Maryland 20877

Telephone 202-275-6241

The first five copies of each report are free. Additional copies are $2.00 each.

There is a 25% discount on orders for 100 or more copies mailed to a single address.

Orders must be prepaid by cash or by check or money order made out to the Superintendent of Documents.

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