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BY THE COMPTROLLER GENERAL

Report To The Chairman, Committee On Government Operations House Of Representatives OF THE UNITED STATES

Implications Of Joint NASA/DOD Participation In Space Shuttle Operations

The space shuttle's emergence as the single launch system for all U.S. spacecraft, civilian and military, has required increased NASA participation in military space operations.

Separate civilian and military space programs have been the topic of substantial debate within NASA, DOD, and the Congress in recent years. The debate has focused on the economies of a joint NASA/DOD space program and the effect that joining the civilian and military space programs will have on the missions of each agency. Advocates of increased cooperation between NASA and DOD argue that this arrangement is economical and efficient. Opponents object to mixing different agency missions and objectives.

This report discusses issues related to joint NASA/DOD space activities and makes recommendations to address these issues.

GAO/NSIAD-84-13
NOVEMBER 7, 1983

COMPTROLLER GENERAL OF THE UNITED STATES
WASHINGTON D.C. 20548

B-205335

The Honorable Jack Brooks
Chairman, Committee on
Government Operations
House of Representatives

Dear Mr. Chairman:

Pursuant to your request of June 8, 1982, we are providing our assessment of joint NASA/DOD participation in space shuttle operations and Air Force activities concerned with developing and acquiring a dedicated Department of Defense shuttle operations control facility. You were concerned that both our military and civilian space programs have the technology and expertise needed to effectively achieve national goals and objectives. This report presents our findings and recommendations regarding your concerns.

As arranged with your office, unless you publicly announce its contents earlier, no further distribution of this report will be made until 30 days from the date of the report. At that time we will send copies to the Administrator of NASA, the Secretary of Defense, and make copies available to others on request.

Sincerely yours,

Charles A. Bowsher

Comptroller General
of the United States

COMPTROLLER GENERAL'S
REPORT TO THE COMMITTEE ON
GOVERNMENT OPERATIONS
HOUSE OF REPRESENTATIVES

IMPLICATIONS OF JOINT NASA/DOD PARTICIPATION IN SPACE SHUTTLE OPERATIONS

D I G E S T

For the past 25 years, in keeping with the National Aeronautics and Space Act of 1958, separate civilian and military space programs have been developed. This separation has been periodically examined and reaffirmed by several high-level policy reviews--each concluding that the different mission characteristics of each program justified the distinct institutional structures that had been developed. These reviews also affirmed that interprogram relations should be continually scrutinized and that opportunities for cooperation should be sought.

In 1972, the President authorized the National Aeronautics and Space Administration (NASA) to develop a reusable spacecraft for transporting satellites to and from space. The space shuttle, which achieved its first operational flight in November 1982, was planned to be a "national" program, and as such, required that NASA and the Department of Defense (DOD) work together to define system and operational characteristics suitable for both agencies.

DOD's evolving space exploitation requirements and needed security emphasis have focused congressional attention on the traditional separation of civil and military space initiatives, as it affects the overall direction of the civilian program. This is particularly important because new capabilities developed under civilian initiatives will likely be adopted for use by the military, thus requiring further NASA/DOD interaction.

Tear Sheet

GAO/NSIAD-84-13
NOVEMBER 7, 1983

GAO did this evaluation in response to a request from the Chairman, House Committee on Government Operations. GAO was asked to focus its efforts on assessing (1) the effect on United States civilian activities by the expanding relationships between NASA and DOD as they relate to space shuttle operations and management and (2) DOD's justification and acquisition approach for a separate Shuttle Operations and Planning Complex. (See p. 5.)

RESULTS OF GAO REVIEW

The Space Act of 1958 established mechanisms, such as the civilian-military liaison committee and the National Aeronautics and Space Council, for interagency coordination on space related matters and development of a comprehensive space program. However, oversight continuity provided for by these mechanisms was interrupted when the committee was abolished in 1965 and the Space Council was abolished in 1973. Their functions were replaced by various ad hoc review groups to develop policy on space matters. To help reestablish an oversight mechanism to provide guidance for space programs, the Office of Technology Assessment, in June 1982, recommended that the Congress should consider reestablishing a mechanism similar to the disbanded National Aeronautics and Space Council. GAO believes that the recommendation is valid. (See pp. 1 to 3 and 14.)

With the advent of the space shuttle, a trend developed toward increasingly integrated NASA/DOD operations. This closer relationship has been formalized by Memoranda of Understanding and indicates that further integration may occur. (See pp. 3 and 4.)

GAO findings concerning the extent of NASA/DOD integration and efforts to establish a separate military Shuttle Operations and Planning Complex are discussed below.

NASA's involvement:

--Interprogram relationships are complicated by the different missions and objectives of the two agencies. This is particularly true considering DOD's requirements for classified operations. (See pp. 7 and 8.)

--A large portion of the cost burden for many military shuttle requirements is being borne by NASA. Its shuttle funding request for fiscal year 1983 was $3.4 billion of which $1.1 billion could be related to DOD needs. DOD's fiscal year 1983 shuttle funding amounted to $581 million. (See pp. 8 to 10.)

--In the shuttle operational era, extensive, long-term NASA support to DOD will be required for launch and landing operations, tracking and data acquisition services, and backup to DOD mission control systems. (See pp. 10 and 11.)

--While NASA's support to DOD is growing, the civilian program's future direction is not clear in that the future shuttle operations organization is undecided and overall civilian space goals are still being defined. (See pp. 11 to 15.)

DOD's shuttle requirements:

--DOD's shuttle operations concept has evolved from a "payload delivery" mode similar to that of the expendable launch vehicle era, to a "full exploitation" mode taking maximum military and security advantage of the shuttle's unique capabilities. This, in turn, makes the payload/shuttle interfaces and overall mission control

much more complex and thus there is the likelihood of a closer relationship with NASA. (See pp. 16 and 17.)

--DOD's security requirements for military space operations have required extensive modifications to NASA facilities to support classified missions. These modifications have increased as DOD's shuttle operations concept has evolved. (See pp. 17 to 19.)

--Security measures may create significant inconveniences and generally complicate support to NASA's civil, commercial, and foreign customers, and otherwise alter the characteristics of NASA's operations. (See pp. 19 to 21.)

DOD's justification for a Shuttle Operations and Planning Complex:

DOD, with NASA assistance, is in the initial phase of developing this facility which is intended to be used solely for military missions. The final implementation decision regarding computer systems for this facility is scheduled for the fall of 1984. The following information should be useful to DOD, NASA, and the Congress in reaching the final decision.

DOD justified its need for a separate complex on the vulnerability of Johnson Space Center (JSC); a requirement for higher levels of security than is being provided at JSC; a need for direct DOD control for military missions and a perception that JSC would not have the capacity to handle projected military missions. GAO found that:

--Presently, JSC is the single, vital element of shuttle mission planning and operations and is vulnerable to environmental and human

threats. However, this facility has not been seriously affected by an environmental threat (e.g., hurricanes) and actions are being taken to provide tighter physical security. (See pp. 23 and 24.)

--Military missions later in this decade will require more stringent security measures than are being provided by current JSC security modifications. Increased NASA and DOD interaction indicates a long-term JSC affiliation with military shuttle missions. Therefore, further security measures may be necessary to satisfy DOD needs. The JSC director has recognized the need for interoperable shuttle backup capability. The director advised DOD to be cautious in its approach to implement the Shuttle Operations and Planning Complex because NASA plans to reorganize its system and enhance shuttle capability to provide primary and backup shuttle control in case of serious incident. (See pp. 24 and 25.)

--Original Shuttle Operations and Planning Complex justification indicated there were no capabilities in existence to provide direct and exclusive military control of shuttle flight operations. However, current NASA/DOD agreements provide DOD with the necessary direct control of military missions. This control conceivably could be exercised from JSC. (See pp. 25 and 26.)

--DOD initially predicted that by the late 1980s, secure mission workloads will exceed the limits of JSC's secure system capabilities. However, NASA recently increased its projection of JSC capacity which should prompt DOD to reexamine its position on this issue. (See pp. 26 and 27.)

Cost and acquisition strategy for DOD's Shuttle Operations and Planning Complex:

Current estimates of escalating Shuttle Operations and Planning Complex development costs and system design options being considered could reduce DOD's mission effectiveness. GAO found that:

--Escalation of Shuttle Operations and Planning Complex development costs from $739 million to over $1 billion have required DOD to reduce planned capabilities for this facility. This will most likely result in increased support from JSC which could further reduce the distinction between civil and military space activities. (See pp. 28 to 30.)

--Current computer system implementation plans for the Shuttle Operations and Planning Complex indicate that developing computer hardware capability equivalent to JSC's current systems and duplication of JSC software is a contractor option. If this option is chosen, GAO believes that (1) duplication of JSC software will not satisfy DOD's space mission requirements such as the need to interface with other DOD organizations and more complex shuttle payload/operations, (2) contractor competition may be restricted, and (3) costly DOD system upgrades will eventually be needed. (See pp. 30 to 33.)

CONCLUSIONS

Increased interaction and integration of NASA and DOD space activities will blur the distinction between civilian and military programs. Retaining separation of these programs has been the topic of substantial debate in recent years. Advocates of increased agency cooperation argue that this arrangement is economical and efficient.

Opponents object to mixing different agency missions, goals, and objectives because any expansion of NASA's role in military space activities would run the risk of compromising the open nature of the United States civil program. While NASA and DOD have presented their separate plans to the Congress for the shuttle, these have not reflected a sufficiently coordinated approach. A joint effort by NASA, DOD, and the Congress will be required to resolve these issues and to decide upon the appropriate degree of separation between the civil and military space programs. (See p. 34.)

The final decision on the need for a separate military shuttle control capability should take into account current information, discussed in this report, that indicates DOD's initial concerns about the use of NASA's JSC may be alleviated, to a large extent, by pending NASA actions to enhance its shuttle control capability. Also, if a decision is made to implement a separate military shuttle control facility according to DOD's current acquisition strategy, it may result in a system not fully capable of satisfying DOD requirements. (See p. 34.)

RECOMMENDATIONS

The issues discussed in this report should assist the Congress in focusing its attention on the manner of interaction and degree of separation needed between the civil and military space programs. In this regard, GAO recommends that the Administrator of NASA, in consultation with the Secretary of Defense, assist the Congress by expediting efforts to define how a fully operational shuttle program will be managed and controlled in the future. Such a definition should include (1) agency roles and responsibilities, (2) performance criteria for the shuttle system which clearly define both the defense and civil capabilities

and interoperability requirements, and (3) alternatives for providing backup capability for the DOD space program. (See p. 35.)

GAO also recommends that the Secretary of Defense direct the Air Force to

--defer implementation of the Shuttle Operations and Planning Complex until NASA and DOD identify the systems configuration needed to support a fully operational shuttle system and

--establish and validate functional system requirements which accurately reflect DOD's "full exploitation" operational concept, taking into consideration the eventual shuttle operations system configuration. (See p. 35.)

MATTERS FOR CONSIDERATION BY THE CONGRESS

Because of the rapidly developing interdependence between NASA and DOD, GAO believes that the Congress should consider requiring the reestablishment of a mechanism similar to the disbanded National Aeronautics and Space Council, as discussed in the Office of Technology Assessment report, to obtain high level attention to space matters and achieve balanced agency interaction.

AGENCY COMMENTS

GAO did not obtain agency comments on the matters discussed in this report. However, issues in the report were discussed with responsible agency officials.

Contents

ABBREVIATIONS

CSOC	Consolidated Space Operations Center
DOD	Department of Defense
GAO	General Accounting Office
JSC	Johnson Space Center
NASA	National Aeronautics and Space Administration
NCC	Network Control Center
SOPC	Shuttle Operations and Planning Complex

CHAPTER 1

INTRODUCTION

At the request of the Chairman, House Committee on Government Operations (see app. I, p. 36), we assessed the evolution and effects of the increasing participation by the National Aeronautics and Space Administration (NASA) in military space operations. Additionally, we evaluated NASA's and the Department of Defense's (DOD's) efforts to enhance the space shuttle's use through major facility upgrades and systems acquisitions. This report describes our response to the Chairman's request.

BACKGROUND

To provide a foundation for later chapters, this section synopsizes the major policies and decisions leading to joint NASA/DOD participation in space shuttle operations. It briefly discusses the United States space program's founding legislation and resulting institutional structure; pertinent policy reviews, presidential directives, and interagency agreements regarding shuttle activities; and major issues concerning current NASA/DOD relationships which have been the subject of congressional debate.

Founding legislation and resulting institutional structure

The basic institutions and policy principles for United States space activities were established in the National Aeronautics and Space Act of 1958 (Public Law 85-568). A key principle of the Act is that civilian and military space activities are to be separated. However, those activities also are to be coordinated to avoid unnecessary duplication of effort and expenditure.

The Act provided for program separation by creating an independent civilian agency (NASA) to exercise overall control of United States aeronautical and space activities, except for those peculiar to or primarily associated with weapons development, military operations, and the national defense. However, it is also one of the objectives of the Act that civilian and military agencies share information about their respective discoveries with each other. The Act also provided two mechanisms for coordinating government agency space activities, which were subsequently abolished by reorganization plans.

First, the Act established a civilian-military liaison committee, headed by a Chairman appointed by the President, and composed of representatives from DOD and each of the three military departments and NASA. The committee was to be the vehicle through which NASA and DOD would consult and keep each other informed about matters relating to aeronautical and space activities. It also was to serve as a vehicle for resolving any interagency disputes. The committee was abolished and its functions transferred to the President under Reorganization Plan Number Four of 1965.

Second, effective and continuing high level interagency coordination was to be provided by the National Aeronautics and Space Council, chaired by the Vice President and consisting of the Secretaries of State and Defense, the Administrator of NASA, and the Chairman of the Atomic Energy Commission. The Space Council was given the responsibility for developing a comprehensive program of aeronautical and space activities to be done by departments and agencies of the United States government and in case of conflict to advise the President in determining which agency (NASA or DOD) would be responsible for an activity. The council and its functions were abolished under Reorganization Plan Number One of 1973.

In explaining congressional intent for dividing responsibility between NASA and DOD, the conference committee on the Space Act of 1958 reported that the separate civilian and military activities "should be so conducted as to avoid unnecessary duplication of effort and expenditure." The committee recognized that "there is a gray area between civilian and military interests, and unavoidable overlapping" and acknowledged that certain projects "may be determined to be of sufficient joint interest to be conducted cooperatively." In this regard, the committee reported that machinery was needed at the highest level of government to decide responsibility and jurisdictional disputes. Both the civilian-military liaison committee and the Space Council, provided for by the Space Act, were to serve this purpose, but as mentioned above, were subsequently abolished.

Division of responsibilities between NASA and DOD generally evolved in a manner consistent with the Space Act of 1958. For example, NASA has been the launch operations manager for the civil sector, including foreign launches, while the Air Force has served similar functions for the national security sector, including foreign defense system launches. Both agencies have developed and currently maintain separate launch sites, control centers,

communications networks, and associated facilities for doing their space operations.

Separate and distinct space programs have permitted NASA to conduct its activities in a free and open manner with maximum dissemination of information concerning its activities to the general public, scientific community, and foreign nations. At the same time, separation has allowed classified military programs to be done under stringent requirements to protect information, including the fact that some programs exist.

Significant changes are underway, however, which in effect integrate the launch operations of the civilian and military space sectors and substantially reduce program separation. The policies, directives, and agreements which have led to this situation are discussed below.

Shuttle related policy reviews, presidential directives, and interagency agreements

In 1969, a space activity review was carried out under the auspices of a presidentially appointed group. The group's efforts resulted in a 1972 presidential decision authorizing NASA to develop a reusable spacecraft, the shuttle, for transporting both civil and military payloads to and from space. This decision required that NASA and DOD work more closely together to define system and operational characteristics suitable for both agencies.

The broad policies and principles that govern interagency relationships relevant to shuttle development, acquisition and operation, were formally established on January 14, 1977, through a NASA/DOD Memorandum of Understanding. Under this agreement, NASA was given overall responsibility for shuttle development, and was to provide for flight planning, operations, and control for all flights regardless of the user or the launch or landing site used.

Although this agreement had been reached, stresses concerning shuttle operational control remained among the civilian and military space program sectors. As a result, presidential level policy reviews were made during 1978-79 to resolve these conflicts and to recommend coherent space principles and national space policy. These reviews, done under the National Security Council policy review process, resulted in three classified presidential

directives which addressed civilian and military relationships and overall civilian space policy. They reiterated the need for separate and distinct civilian and military programs, but did not establish specific goals and objectives for the civilian program.

After the 1978-79 policy reviews, the NASA/DOD Memorandum of Understanding was modified in March 1980 to increase DOD's participation in shuttle operations. Key points of this agreement are that (1) DOD will have priority in mission preparation and operations consistent with established national space policy, (2) certain missions will be executed from Johnson Space Center (JSC) by DOD mission and flight directors through the Air Force chain of command, and (3) DOD, using NASA assistance, will develop the capabilities and the facilities from which to plan and control military missions. The current administration's space policy, issued on July 4, 1982, established the renegotiated Memorandum of Understanding as the national policy concerning shuttle activities.

Major issues surrounding current NASA/DOD relationships

The shuttle, which achieved its first operational flight in November 1982, has fostered increasing NASA/DOD interactions, thus changing past agency relationships. Shuttle operations bring unclassified civilian and classified military payloads into the same stream of activities. Therefore, major DOD procedural, facility, and system modifications are required at NASA's centers to ensure that adequate protection is provided to sensitive military information and systems.

DOD's evolving space exploitation requirements and needed security modifications have focused congressional attention on the traditional separation of civil and military space initiatives, as it affects the overall direction of the civilian program. This is particularly important because new capabilities developed under civilian initiatives will likely be adapted for use by the military, thus requiring further NASA/DOD interaction. This trend provides several advantages, such as giving DOD full access to NASA's experience base and potential for decreasing overall project costs. It has also raised other issues, such as the

--inconsistency between DOD's security requirements and NASA's traditional open mode of operation,

--effect of military activities on NASA's civilian research and development focus,

--effect of merging possible different agency missions and objectives, and

--possibility that special DOD system configurations may be unsuitable for general purpose civil usage or that unique military needs for ensured access to space in time of crisis and conflict may be impaired.

OBJECTIVES, SCOPE, AND METHODOLOGY

The Committee Chairman requested us to determine

--whether the Air Force's plans to "replicate" the JSC's computer capability at Colorado Springs, Colorado, have been fully justified;

--if a combined center is truly needed since DOD and NASA are planning on handling classified missions in any case over the next 4 to 5 years;

--the cost and benefits of duplicating a capability at Colorado Springs which already exists at JSC;

--the justification for acquiring sole source, a limited capability that may not meet the requirements of a modern space mission; and

--why the Air Force could not competitively acquire commercial state-of-the-art technology to meet mission needs.

Additionally, we were requested to assess the extent to which the Air Force, as DOD's executive agent, plans to replicate NASA functions worldwide and the justification for doing so.

In developing the scope of our work, we met with the Committee's staff. At that time, they asked us to focus our effort on assessing (1) the effect on United States civilian space activities by the expanding relationships between NASA and DOD as they relate to space shuttle operations and management and (2) DOD's justification and acquisition approach for a separate Shuttle Operations and Planning Complex (SOPC). To

effectively address these issues, it was necessary to analyze the national space policy and to evaluate the adequacy of its implementation by both NASA and DOD.

During the course of our work, we briefed the Committee's staff on our tentative response to the Chairman. Based on information provided to the staff concerning the justification for SOPC, we were told that the cost-benefit analysis originally requested by the Chairman would no longer be required.

In doing our evaluation, we attended briefings, toured facilities, did interviews, and analyzed documents obtained from NASA and Air Force officials cognizant of these matters. This was accomplished at the respective NASA/DOD Headquarters, centers, and command levels. We also reviewed our past reports on NASA and Air Force space operations, as well as studies done by the Office of Technology Assessment and the Congressional Research Service. The Office of Technology Assessment's June 1982 report entitled Civilian Space Policy and Applications was particularly valuable since many issues it raised were pertinent to the Committee Chairman's request.

This review was made in accordance with generally accepted government auditing standards. We did not obtain agency comments on the matters discussed in this report. However, issues in the report were discussed with responsible agency officials.

Our other recent reports relating to NASA/DOD shuttle activities are listed in appendix IV, page 43 of this report.

CHAPTER 2

NASA INVOLVEMENT IN MILITARY SHUTTLE OPERATIONS

The 1958 Space Act's key principle of separate civilian and military space programs has guided and influenced United States space activities for the past 25 years. Successful space shuttle development, however, has brought about increased NASA/DOD interaction.

SPACE SHUTTLE PROGRAM INCREASES AGENCY INTERACTION

The space shuttle was planned to be a "national" program serving civil and military needs. The major premise underlying this designation was that such a substantial investment in a new technological capability could not reasonably be made unless it served the broadest national objectives. This arrangement required NASA and DOD to jointly define a common acceptable payload bay size, operating characteristics, and compatible subsystems. Consequently, the shuttle was a catalyst for agency integration that has led to complex management and budget relationships which will probably be long term.

When NASA was directed to build the shuttle, it was also delegated authority for overall management responsibility, including operational control of all missions. In addition, it was given responsibility for the development and acquisition of shuttle flight hardware, launch and landing facilities at Kennedy Space Center in Florida, and flight planning and control facilities at JSC in Texas. Tracking and data acquisition services are also primarily NASA's responsibility.

The Air Force, as DOD's executive agent, was directed to define military requirements and otherwise participate to ensure the effectiveness of military missions. Additionally, it was charged with developing an inertial upper stage[1] for use by both agencies to deploy payloads from shuttle orbit into higher orbits; developing and operating launch and landing facilities at Vandenberg Air Force Base in California, and specifying and funding security modifications needed at NASA's centers.

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[1]A program to develop rocket boosters to launch payloads from shuttle orbit into higher orbits.

Interprogram relationships

Increased interaction resulting from shuttle development and operations is complicated by the different missions, goals, and objectives of the two agencies. For example, NASA's primary mission is the development and demonstration of space and aeronautics systems and associated technology, the provision of launch services, and the operation of research and scientific satellites. While these activities are linked to the requirements of various users, NASA's primary emphasis has been on developing new technologies rather than meeting short-term user needs.

DOD's space activities, on the other hand, have some technology advancement characteristics, but are primarily responsive to operational military requirements. DOD has a vital, immediate mission--national defense--and space technology is seen as one means, among others, for accomplishing it.

In addition to mission differences, close agency interaction is further complicated by different information disclosure policies. The 1958 Space Act requires that information concerning NASA's activities be given ". . . widest practicable and appropriate dissemination of information concerning its activities and the results thereof." This contrasts with restrictions governing the disclosure of information relating to classified military programs, which often must operate under stringent security requirements.

These mission differences and information disclosure requirements assume additional importance when considering the probability that future manned space flight initiatives will require the continued coordination of NASA and DOD efforts. For example, if a decision is made to proceed with a space station development, it will probably be required to serve the same broad national objectives as the shuttle. This again will raise issues concerned with separating civilian and military operations, creating joint management structures, and providing adequate long-term funding. Issues regarding funding were particularly prevalent during the shuttle's development.

Shuttle costs

For fiscal years 1971 through 1983, shuttle funding has amounted to about $21 billion. NASA, as the shuttle developer, has predominantly borne the cost burden. This included research, design, development, production, test and evaluation, and space

flight operations amounting to about $18 billion or 86 percent of total funding. As the major post-Apollo era program, the shuttle has dominated NASA overall program and funding requests. Consequently, this has restricted NASA's ability to engage in many other civilian space related projects.

DOD's shuttle related costs for this same period amounted to about $2.8 billion or 14 percent of total funding. DOD is developing those aspects for which it was directly responsible, namely, an inertial upper stage capability for boosting shuttle payloads into higher orbit, launch pad construction at Vandenberg Air Force Base, and some limited shuttle operations capability.

The following table summarizes shuttle funding distribution for fiscal years 1971 through 1983.

Shuttle Funding Distribution[a]

FY	NASA	Percent	DOD	Percent	Total
	----------(millions)----------				
1971-1980	$ 8,764	88	$ 1,239	12	$10,003
1981	2,679	85	491	15	3,170
1982	3,105	86	523	14	3,628
1983	3,468	86	581	14	4,049
Total	$18,016	86	$ 2,834	14	$20,850

[a]Source: Space Shuttle Issue Brief IB81175, Congressional Research Service, September 20, 1982.

This distribution of NASA and DOD costs appears to be generally in accordance with the distribution of responsibility previously discussed. However, analysis of NASA and DOD fiscal year 1983 budget requests in relation to the above table indicates (1) shuttle has and will continue to consume a substantial portion of NASA's budget and (2) a significant portion of NASA's recent funding is being used to satisfy DOD requirements. For example, NASA's fiscal year 1983 budget request totaled $6.6 billion, of which $3.4 billion (52 percent) was shuttle related.

In comparison, DOD's 1983 space budget totaled $8.5 billion unclassified funding, of which $581 million (6.8 percent) was shuttle related.[1]

We analyzed NASA's fiscal year 1983 budget request and in April 1982[2] reported that about $1.1 billion (31 percent) of NASA's shuttle budget could be extrapolated to be in direct support of DOD requirements. Considering DOD's direct shuttle contribution of $581 million, total shuttle funding for fiscal year 1983 amounted to about $4 billion, of which $1.7 billion (42 percent) is DOD related. Although DOD's percentage of shuttle cost contributions has remained relatively constant, as shown in the table on page 9, its need for integration has grown.

Potential long-term affiliation

DOD's shuttle requirements are such that program separation will be difficult in the years ahead. Although DOD is attempting to develop its own SOPC, continuing support will be required from JSC for payload integration activities, engineering support, scheduling, logistics, and mission control backup. Furthermore, even with a DOD dedicated mission control capability in place of JSC, continued support from NASA will still be necessary in other areas for the shuttle's operational life. Primary among these are launch and landing operations from Kennedy Space Center, and tracking/data acquisition services provided by Goddard Space Flight Center facilities.

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[1]An additional $116 million of fiscal year 1983 funds were budgeted for Consolidated Space Operations Center (CSOC) development. This is a proposed DOD facility for conducting military operations in space. As currently being planned by the Air Force, it is supposed to consist of a Satellite Operations Complex and a SOPC, with the eventual addition of other satellite mission control complexes. Including these funds, which are not considered by DOD to be shuttle related, would raise DOD's shuttle funding to 8.2 percent of their total space budget.

[2]Analysis of NASA's Fiscal Year 1983 Budget Request for Research and Development to Determine the Amount That Supports DOD's Programs (MASAD-82-33, Apr. 26, 1982).

Operations at Kennedy Space Center involve preparing the shuttle for launch, processing and integrating upper stages and payloads, and installing cargo in the orbiter bay. In addition, a firing room monitors and controls these activities as well as launch operations. Goddard will be the primary source of shuttle communications and tracking services through its Tracking and Data Relay Satellite System and NASA Communications Network. While the Air Force is also modifying its Satellite Control Facility tracking stations to handle shuttle communications, this, according to Air Force officials, only constitutes a backup to NASA and is not intended to provide full operational support capabilities.

While NASA's involvement in military space operations is growing, the direction of its future civilian activities is currently unresolved. Issues regarding the civil program's direction are discussed below.

CIVIL PROGRAM DIRECTION

Now that shuttle development is for the most part completed, NASA must decide how to efficiently operate the shuttle system and what major new programs should be pursued.

Future shuttle operations structure

Since the mid-1970s, NASA has explored various alternatives for managing an operational shuttle. A 1976 Aerospace Corporation review identified seven options and stressed the need for an early decision. These included:

--Evolving the traditional NASA research and development organizations into an operational organization.

--Separating the shuttle organization from NASA's normal research and development organization.

--Having a contractor perform all day-to-day operations (including mission planning, launch operations, etc.) under NASA's guidance and purview.

--Establishing a governing board of NASA and DOD representatives to manage all shuttle operations.

--Shifting operational responsibility to a new federal agency when the shuttle achieves a reasonable level of maturity.

--Establishing a quasi-public corporation to manage shuttle operations.

--Selecting a commercial organization to manage and perform all operational functions.

As part of this study, several top level NASA managers were asked about NASA's future involvement in shuttle operations. These officials generally felt that NASA should divest itself of any major operational role to (1) reduce costs, (2) prevent DOD restrictions on NASA activities, (3) ensure fair treatment of the user community, and (4) avoid possible unfavorable congressional reactions toward NASA having a large operational organization.

In 1977, NASA requested the National Academy of Public Administration to study the possible organizations for shuttle operations management. This review concluded that economic factors precluded private or mixed shuttle ownership for the near term and that as long as federal agencies were the prime system users, then federal ownership and control were appropriate. In this regard, the study specifically concluded that NASA should manage the operational shuttle at least for the near term because NASA and DOD would be the major users, and funding and management would be simplified.

This study cautioned, however, that DOD requirements could be expected to have a considerable effect on determining the kind of space transportation organization which would be effective in the 1980s. It specifically pointed out that:

> ". . . the Shuttle represents a maneuverable, manned vehicle, thus offering to the Department of Defense a capability not previously available. . . . the history of military technology suggests that it is prudent to anticipate the possibility of major change. That is, out of Defense R&D [research and development] there may emerge some space application which offers important, perhaps even critically important, contributions to national defense. The support which Defense will need from the STO [Space Transportation Organization] thus might change, and perhaps greatly."

Our review disclosed that these predicted changes are in fact taking place. These are discussed in more detail in chapter 3.

Current national space policy, issued on July 4, 1982, provides that for the near term (3 to 5 years), the shuttle will continue to be managed and operated in an institutional arrangement consistent with the current NASA/DOD Memorandum of Understanding. This, in effect, is an evolving partnership, highlighted by: the infusion of DOD personnel into functional line management positions within NASA and major facility upgrades and modifications for security purposes at NASA locations. Although the policy directs that flexibility to transition into a different institutional structure be maintained, this may not be feasible, particularly in the near term, given current program initiatives.

Overall civilian space goals

In recent years, congressional committees have been concerned about the lack of clearly defined space goals to restore a sense of purpose and commitment to the civilian space program. For example, the Subcommittee on Space Science and Applications of the House Science and Technology Committee, in April 1981, recommended that

--NASA propose to the Congress a set of long-term goals reflecting a balance between space science, applications, and space transportation activities;

--the administration commit to a major, high-challenge space engineering initiative, such as a multipurpose space operating base;

--NASA undertake studies to analyze the economic benefits of space activities; and

--the administration reaffirm the need for separate military and civilian space programs, and that the budgets for each be examined separately and adjusted according to the requirements for each program.

In this regard, the presidential space policy directive issued on July 4, 1982, was intended to address space goals over the next decade. This document outlined general goals for civil and military space programs such as

--strengthen the security of the United States,

--maintain United States space leadership,

--obtain economic and scientific benefits through the exploitation of space,

--expand the United States private sector investment and involvement in civil space and space related activities,

--promote international cooperation activities in the national interest, and

--cooperate with other nations in maintaining the freedom of space.

The directive also reaffirmed that United States space activities will continue as two separate, distinct programs for civil and military purposes. These, however, are to be strongly interacting programs with close coordination, cooperation, and information exchange to avoid unnecessary duplication. The directive did not specify concrete boundaries or assign specific responsibilities between programs.

Past oversight mechanisms such as the civilian-military liaison committee and the National Aeronautics and Space Council which did provide continuous high level attention to space policy and interprogram coordination matters have been previously abolished. To help reestablish an oversight mechanism to provide guidance for space programs, The Office of Technology Assessment recently recommended in its June 1982 Civilian Space Policy and Applications report that the Congress should consider reestablishing a mechanism similar to the disbanded National Aeronautics and Space Council as a means of again providing continuous high level attention to space policy and interprogram coordination matters.

This recommendation appears to be valid for the following reasons. First, constrained budgets have forced NASA to scale back significant new civil space initiatives, while at the same time DOD's space budget has grown. Second, the two programs serve differing purposes which complicate strong cooperative interaction. For instance, whereas NASA is to emphasize its openness, most DOD space activities are kept under tight security. Also, where NASA has an obligation to pursue international cooperation, DOD is charged with protecting the national security

of the United States and must be prepared for shifts in the international situation. Finally, our past experience with evaluating DOD systems indicates that defense requirements are evolutionary in nature, can expand rapidly as programs proceed, and as a result, place increased demands on supporting organizations, which in NASA's case could mean continued difficulty maintaining a strong civilian program focus.

CHAPTER 3

DOD'S SHUTTLE REQUIREMENTS

A unique shuttle feature is that humans are an integral system component, required for its successful operation. In addition to payload deployments, they must be available to do experiments, recover payloads for return to earth or to repair and refurbish them in orbit. Once these operations go beyond payload deployment, close interaction is required between the whole shuttle crew, mission control centers, and payload control centers. Further, the increased complexity of these operations mandates more planning, additional training, and enhanced ground control to ensure mission success. DOD's evolving shuttle operations concept and its associated security requirements will necessitate a closer NASA/DOD relationship.

EVOLVING MILITARY OPERATIONS CONCEPT

DOD initially developed an operational concept that primarily used shuttle in a "payload delivery" mode similar to the expendable launch vehicles it was replacing. It was believed that this operational mode would substantially lessen the need for dedicated DOD support facilities, such as mission control centers, and would, for the most part, eliminate the possibility of NASA becoming intimately involved in critical and sensitive military operations.

However, as shuttle development proceeded and significant milestones were passed, a restructured DOD approach, known as the "full exploitation" concept, evolved from recognition that continuation of a payload delivery operational concept was no longer a preferred strategy. According to DOD documents, this was decided from (1) a cost efficiency viewpoint if the United States is to extract maximum benefit from the billions of dollars invested in the shuttle program and (2) an effectiveness viewpoint recognizing that the nation is increasing its use of the space medium, and is therefore depending more on satellite systems as key instruments of national security. These decisions were supported by several classified studies done in the 1978-79 time frame.

DOD's decision to fully exploit shuttle capabilities and associated increases in shuttle mission control interaction necessitated significant changes concerning operational roles and responsibilities and security requirements. For example, before

implementing DOD's full exploitation concept, NASA was to have full responsibility for all shuttle flights, both civil and military, including their planning, management, integration, flight operations, and control. However, these roles were altered through a March 1980 renegotiated NASA/DOD Memorandum of Understanding increasing DOD's control over shuttle flights made from NASA facilities. Major points in this new agreement regarding operations at JSC are that

--DOD will have priority in mission preparation and operations consistent with established national space policy,

--certain DOD missions will be specified as "Designated National Security Missions" and will be executed by DOD Mission Directors and Flight Directors who will exercise operational command and control through the Air Force chain of command, and

--DOD personnel will be integrated into NASA line functions to develop the capability to carry out military missions.

In addition to these changes, DOD's full exploitation concept created the need for increased security modifications at NASA locations.

SHUTTLE RELATED SECURITY REQUIREMENTS

Shuttle operations are supported by an extensive network of NASA facilities and systems located at centers throughout the world. All were originally developed without the need for rigid security and have generally operated in an open environment with maximum public exposure. This has allowed NASA to freely provide the widest practicable and appropriate dissemination of information on the results of its activities. However, since NASA must now support all DOD shuttle operations, portions of its activities can no longer be done in this open environment.

Baseline security modifications

Security at NASA facilities first became an issue in April 1976 when it was decided that dedicated DOD facilities for shuttle operations would be cost prohibitive. This led to an interagency study to identify shuttle minimum essential

security requirements. It was completed in 1977 and stipulated that Secret was the highest classification level needed to protect shuttle missions involving DOD payloads and recommended that NASA and DOD work together to satisfy their respective requirements to the maximum degree possible within existing and programmed facilities.

Taking these views into account, an Ad Hoc Shuttle Security Group was formed by the Aeronautics and Astronautics Coordinating Board[1] to reassess the security problem and endeavor to select a mutually acceptable low cost approach allowing JSC support of classified missions. The group's report, issued in late 1977, formed the basis for NASA's current baseline security capabilities by endorsing the "Controlled Mode" approach at JSC. Later, in 1980, similar studies were completed by NASA regarding security modifications needed at the Kennedy Space Center (eastern launch site) and the Goddard Space Flight Center (provider of tracking and data acquisition services).

The Controlled Mode and other baseline modifications generally involve common facilities shared between NASA and DOD in accordance with DOD security guidelines. Support systems within these facilities consist of both dedicated equipment and equipment with isolation devices (either manual or software switches) installed where required to allow for the separation of unclassified NASA and classified DOD data. Security protection is certified up to the Secret level.

This approach, based on the payload delivery concept, was expected to provide adequate security with least cost by using generic training and standard missions to minimize the exposure of classified information and otherwise minimize the effect of having classified data at JSC. In addition, it was DOD's intention to separate payload and shuttle operations, thus lessening the need to protect shuttle information. DOD representatives now believe, however, that by knowing specific characteristics of the shuttle, relative to a given mission, an adversary could reasonably deduce

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[1]The Aeronautics and Astronautics Coordinating Board was established by interagency agreement on September 13, 1960, as a joint NASA/DOD body responsible for planning activities to avoid undesirable duplication, coordination of common interest activities, problem resolution, and information exchange.

--the payload's general size and sometimes shape,

--that an upper stage is used,

--whether single or multiple payloads are on board, and

--that a payload is to be deployed or flown attached.

Moreover, DOD representatives believe that combining these types of information, particularly after several repeat flights, could yield military program deployment strategies, mission objectives, and vulnerabilities.

Consequently, in May 1982, DOD established a comprehensive shuttle era security concept to protect the status of the national security space force. Key factors of this concept are to (1) use shuttle to blur the distinction among DOD programs and (2) protect the revealing details of DOD system deployment and operations by classifying direct signatures, such as orbiter configuration, and applying operational security procedures to control other indicators. In effect, this policy requires that all DOD launches[1] using shuttle be classified, and thus mandates further upgrades to NASA facilities to accommodate this approach. For example, in addition to the current security baseline, which primarily secures operational support systems, many Air Force recommended upgrades concern widely distributed NASA general information management system's supporting functions such as accounting and logistics. Additionally, Air Force officials have indicated that even further upgrades may be warranted in the future, as operating roles are clarified.

Security may affect civilian support

Although secure operating experience is not yet completely available, DOD's security measures could create inconveniences and generally complicate support to NASA's civil, commercial and foreign customers, and otherwise alter the characteristics of today's open NASA operations. This will be particularly true when mixed payload operations (where unclassified civil payloads and classified DOD payloads share the same shuttle

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[1]Exceptions have been granted for DOD's Global Positioning System when mixed on NASA flights.

flight) become a common occurrence. Under these conditions, information concerning all shuttle activities, including those affecting non-DOD payloads, could be classified and thus denied to uncleared civil users. Without access to information such as (1) crew activity plans, (2) on-orbit mission time lines, (3) launch window length and constraints, (4) angle of inclination, and (5) shuttle altitude data, and so forth, prelaunch and on-orbit mission planning and scheduling for civil payloads could be adversely affected by DOD's requirements. Also, contingency operations requiring real-time planning and problem resolution may become particularly difficult.

A specific area broadly affected by secure operations is Goddard Space Flight Center's tracking and data acquisition services. Goddard provides a wide range of supporting services to orbiting spacecraft, and more than other NASA centers, has extensive interfaces with the scientific community. Under current plans, these facilities will support all DOD shuttle operations, as well as some other operational DOD satellites.

The nucleus of these activities is Goddard's Network Control Center (NCC), which is comprised of a variety of data processing and display equipment, support and operational software, and mission control personnel. As the overall tracking and data acquisition management center, NCC provides:

--Real-time user interfaces: all operations control functions, including real-time or emergency scheduling, data monitoring and accountability, fault isolation, and troubleshooting, as well as testing and simulations involving network resources.

--Operations support: developing network support schedules, controlling changes to operational documentation, processing requests for information, and analyzing service performance.

--Standardized operations planning: standardization through common systems, software, procedures, and data interfaces to multiuser facilities at Goddard and other NASA operations centers and tracking facilities.

Traditionally, these NCC-type functions have been performed in a totally open environment allowing unclassified users access to scheduling, system status, and other necessary operational information. This helped effective operations in that users could freely work together to resolve scheduling conflicts and other anomalies, particularly during emergency situations requiring rapid support from unscheduled resources. Under secure operations, however, these interactions may be greatly constrained since much of this information will be classified and possibly denied to civil users. Instead, NCC personnel will have to negotiate conflicts with DOD for unclassified users, which could conceivably reduce the system's responsiveness and hamper civil support, particularly during contingency situations.

Considering DOD's growing reliance on NASA for support, and the extensive security modifications underway to help that support, long-term NASA and DOD interdependence is likely.

CHAPTER 4

DOD'S NEEDS REGARDING A SEPARATE SHUTTLE CONTROL FACILITY

To satisfy military needs for the space shuttle, DOD, with NASA's assistance, is in the initial phase of developing a shuttle operations and planning facility to support military missions.[1] This facility, according to DOD documents, is supposed to reduce the military's dependence on NASA, provide direct military control over DOD shuttle missions, and provide for a higher level of responsiveness during situations where national security is threatened. Although these factors appear to support the need for separate military control, NASA is studying modifications to its shuttle control facilities that could affect DOD's need for a separate shuttle operations and planning facility. The final decision regarding SOPC computer system implementation is currently scheduled for the fall of 1984. This chapter provides information that should be useful to DOD, NASA, and the Congress in reaching the final decision.

UNCERTAINTIES RELATED TO SOPC JUSTIFICATION

DOD's need for SOPC is based on several perceived JSC inadequacies concerned with planning and operating military shuttle missions. According to Air Force documents, SOPC is justified because

--JSC is a single, critical and vulnerable element of shuttle operations;

--a higher level of security than can be provided by the current JSC capabilities is needed;

--national policy and military doctrine require direct control of DOD shuttle operations; and

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[1]On January 29, 1982, we reported on the CSOC (MASAD-82-14), of which SOPC is a part. At that time, we expressed our reservations about beginning full-scale construction until operational requirements and associated costs were sufficiently defined.

--JSC will have insufficient capacity to handle DOD's projected shuttle missions.

Our evaluation of each of these concerns follows.

Vulnerability of JSC

Recent presidential directives on national space policy have contained requirements for secure, survivable systems that can meet DOD objectives for space operations. According to this direction, the SOPC element of CSOC was authorized after several studies by DOD and NASA concluded that a separate, DOD-operated shuttle control facility was desired to achieve DOD's requirements for security, autonomy, and survivability.

Presently, JSC is the single, vital element of shuttle mission planning and operations and is subject to certain environmental and human threats. For example, JSC is located in an area where flooding from hurricanes could conceivably cause significant damage to facilities and interruption of operations. Also, because JSC is generally open to the public and foreign nationals, it could be susceptible to various hostile acts such as sabotage. Therefore, DOD believes JSC is susceptible to loss of operations and that this could significantly disrupt the United States space operations.

Although environmental and human threats to JSC certainly exist, past experience indicates that operations at this facility have not been significantly affected by any such threat. Despite past experience and increased JSC security, the issue still remains that JSC is a single critical node in shuttle operations. This, in itself, gives DOD good reason to want an alternative shuttle operations and planning facility. However, NASA is considering its own backup alternatives.

As mentioned on page 12, NASA officials were concerned about possible DOD restrictions on their agency's activities in the mid-1970s. However, subsequent events, such as DOD's shuttle operational concept migration from payload delivery to full exploitation have apparently required NASA to alter its previous position. On December 6, 1982, the Director, JSC told the Commander, Space Division (CSOC Program Office), that NASA is now looking at its own backup to single operation elements to maintain expected civil and military flight rates in case of serious incident. Therefore, the Director concluded that CSOC developers should be cautious in developing the SOPC portion.

Our discussions with NASA officials disclosed that, in their opinion, these concepts involve possible modifications to existing JSC assets and most likely could be implemented at minimum additional cost.

Increased security

According to the current DOD mission model, military missions later in this decade will require more stringent security measures than are being provided by JSC's Controlled Mode configuration. This raises questions concerning JSC's ability to interoperate with, and provide backup to SOPC. NASA studied this problem in August 1982 and issued a report which addressed interoperability needs, various interoperability concepts, and analyzed possible costs and system requirements. Three backup states were discussed. They were:

--Cold state: Involves little or no preparation by JSC, other than maintaining a small cadre of people familiar with the DOD mission.

--Warm state: Involves more familiarization by JSC. In this state, actual physical products are periodically transferred from SOPC to JSC, where they are stored in case a handover of control is required.

--Hot state: JSC is processing the mission parallel to SOPC with frequent coordination to ensure that data is consistent between the two facilities.

The study generally indicated that full mission continuation would be possible only if JSC were in the hot state before launch and throughout the flight period. Otherwise, significant launch delays could occur and JSC ground systems could only support the shuttle's safe return. For example, if handover occurred before launch with JSC in a cold or warm state, respective launch delays of up to 170 and 120 days could be expected. In addition, handover during these states would, according to the study, have substantial effect on JSC schedules or manifests.

The need for an interoperable backup capability, which minimizes both launch delay and mission degradation, is based on the criticality of national security missions and has been recognized by the JSC director. In a December 6, 1982, letter to Air Force SOPC developers, the JSC director stated, among other things, that "It is our intention to develop these systems and perhaps

some new techniques into an adequate [shuttle] program backup." Typical actions discussed were reconfiguration of existing NASA computer systems within the program and increasing onboard shuttle capability. (See app. II, p. 37.)

Assuming NASA implements the shuttle control approaches outlined in appendix II, it could conceivably provide primary and backup capability for civilian and military missions and perhaps eliminate the need for SOPC. To do this, however, would require additional security upgrades to NASA facilities (many military missions are expected to exceed the Secret level) and significantly advance NASA/DOD integration. Currently, it is not clear how NASA and the DOD will resolve future civilian and military needs for shuttle control and backup in light of evolving options. In this regard, we believe it would be prudent for NASA and DOD to develop a clear strategy defining system interoperability requirements before DOD proceeds with SOPC implementation.

Direct DOD control

Another DOD justification for SOPC is that national policy and military doctrine require direct DOD control of military shuttle operations. Existing legislation--the National Aeronautics and Space Act of 1958 and the DOD Reorganization Act of 1958--as well as several policy directives, provide the basis for direct military control.

The 1958 Space Act assigns to DOD "activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States . . ."

The DOD Reorganization Act provides more specific guidance

> ". . . The President, through the Secretary of Defense, shall establish . . . combatant commands for the performance of military missions . . . commands are responsible to the President . . . forces assigned to such . . . commands shall be under the full operational command of the commander of [such] . . . command . . ."

According to DOD policy, control is the authority to manage, direct, superintend, regulate, govern, administer, or oversee. Also, recent presidential directives have expanded the policy contained in these two Acts.

In accordance with this guidance, DOD believes SOPC is required to ensure DOD responsiveness to shuttle operations in times of national crisis, through a direct military chain of command. In justifying a dedicated shuttle operations and planning facility, DOD indicated, as early as 1979, that current capabilities do not exist for direct and exclusive military control of shuttle flight operations.

However, DOD direct control of shuttle military missions was included in the renegotiated 1980 NASA/DOD Memorandum of Understanding largely at DOD's request because of problems experienced under the original 1977 Memorandum of Understanding. This change, coupled with NASA's evolving strategy to modify JSC to enhance its accommodation of DOD missions (see app. II, p. 37), indicates that SOPC justification based on the need for direct DOD control of shuttle missions should be further reviewed by DOD.

Additional capacity

The final major JSC deficiency used as justification for SOPC development is the inadequate capacity of Controlled Mode systems. In 1981, DOD predicted that by the late 1980s, secure mission workloads will exceed the limits of Controlled Mode system capabilities. However, recent NASA projections concerning the Controlled Mode would seem to justify DOD reexamining its position on this issue.

As originally designed, the Controlled Mode was intended to support up to 15 classified flights annually with only one launch, landing, or critical on-orbit mission phase supported at one time. Until recently, however, NASA estimated that the JSC secure systems would only support six to eight classified missions per year. This reduction from the original design capability was based on analyses of ground support operations for the first several shuttle missions. Using this level of supportable flights and the projection of future military shuttle missions, DOD concludes that the Controlled Mode systems' capacities will be exceeded in 1989 when 10 secure DOD missions are planned. However, according to the JSC director, NASA is considering actions that would increase the number of secure missions the Controlled

Mode will be able to handle. (See app. II, pp. 37 to 39.) NASA now projects that 10 to 12 classified DOD missions can be operated out of JSC annually.

CHAPTER 5

DOD'S COST AND ACQUISITION STRATEGY FOR SOPC

We noted in our January 1982 report on CSOC that its development was not being adequately planned and that this could result in extensive cost overruns, schedule slippages, and inadequate capabilities. Furthermore, we indicated that proper planning is essential to successful system development. We also questioned the time criticality for the SOPC portion of CSOC in view of the Controlled Mode capabilities being implemented at JSC. In response, the Air Force firmly supported a need for shuttle operations capability by 1987.

The Air Force now plans, however, to evolve the SOPC portion of CSOC more slowly than originally planned with flight control capability delayed until 1990. According to the Under Secretary of the Air Force (see app. III, p. 41), this resulted from mission model changes which slip some critical missions requiring a facility capable of handling highly classified information from 1988 to 1990.

The following sections describe our concerns regarding the current SOPC acquisition strategy.

ESCALATING COSTS

Originally, the Air Force SOPC configuration included shuttle mission simulation capabilities, two shuttle flight control rooms, and autonomous shuttle flight planning capabilities. These were considered the essential shuttle operations and planning elements required to meet the DOD mission projections for the late 1980s.

However, in November 1982, results from an independent cost study of CSOC, performed by Thompson Ramo Woolridge, Inc., revealed that significant cost growth had occurred. The factors behind this growth are the continued definition and redefinition of DOD shuttle operations and training requirements. These requirements have been elusive because there are many unknowns about the shuttle program and its transition to an operational system. In fact, NASA is just now assessing its facilities and systems for the shuttle operations era. As previously mentioned, NASA has advised Air Force developers to be cautious with the current SOPC development approach since the shuttle's operations

phase will probably require significant changes to existing systems, procedures, and concepts.

As a result of the cost study, program officials have identified three alternative configurations for the system since the cost estimates of the full capability were becoming exorbitant. The least costly alternative, which is in line with currently approved funding levels, proposes eliminating the flight crew simulator and overall flight control at SOPC. In this case, NASA would control shuttle launch and landing operations with DOD taking over on-orbit operations. This alternative is estimated to cost about $543 million. The second alternative limits SOPC to one, rather than two, flight control rooms, and provides only a partial flight crew simulation capability (i.e., no launch or landing simulation). Cost estimates of this proposal approximate $739 million. The third alternative provides for full SOPC capabilities as originally set forth at an estimated cost of approximately $1 billion.

After considering the three alternatives, DOD decided to make a firm commitment to the second alternative and, thus, reduce previously planned SOPC capability. Combined with this reduction is an overall $232 million shortfall in CSOC funding through fiscal year 1990 that must still be approved to support this scaled down version. The chart on page 30, compiled from a December 1982 Air Force briefing, summarizes DOD's alternatives for CSOC development. It indicates that SOPC shuttle operation control requirements are the predominate factors in CSOC's cost escalations.

Acquisition Costs of CSOC Alternatives

Alternative	Satellite operations	+	SOPC	=	CSOC	Approved funding	Funding shortfall
	(Cost in millions of dollars thru 1990)						
1	$ 622		$ 543		$1,165	$1,148	$ 17
2	641[a]		739[b]		1,380	1,148	232
3	641		1,015[c]		1,656	1,148	508

[a]Adds a fourth Satellite Mission Control Center.

[b]Adds shuttle flight control.

[c]Adds second shuttle flight control room and enhances shuttle simulator capability.

Limiting SOPC to a single flight control room configuration could reduce DOD's ability to independently control shuttle operations. For example, this will limit DOD's ability to do simultaneous operations such as on-orbit control and launch preparation; on-orbit control and mission simulation; or dual-mission control. The need for total shuttle operational control capability was one of DOD's strongest arguments for SOPC. However, DOD plans for operational control capability have been scaled down and no longer contemplate total shuttle control. Based on its plans for SOPC, we believe DOD will be required to rely on NASA for much of its shuttle operations support.

SOPC REPLICATION STRATEGY

Initially, SOPC's development depended on maximum use of JSC's existing systems for shuttle flight planning, readiness, and operations. This approach emphasized duplicating JSC's software and functional replication of JSC hardware so that impacts from software duplication could be minimized. In June 1982, DOD defended this method in commenting on our CSOC report by stating that

"at the present time, the most attractive approach seems to be to utilize DSM [Data System Modernization] mainframes and real time executive and to transfer the bulk of JSC Shuttle software."[1]

Air Force officials have since partially modified their position and now contend that SOPC will be developed by a competitively selected system contractor. According to the Under Secretary of the Air Force (see app. III, p. 40), this contractor will be asked to propose computer mainframes and will be allowed to use some, all, or none of the JSC software as they see fit to do a cost-effective job. In light of the above mentioned options, the Air Force must carefully evaluate contractor proposals to insure that (1) mission requirements are satisfied and (2) life-cycle costs and competition are reasonable. In addition, SOPC implementation should be closely monitored.

Mission satisfaction

NASA, from January 1982 to April 1983, performed a $10 million Air Force funded study to define SOPC system level requirements and to identify potential computer systems to satisfy those requirements. Six engineering teams were involved in the study, each being responsible for particular shuttle elements, such as flight control, flight readiness, flight planning, and flight support. The predominant assumptions that the NASA engineering teams worked under were that replication of existing JSC components, configuration, and software would be strongly considered for the final SOPC implementation. Also, the teams were required to provide for maximum interoperability between JSC and SOPC in their proposed designs.

Based on their study efforts, NASA's engineering teams essentially recommended a SOPC configuration based on extensive duplication of existing JSC software, functional replication of JSC hardware, and, in some cases, use of specific brands of computers. We agree that capitalizing on NASA's experience in shuttle operations is a reasonable approach to successful SOPC development. However, we believe that the potential

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[1]Data System Modernization is the current Air Force Satellite Control Facility upgrade. The mainframes referred to were IBM 3033s which have subsequently been changed to IBM 3083s.

replication of NASA's current software, hardware, and shuttle systems' configurations has two serious deficiencies.

First, NASA's current systems were designed primarily to support shuttle research and development activities, and as such are human intensive and their efficiency can be enhanced. NASA has recognized this, and is currently studying streamlined system configurations more suitable for the mature operations era. In addition, NASA officials believe increased onboard capabilities, also under study, could significantly reduce the need for substantive ground control systems in the future. Since NASA is preparing to optimize its existing system configuration, including hardware, software, and backup capability, we question the value of implementing the recommendations of the above mentioned Air Force funded study. To reiterate, the study recommended a SOPC configuration based on extensive duplication of JSC software, functional replication of JSC hardware, and use of specific brands of computers.

Second, and most important, replicating would most likely not incorporate DOD system requirements needed to implement its full exploitation concept. These include unique interfaces with other DOD organizations, as well as more complex and closely integrated shuttle/payload operations. Meeting these needs would probably require substantial upgrades in the future.

LIFE-CYCLE COSTS AND COMPETITION

If the decision is made to implement SOPC, use of existing NASA capabilities could have life-cycle cost implications that, in our opinion, are not being fully considered. One such implication relates to the use of outdated programming languages discussed in our January 1982 report. We noted that JSC's software systems are predominately coded in FORTRAN which lacks many capabilities inherent in the structure of DOD's new standard Ada language. Potential benefits precluded by this approach include high system reliability, reduced software maintenance costs, enhanced real-time processing capabilities, and manufacturer independence. All these provide incentive for substantial cost reductions over a system's life.

Nevertheless, in the SOPC development, DOD has not emphasized the use of its new standard programming language, Ada. For example, as mentioned above, DOD is planning to give the responsibility for making SOPC software decisions to industry. Since duplicating JSC software is not as costly as recoding in Ada, industry bidders

on SOPC contracts may choose duplication to keep their bids low and, thus, increase their chances of being awarded contracts--especially since this course of action is generally advocated by the previously mentioned NASA study to define SOPC requirements and identify computer systems to satisfy those requirements. The use of Ada is consistent with DOD interim policy, announced on June 10, 1983, which states that Ada ". . . shall become the single, common computer programming language for Defense mission-critical applications." Accordingly, it appears that DOD should reinforce this policy by encouraging industry to incorporate Ada as the language for the SOPC design.

In addition, if replicated JSC systems and duplicated software at SOPC are used, they may inevitably require extensive costly modification as DOD requirements evolve. For example, costs for software maintenance (i.e., correcting errors and deficiencies that remain from development, adding software for new requirements, deleting capabilities no longer needed, and optimizing for efficiency) increase at an exponential rate over a system's lifetime. Furthermore, over its lifetime, a system's original software baseline can be expected to completely change. These considerations are applicable to SOPC because of the anticipated changes that will be necessary to satisfy DOD's evolving full exploitation shuttle operations concept.

DOD has stated that, over a 10-year life cycle, $1 billion will be required to maintain the SOPC software systems. This is probably a conservative estimate considering the extensive modifications SOPC may need as DOD's operations and interoperability requirements for the space mission expand and shuttle operations mature. Therefore, successful development should require a design based on DOD's shuttle exploitation requirements, rather than JSC replication. Such a design should increase productivity and reliability, reduce technical risk, and as a result, lower SOPC life-cycle costs.

Another concern with replicating JSC systems relates to the degree of competition in SOPC development (sole-source versus competitive selection). We believe that replication of JSC systems could restrict competition. For example, by making maximum use of existing software, only those computer manufacturers that currently support JSC or manufacturers that produce brand equivalent hardware could, realistically, be awarded SOPC development contracts. This may severely restrict competitive development and the positive effects such a development could have on life-cycle costs.

CHAPTER 6

CONCLUSIONS, RECOMMENDATIONS, AND MATTERS FOR CONSIDERATION BY THE CONGRESS

CONCLUSIONS

Increased interaction and integration of NASA and DOD space activities will blur the distinction between civilian and military programs. This raises a fundamental question regarding how evolving shuttle operations will affect the respective missions of NASA and DOD. This question has already engendered substantial debate, both in and out of Congress, on the degree of program separation, if any, that should be maintained. On one hand, advocates for increased NASA/DOD cooperation argue that this arrangement is in the best interest of economic and efficient operation of the evolving Space Transportation System. On the other hand, opponents object to mixing different agency missions, goals, and objectives because any expansion of NASA's role in military space activities would run the risk of compromising the open nature of the United States civil space program. While NASA and DOD have presented their separate plans to the Congress for the shuttle, these have not reflected a sufficiently coordinated approach. A joint effort by NASA, DOD, and the Congress will be required to resolve these issues and to decide upon the appropriate degree of separation between the civil and military space programs.

One method for achieving balanced agency interaction was suggested in June 1982 by the Office of Technology Assessment in its Civilian Space Policy and Applications report. (See pp. 276 to 277.) It recommended that the Congress consider reestablishing a mechanism similar to the disbanded National Aeronautics and Space Council as a means of providing continuous high level attention to space policy and interprogram coordination matters.

Regarding the decision on the need for a separate military SOPC, current information indicates that DOD concerns about the use of JSC may be alleviated, to a large extent, by pending actions relating to NASA's enhancement of its control facilities. If a decision is made to implement SOPC according to DOD's current system acquisition strategy, contractors would be permitted the option to functionally replicate JSC hardware and duplicate its software. Such an approach may not yield a system tailored

to DOD's mission requirements and full exploitation operational concept; may require extensive and expensive future upgrades to fully exploit shuttle capabilities; and may preclude the inherent benefits obtainable from state-of-the-art techniques such as more efficient software, manufacturer independence, and economical software maintenance.

RECOMMENDATIONS

The issues discussed in this report should assist the Congress in focusing its attention on the manner of interaction and degree of separation needed between the civil and military space programs. In this regard, we recommend that the Administrator of NASA, in consultation with the Secretary of Defense, assist the Congress by expediting efforts to define how a fully operational shuttle program will be managed and controlled in the future. Such a definition should include (1) agency roles and responsibilities, (2) performance criteria for the shuttle system which clearly define both the defense and civil capabilities and interoperability requirements, and (3) alternatives for providing backup capability for the DOD space program.

We also recommend that the Secretary of Defense direct the Air Force to

--defer SOPC implementation until NASA and DOD identify the systems configuration needed to support a fully operational shuttle system and

--establish and validate functional system requirements which accurately reflect DOD's full exploitation operational concept, taking into consideration the eventual shuttle operations system configuration.

MATTERS FOR CONSIDERATION BY THE CONGRESS

Because of the rapidly developing interdependence between NASA and DOD, we believe that the Congress should consider requiring the reestablishment of a mechanism similar to the disbanded National Aeronautics and Space Council, as discussed in the Office of Technology Assessment report, to obtain high level attention to space matters and achieve balanced agency interaction.

APPENDIX I

NINETY-SEVENTH CONGRESS

Congress of the United States

House of Representatives

COMMITTEE ON GOVERNMENT OPERATIONS

2157 Rayburn House Office Building

Washington, D.C. 20515

June 8, 1982

The Honorable Charles A. Bowsher
Comptroller General
General Accounting Office
441 G Street, N.W.
Washington, D.C. 20548

Dear General:

I have reviewed your report on the Air Force's plans to construct a Consolidated Space Operations Center near Colorado Springs in 1983. It is my understanding that this joint military satellite/shuttle operations control facility will cost about $1.4 billion when fully operational in 1990. In the report, you indicate that GAO has reservations about beginning full-scale construction at this time and suggests that construction of other than a critical backup capability would be premature.

I have long been concerned about our military and civilian space programs. It is essential that both have the most modern technology available and the expertise to fully use this technology. NASA has a long history of technical achievements of which we can all be proud.

However, the military space program appears to be going astray. It is disturbing to note that after years in space, we still do not have an overall military space plan and our military space operations are badly fragmented. These are the very factors which led to the failure of the Air Force's large-scale systems development efforts in the 1970's. Notwithstanding your excellent report, I believe additional questions have been raised concerning the Air Force's handling of the planned operations center.

I therefore request that you initiate a follow-on review to determine (1) whether the Air Force's plans to "replicate" the Johnson Space Center's computer capability at Colorado Springs, Colorado, have been fully justified, (2) if a combined center is truly needed since DOD and NASA are planning on handling classified missions in any case over the next four to five years, (3) the cost and benefits of duplicating a capability at Colorado Springs which already exists at Johnson Space Center, (4) the justification for acquiring sole-source a limited capability that may not meet the requirements of a modern space mission, and (5) why the Air Force could not competitively acquire commercial state-of-the-art technology to meet mission needs. In this review, I would also like you to assess the extent to which the Air Force plans to replicate the NASA functions worldwide and the justification for doing so. As you know, the Air Force is moving rapidly to implement its plans. I therefore request your review be completed within six months.

With best wishes, I am

Sincerely,

JACK BROOKS
Chairman

APPENDIX II

National Aeronautics and
Space Administration

Lyndon B. Johnson Space Center
Houston, Texas
77058

NASA

Reply to Attn of: LA

December 6, 1982

Lieutenant General Richard C. Henry
Commander
USAF Space Division
P. O. Box 92960
Worldway Postal Center
Los Angeles, CA 90009

Dear General Henry:

In recent weeks we have been revisiting our concepts for STS operations in the future. This revisit was felt to be prudent with the knowledge we gained during the very successful OFT sequence and the recent completion of the first operational flight. As you know, we have long been driven by the continued incentive to reduce costs and the level of manpower required. There are, in addition, two other strong considerations as to our future operations. The first is the need to have adequate backups to single-operation facilities (nodes) in order to maintain the STS flight rate. Secondly, as we have discussed, you are at a critical stage in the definition of the details of the SOPC configuration.

With respect to adequate backups, JSC is currently addressing this issue across the program. This activity has already led us to the present plans for a simulator load development facility in another building at JSC, building 35. For the MCC, we are assessing the other existing assets within the program for a suitable backup to continue flight operations in the case of a serious incident, such as a fire, in the MCC building. Our preliminary direction is to explore the inherent capabilities of other data processing systems already within the program or in development. There are a number of emerging ideas for using some of our support-type systems or elements of the launch site systems. We believe that these concepts and/or the LPS capabilities at KSC could be reconfigured for such adequate backup and, at some future time in the mature operations phase, some reduced set of these type facilities will be adequate for on-orbit control. It is our intention to develop these systems and perhaps some new techniques into an adequate program backup.

Another node receiving considerable study is the capability in the Orbiter itself which, after 5 flights, is proving to be very capable and reliable. This on-orbit node will require some increased onboard capability and, for example, we have embarked on the testing of onboard orbital navigation with the TACAN system to provide a backup to the primary capability.

CF ltr

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The use of the total assets already in place or in development offers promise of allowing us to meet the NASA objective of an STS flight rate of 40 flights per year with only modest funding requirements for the MCC-class of facility. So, you can see that this is a subject of importance to us. It is also timely to begin this process towards these NASA objectives now that we have the experience of 5 flights and 5 more upcoming in CY83.

Based on this direction, we conclude that it would be prudent of you to be cautious in the development of the SOPC. We understand that your present plans for the SOPC are to "approximately duplicate" the JSC facilities, especially the MCC and the SMS. The relatively high cost of these facilities and the likelihood of a more modest scheme, especially for the MCC, indicate that a phased approach to implementation will be much more cost effective for you.

We understand that the CY87 IOC is driven by the fact that you want the SOPC online when the classified flights exceed the advertised JSC controlled mode capability of 6-8 flight per year. At present, the DOD traffic model reaches 10 flights in 1989. Recognizing that mission models are uncertain to some degree, we are willing to commit that the program and its facilities (without the SOPC) will be able to handle a higher flight rate of up to 10-12 per year in this period. We believe that some combination of our direction to establish adequate backup facilities, maturity of experience, and possible improvements in the controlled mode capability will assure that. Inherent in this commitment is the assumption that the security level of these flights can be accommodated within the capabilities of controlled mode and are of such a nature as not to require extensive planning and testing. In addition, you also could help, if necessary, by dropping the look-alike security umbrella for a very few selected missions. Certainly, this should give you the programmatic basis for a confident decision to adjust the IOC for full capability at SOPC to some later year.

Any of these developments will still be consistent with the Air Force role of "mission control" of Air Force objectives on your flights. We already have some limited experience in this mode and will continue to add to that base of operating experience with ~~the flight of~~ 84-1 next year.

In summary, we are embarking on a program of assuring adequate backups to operational facilities, which has promise of satisfying the NASA objective of 40 flights per year, and which also will result in a significant change to the STS mission control and training concepts. Although this program is in an early stage, we believe that this direction indicates that a more cost-effective phased approach on SOPC is likely to profit greatly from the NASA redefinition. We are confident and are willing to commit to you that our approach and other inherent flexibilities will allow us to handle up to 10-12 classified

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flights per year. Of course, we look forward to our continued mutual cooperation on these and other STS activities.

Please feel free to call me if you have any questions.

Sincerely,

Gerald D. Griffin
Director

cc:
NASA Hqs., M/Lt. Gen. J. A. Abrahamson
USAF SD-Los Angeles, CF/Brig. Gen. Kutyna
USAF SD-Houston, ZR1/G. M. Risch

APPENDIX III

DEPARTMENT OF THE AIR FORCE
WASHINGTON, D C 20330

OFFICE OF THE SECRETARY

December 15, 1982

Honorable Charles A. Bowsher
Comptroller General
General Accounting Office
441 G Street
Washington DC 20330

Dear Mr Bowsher:

As promised in our letter of November 22, 1982, I am forwarding (attached to this letter) the TRW and NASA cost estimates which you requested. Also as promised, we in the Air Force conducted a thorough review of the program to assure that the development and acquisition activities are being pursued in the most efficient manner possible and that we indeed were acquiring the right capabilities to support our missions. I would like to share some of the conclusions of that review with you.

Our basic philosophy regarding CSOC development remains sound. That philosophy is built on the fact that we have already developed a substantial space operations capability in Colorado Springs. It is therefore reasonable to place the technical support facility called CSOC in that location. It must be emphasized, however, that we are indeed building a single facility to house two very different space support functions. The first, the Satellite Operations Complex or SOC, provides service to our unmanned spacecraft. The second, the Shuttle Operations and Planning Complex (SOPC) will, of course, perform the function suggested in the name. The Air Force has reaffirmed that the savings to be accrued from collocating these two technical support functions is principally in overhead.

With regard to the SOC we are proceeding toward achieving a FY86 capability to support DOD unmanned spacecraft. That capability should exist today, and every year's delay forces us to face the spectre of a potential loss of critical national security missions if the single node center at Sunnyvale, California becomes incapacitated. Most of the FY83 procurement funds authorized by Congress (but not yet appropriated) are planned for initial SOC and communications equipment acquisiton. As you may recall, we conducted a lengthy competition for the SOC as part of the Air Force Satellite Control Facility Data System Modernization (DSM) work. The SOC's four Mission Control Centers (MCCs) are to be procured as an option to the DSM contract. When we exercise that option in the fall of 1983 (if the Congress approves), we will specify that the contractor shall use the latest model off-the-shelf computer mainframes for satellite operations. Please note we will not buy IBM 3033s. In view of the

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work in progress already at Sunnyvale, California and the great similarity which the SOC will have to that function, we have very high confidence in our cost figures and floor space requirements. On the floor space question, it should be observed that modern technology helps. Computer mainframes are smaller (require less electrical power) and more powerful today than they were just a year ago. Replacement machines of the future promise to be even smaller and more powerful. We have specified use of Ada design language for the SOC in order to enhance the transportability of the software to those not-yet-invented computers of the future.

In the SOPC area we are continuing the intense in-depth planning process started 18 months ago. The inclosed NASA and TRW cost data are some of the products of that process. Most of the authorized (but not yet appropriated) FY83 CSOC RDT&E funds are earmarked to support that planning, which the GAO quite correctly noted is critical to the success of SOPC. As you would expect, our analyses to date have resulted in some refinements and adjustments to our earlier plans. For example, even though most of the Johnson Space Center (JSC) software for Shuttle control was designed for Shuttle, some of the displays are holdovers from the Apollo program and need to be replaced. We and NASA are now considering the potential cost saving move of a joint procurement of that equipment for both CSOC and JSC. Further, it is possible that less equipment will be needed at SOPC than we envisioned earlier. As we have proceeded with the planning, the Shuttle mission model has changed. Some of the very critical missions which must have the support of a facility capable of handling Special Compartmented Information (SCI) have slipped from 1988 to 1990. We will, therefore, evolve the SOPC more slowly. As stated in our earlier planning, however, the transition to SOPC must start in 1987. That simply means that certain SOPC functions having to do with the generation of SCI tapes for Shuttle missions must come on line by 1987 but the more robust capabilities previously planned for 1988 can now wait until 1990. Until it is possible to perform work at the SCI level, DOD will be limited in its ability to fully exploit the Shuttle.

It has been asked why not "do it all" at JSC. The answer, of course, is JSC could "do it all" including processing SCI data. In doing so we create the very "single node" deficiency we're trying to fix for unmanned satellite control; and we will basically turn JSC into a DOD facility. Further, the costs would not be substantially reduced. We are now moving toward a 1984 competitive selection of the system contractor for SOPC. The contractor will be asked to propose computer mainframes as part of the competition; the offerors will be allowed to use some, all, or none of the JSC software as they see fit to do a cost effective job. The floor space planned for the SOPC is adequate now and anticipated greater efficiencies from competitive bidding will provide additional flexibility in meeting any future requirements.

In summary, the Air Force has now estabished a program baseline for the CSOC. The baseline program includes: the facilities currently defined in the FY83 and FY84 MCP budget requests, a Satellite Operations Complex to share the normal satellite control workload with the Satellite Test Center in Sunnyvale, California; a Shuttle Operations and Planning Complex to provide planning and operational

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control of both the Shuttle mission applications activities and the flight of the Shuttle vehicles, themselves; an operations command center; the necessary internal and external communications to integrate satellite and Shuttle operations within the CSOC, to interface CSOC with the other components of the Air Force Satellite Control Network, and to permit mutual backup between the STC and the SOC; and facilities/utilities for a colocated GPS Master Control Station and a mid-CONUS Remote Tracking Station. Implicit in the baseline concept is the recognition that the baseline cost estimate is uniquely associated with a defined package of effort. The Congress has anticipated the probable future need for additional land at the CSOC site in Colorado. Similarly, the Air Force experience at the Satellite Test Center shows that we should anticipate future additions to the current CSOC baseline program as the supported satellite programs are modified, new programs become operational, the Shuttle operations mature and the fleet is modified. For example, the full simulation capability is not included in the current baseline and we are protecting the option to expand the CSOC to include full Shuttle flight control capacity, pending better definition of flight control requirements. We will use the baseline management concept to add or delete discrete packages of defined and costed effort as the CSOC evolves to meet the future needs of the supported space programs. The total investment cost for the current baseline program is estimated to be $1.4 Billion, which remains consistent with our prior testimony to Congress.

Please treat the attached data as Pre-Procurement Sensitive.

Sincerely,

E. C. Aldridge, Jr.
Under Secretary of the
Air Force

2 Atch
1. JSC Management Document
2. TRW Cost Data

OUR RECENT REPORTS CONCERNING SHUTTLE OPERATIONS

Report title	Report number	Report date
Issues Concerning the Future Operations of the Space Transportation System	GAO/MASAD-83-6	12/28/82
Evaluation of NASA Comments on GAO Report MASAD-82-14 "Consolidated Space Operations Center Lacks Adequate DOD Planning"	GAO/MASAD-82-43	8/12/82
GAO Position on Several Issues Pertaining to Air Force Consolidated Space Operations Center Development	GAO/MASAD-82-45	8/12/82
Analysis of NASA's Fiscal Year 1983 Budget Request for Research and Development to Determine the Amount That Supports DOD's Programs	MASAD-82-33	4/26/82
NASA Must Reconsider Operations Pricing Policy to Compensate for Cost Growth on the Space Transportation System	MASAD-82-15	2/23/82
Consolidated Space Operations Center Lacks Adequate DOD Planning	MASAD-82-14	1/29/82

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