PREFACE

On July 4, 1982, the President of the United States announced a national space policy that is to set the direction of space efforts for the next decade. It sets forth the Space Shuttle as a major factor in the evolution of future U.S. programs and commits the United States to maintaining world leadership in space transportation with a Space Transportation System capacity to meet appropriate national needs. The Congress and the Nation have a keen interest in its future development.

The first priority of the Space Transportation System program is to make the system fully operational and cost effective in providing routine access to space. However, it will take several years before the Space Transportation System will reach its peak operational capacity.

Our objective was to identify the major Space Transportation System operational issues facing the National Aeronautics and Space Administration as it begins this new era in space operations. This study provides a basis for any future assessments we may conduct either on our own initiative or at the request of congressional committees responsible for the oversight of the National Aeronautics and Space Administration's budget.

Chapter 1 briefly describes the Space Transportation System and the operational responsibilities of the National Aeronautics and Space Administration and the Department of Defense. Chapters 2 through 9 present information we have obtained on a broad range of operational issues that the National Aeronautics and Space Administration must deal with in the years ahead in achieving the national space transportation goal.

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SUMMARY

The Space Transportation System (STS) is the primary U.S. launch system for both military and civil missions. It consists of the Space Shuttle, expendable upper stages, spacelab, and launch and landing facilities. The Space Shuttle includes a reusable orbiter, two reusable solid rocket boosters, and an expendable liquid propellant external tank. Development of the Space Shuttle has cost over $10 billion and production of four orbiters will cost about $3.8 billion in fiscal year 1983 dollars.

The National Aeronautics and Space Administration (NASA) completed the Shuttle flight test program in July 1982 and launched the first operational flight from the Kennedy Space Center in Florida on November 11, 1982. There are five operational flights scheduled in fiscal year 1983 estimated to cost $266 million each. NASA projects significant reductions in launch costs through learning and increased operational efficiencies as the system matures. However, it will take several years for STS to reach peak operational capacity. The third and fourth orbiters are not scheduled for delivery until September 1983 and December 1984, respectively, and the west coast launch site at Vandenberg Air Force Base will not be operational until at least October 1985.

NASA's first program priority is to make STS operational and cost effective for routine access to space. GAO's objective was to identify the major STS operational issues facing NASA as it begins this new era in space operations. This study provides a basis for any future assessments GAO may conduct either on its own or at the request of congressional committees responsible for the oversight of NASA's budget.

The study identified eight issues that GAO believes NASA must deal with in the years ahead and for which budgetary decisions will most likely have to be made by the Congress.

STS OPERATIONS

NASA is again faced with the question similar to that experienced on its communications and weather satellite programs, and which it is now experiencing with regard to LANDSAT. The issue is whether NASA should manage Shuttle operations or shift management responsibility to another federal agency or commercial organization once the Space Shuttle achieves a reasonable degree of maturity. This decision will determine whether NASA remains primarily a research and development organization or increases its role in space operations.

SPACE SHUTTLE OPERATIONS LOGISTICS SUPPORT

An economical and effective logistics system is needed to support the Shuttle during its operational life. During Shuttle development, Johnson Space Center provided this support for the orbiter; Marshall Space Flight Center for the main engine, solid rocket booster, and external tank; and Kennedy Space Center for launch, landing, recovery, and refurbishment projects. NASA's plan for several years has been to transfer logistics management to the Kennedy Space Center. A March 1982 NASA study on Shuttle logistics management concluded that an early decision is needed on the NASA management to support operations. However, NASA issued a draft interim logistics support policy on July 8, 1982. It states:

> "There will not be a significant transfer of functions, hardware, or responsibilities from the other Space Shuttle projects to the KSC Launch and Landing project during the interim operations period."

It also defines the interim operations period as starting with the STS-4 landing through the date that major organizational and support changes are made to manage and process the Space Shuttle in a fully operational mode. However, no specific date has been established for the end of the interim operations period. This raises a question on whether adequate logistics procedures are being developed and implemented on a timely basis.

LAUNCH AND MISSION CONTROL OPERATIONS

There are two launch control centers--one at Kennedy Space Center and another at Vandenberg Air Force Base. They are responsible for all launch activities until the solid rocket boosters are ignited.

The mission control center located at Johnson Space Center is responsible for preflight operations as well as directing Shuttle flight operations beginning with solid rocket booster ignition and concluding when the orbiter stops on the runway. The Johnson Space Center plans to upgrade the mission control center for multiple flight capability and provide an interim secure control facility for Department of Defense (DOD) flights from November 1983 to 1987.

The multiple flight control capability was scheduled to be available in 1984 to support 14 launches with increases to 24 launches in 1986. However, launches have been reduced to 5 in 1984 and increasing to only 13 in 1986. Also, an August 1981 NASA planning document stated that mission control should be transferred to the launch sites to increase operations efficiency and reduce costs. NASA Headquarters officials reportedly have requested the examination of the options available to NASA, including a consolidation of launch and mission control activities at Kennedy. In view of this study, NASA's $85 million in construction costs to upgrade the Mission Control Center at Johnson Space Center may only be an interim measure since other mission control options may prove more efficient and less costly.

The solid rocket boosters provide most of the initial thrust for Space Shuttle launch. About 2 minutes into the launch the boosters are separated from the orbiter and external tank and parachute into the ocean some 150 nautical miles downrange for recovery and reuse. The solid rocket booster recovery area for Kennedy launches extends about 120 to 170 nautical miles off the Florida coast into the Atlantic Ocean. However, the Department of the Interior plans to lease part of this area beginning in July 1983 for oil and mineral deposits exploration. The leases will run for 10 years.

NASA and the Air Force are concerned that the oil and minerals exploration in this area could increase Shuttle launch costs and risks to flight safety because of (1) potential launch restrictions, (2) increased risk of damaging returning solid rocket boosters, and (3) range safety considerations.

ASTRONAUT RECRUITMENT AND TRAINING

In 1977 NASA projected that about 40 pilots and 40 mission specialists would be needed to support 487 flights during the first 12 years of Shuttle operations. As of February 1982, NASA had 77 astronauts about evenly divided between pilots and mission specialists. However, since 1977 the number of planned flights has decreased from 487 to 234. Thus, while the astronaut requirements have remained constant, the flight requirements have been reduced more than 50 percent.

NASA astronauts must train for 3 years. As a result, 54 astronauts will complete training and be ready fo fly during the 1981-1983 time frame when NASA will just be starting to build up its launch rate. Military astronauts only serve for a period of 5 to 7 years. This will leave a maximum of 4 years flight service for military astronauts.

A logical question as NASA begins Shuttle operations is whether there are alternative recruitment and training procedures that could better provide for some flexibility in fulfilling NASA's astronaut requirements.

ACCOUNTING FOR SHUTTLE OPERATIONS COSTS

NASA will support frequent Shuttle launch, operation, and recovery for a variety of users including NASA, DOD, and commercial organizations. NASA will charge a fixed price for standard launch services and also establish separate fixed prices for each optional or special service. The standard cost per flight will be determined annually by totaling the Shuttle operations cost for all locations and dividing by the total number of missions for the year. However, the overall question is whether NASA's current accounting system and procedures provide adequate data for NASA to manage STS and carryout its pricing policy.

LAUNCH AND LANDING FACILITIES

The Kennedy Space Center in Florida is the primary launch, landing, and orbiter refurbishment site. A second site, Vandenberg Air Force Base, is being funded by DOD and is to become operational in October 1985.

Turnaround time is the time between orbiter landing at the launch site and its next launch. NASA's initial operational design goal was for Shuttle turnaround time not to exceed 160 working hours. NASA's May 1982 estimate was that it will attain a Shuttle turnaround time of 888 hours by its 26th launch which exceeds by about 4-1/2 times its 160-hour goal.

As the Shuttle turnaround time increases, it reduces the number of orbiters that can be processed and launched at Kennedy Space Center. As a result, NASA may require additional facilities if they plan to maintain or increase the Shuttle launch rate.

LAUNCH VEHICLES

The Space Shuttle was approved on the premise that NASA and DOD would phase out expendable launch vehicles. NASA's commitment to phase out all expendable launch vehicles in favor of the Shuttle is inherent in the goals established for STS--low cost access to space with a reusable system. However, it is also NASA's stated policy to provide an assured launch capability for domestic and foreign payloads.

It appears that the Space Shuttle cannot adequately support the traffic demand in the near future. The question is whether there is a need for additional launch vehicles and, if so, should it be more orbiters, expendable launch vehicles, a new system, or a combination of these alternatives.

STS DESIGN GOALS

One STS design goal is to place payloads weighing up to 65,000 pounds into a 150-nautical mile due-east orbit from Kennedy and up to 32,000 pounds into a specified 100-nautical mile, near-polar (north-south) orbit from Vandenberg. It was also to be designed to retrieve payloads in orbit for refurbishment and reuse.

Although the first operational flight of the Shuttle was launched in November 1982, NASA is still working toward the design goals. NASA must continue to fund Shuttle development to achieve design requirements and fund Shuttle improvements to achieve payload savings through satellite retrieval, on orbit maintenance, or return to earth for refurbishment. How long the development and improvements will continue, how much they will cost, and their impact on future NASA budgets should be clearly identified.

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We did not request official comments on this study. We did, however, discuss a draft of the study with NASA officials and have incorporated their comments where appropriate.

The above issues are discussed in more detail in the body of this staff study.

Contents

ABBREVIATIONS

DOD	Department of Defense
GAO	General Accounting Office
IG	Inspector General
NASA	National Aeronautics and Space Administration
STS	Space Transportation System

CHAPTER 1

INTRODUCTION

The Space Transportation System (STS) is a vital element of the U.S. space program and is the primary space launch system for both military and civil missions. Developing STS and producing a fleet of operational vehicles has dominated the National Aeronautics and Space Administration's (NASA's) management efforts and budget resources in recent years. The Space Shuttle design, development, test, and evaluation has cost over $10 billion and the production of four orbiters will cost about another $3.8 billion in fiscal year 1983 budget dollars. NASA has completed the Shuttle's orbital test flight program and is preparing for Shuttle operations. NASA estimates the cost of each of five Space Shuttle launches planned for fiscal year 1983 to be about $266 million each in real-year dollars. NASA projects significant reductions in launch costs through learning and increased operational efficiencies as the system matures.

NASA's first STS program priority now is to make the system fully operational and cost effective in producing routine access to space. However, it will take several years before STS will reach its peak operational capacity. Although NASA launched its first operational flight from Kennedy Space Center in Florida in November 1982, the third and fourth orbiters are not scheduled for delivery until September 1983 and December 1984, respectively. The west coast launch site at Vandenberg Air Force Base will not be operational until at least October 1985.

STS

STS is composed of the Space Shuttle, expendable upper stages, spacelab, and related launch and landing facilities.

Space Shuttle

The Space Shuttle consists of a reusable piloted orbiter with three main engines, two reusable solid rocket boosters, and an expendable liquid propellant tank referred to as the external tank. After additional modifications, the Space Shuttle is expected to have the capability to place payloads weighing up to 65,000 pounds into a 150-nautical mile, due-east orbit from the Kennedy Space Center and up to 32,000 pounds into a specified 100-nautical mile, near-polar (north-south) orbit from Vandenberg Air Force Base.

Upper stages

STS upper stages are required to deploy Shuttle-launched payloads to orbits not attainable by the Shuttle alone. These upper stages are the spinning solid upper stages, the inertial upper stage, and the Centaur. Each upper stage has its own unique capabilities.

The spinning solid upper stage was developed commercially by the McDonnell Douglas Astronautics Company and includes two models. The D and A models will be used to deploy payloads of up to 2,750 pounds and 4,400 pounds, respectively, from the Shuttle's low Earth orbit of about 150 nautical miles into a geosynchronous orbit which is about 22,300 nautical miles above the Earth.

The Department of Defense (DOD) is developing a solid-fueled, "two stage" inertial upper stage for use by DOD and NASA. The inertial upper stage is designed to place a 5,000 pound payload into geosynchronous orbit.

NASA canceled a "three stage" inertial upper stage needed for NASA's planetary missions because of cost overruns and performance deficiencies and planned to use the two stage inertial upper stage to launch the Galileo and the International Solar Polar Missions. However, language in the Urgent Supplemental Appropriations Act, 1982, directed the Air Force to terminate the inertial upper stage development for these two missions and directed NASA to restart development of the Centaur for use with Galileo and the International Solar Polar Mission. The Centaur will be able to place a 13,000 pound payload into geosynchronous orbit, which is more than double the capability of an inertial upper stage.

Spacelab

The spacelab is a cooperative venture between NASA and the European Space Agency. The major program objective is to provide versatile, low-cost laboratory and observatory facilities. This self-contained laboratory will be carried into orbit in the Shuttle's cargo bay and will remain in the orbiter throughout its mission. Early spacelab flights will last up to 7 days with future missions projected for as long as 30 days. The orbiter will provide all of spacelab's support requirements. Using the spacelab, scientists can conduct space research in a shirt-sleeve environment.

The spacelab consists of module and pallet sections used in various configurations to suit the needs of a particular mission. The pressurized module is accessible from the orbiter's cabin through a transfer tunnel. Pallets accommodate experiment equipment for direct exposure to space. NASA considers research for manufacturing in space to be one of spacelab's most promising uses. The spacelab will also have advantages for life science research because such research on previous spacecraft had to be fully automated and self-contained. This did not allow interaction with the investigator after the experiment had started, as spacelab will do.

Launch and landing facilities

NASA and DOD agreed that the program would require two launch and landing sites to be fully operational--Kennedy Space Center in Florida and Vandenberg Air Force Base in California. Missions from Kennedy are launched eastward out over the Atlantic Ocean and include all satellites for geosynchronous orbit. Missions requiring north-south orbits, including many weather and Earth-survey satellites, are launched southward over the Pacific Ocean from Vandenberg.

MANAGEMENT OF STS

NASA and DOD have been jointly involved from the beginning in planning for the Space Shuttle. As the Shuttle design evolved in the early 1970s, DOD requirements were a driving factor, and DOD is now anticipated to be the single largest user and a major investor in the Shuttle.

In January 1977 DOD and NASA executed a Memorandum of Understanding to define their responsibilities. This memorandum was revised in March 1980 to better define DOD/NASA management interfaces.

DOD is responsible for the conduct of all national security missions. Also, DOD will develop and acquire specified elements of STS and ensure that other aspects of the STS program are consistent with national security requirements. On behalf of DOD, the Air Force will provide and operate the facilities for all Shuttle operations at Vandenberg in California.

NASA's responsibility under the revised Memorandum of Understanding is to develop, manage, provide systems engineering, and operate the Shuttle to serve all authorized space users. NASA will also provide and operate the facilities and equipment for Shuttle mission planning, simulation, training, and flight operations at the Johnson Space Center and for Shuttle launch, landing, and turnaround activities at the Kennedy Space Center.

OBJECTIVE, SCOPE, AND METHODOLOGY

Our objective was to identify the major STS operational issues facing NASA as it begins this new era in space operations. This study provides a basis for any future assessments we may conduct either on our own initiative or at the request of congressional committees responsible for the oversight of NASA's budget.

Our staff study was conducted primarily at Kennedy Space Center, Florida, and at NASA Headquarters, Washington, D.C. We selected Kennedy because it has major responsibility for STS operational activities. We selected NASA Headquarters because it manages the overall program and is the source for official NASA policy decisions. Additional information was obtained at DOD Headquarters and from Johnson Space Center, Texas, and the Air Force Systems Command's Space Division, California.

We initiated our study by examining our prior reports and pertinent workpapers. We reviewed NASA's budget presentations to the Congress, including related congressional testimony and NASA's planning documents. Also, we reviewed various NASA studies and assessments on who should operate STS, its proposed organizational structures, and the related advantages and disadvantages. We toured NASA and DOD-related STS facilities and reviewed documents and supporting data prepared by the STS program office and related working panels such as the Shuttle Turnaround Analysis Group. We also interviewed responsible NASA and DOD officials concerning the rationale and justification for STS decisions made and for actions planned or taken.

We did not request official comments on this study. We did, however, discuss a draft of the study with NASA officials and have incorporated their comments where appropriate.

CHAPTER 2

WHO SHOULD OPERATE THE SHUTTLE FLEET?

NASA is primarily a research and development agency. As NASA-developed technologies mature into operational systems, the question is who should operate the systems.

Decisions have been made ad hoc. For example, operation of weather satellites was transferred to another government agency, the Commerce Department's National Oceanic and Atmospheric Administration, whereas operation of communications satellites was transferred to COMSAT, a quasi-private firm chartered by the federal government. The current administration has been considering how to transition LANDSAT to the private sector but, because of the small market, no viable proposal has surfaced.

STS became operational in November 1982. NASA is again faced with the question about who should operate the system. Because of the resources that will be required, the decision as to whether NASA will operate STS is a much more important decision.

Many experts agree that routine space operations will require a radical change in management philosophy. Some experts believe that NASA should establish a separate organization to manage Shuttle operations. Others believe that Shuttle operations should be shifted to another federal agency or to a commercial organization after the Shuttle achieves a reasonable degree of maturity.

OPTIONS FOR MANAGING SHUTTLE OPERATIONS

A 1976 contractor study identified seven options for Shuttle operations and stressed the need for an early decision. These options included:

--Evolving the NASA research and development organizations into an operational organization with no distinct separation.

--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 DOD and NASA 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 1976 study, several top-level NASA managers were asked about NASA's future involvement in Space Shuttle operations. These officials generally felt that NASA should divest itself of any major role in Shuttle operations to (1) reduce operational costs, (2) prevent DOD restrictions on NASA activities, (3) ensure fair treatment of the user community, and (4) avoid possible unfavorable congressional reaction toward NASA having a large operational organization.

A 1977 National Academy of Public Administration Panel concluded, however, that NASA should manage the Shuttle operations. The panel believed that federal ownership and control is appropriate so long as federal agencies remain the major users and NASA is the best federal agency to manage the program. The panel also stated that if commercial usage flourishes, some private investment in the systems could become financially feasible.

But another recognized panel of experts, the Aerospace Safety Advisory Panel, suggested in early 1982 that a purely operational organization should be created to achieve routine, low-cost operational capability. This organization would function much like an airline or a military mission command rather than an engineering and development organization. Although the panel recognized that the operational organization would have to purchase services and hardware from NASA, it believes that the operational entity would (1) relieve the research and development organization of responsibilities it is ill-equipped to handle and (2) stabilize the Shuttle's performance requirements.

In August 1981 the Office of Science and Technology Policy began a study of the Nation's civilian and military space policy. This study resulted in the July 4, 1982, national space policy which provides that for the near term, STS will continue to be managed and operated in an institutional arrangement consistent with the current NASA/DOD Memorandum of Understanding.

The analysis supporting the space policy decision was issued by NASA in August 1982. It states that the evolving NASA/DOD partnership, strengthened by infusion of DOD personnel into the functional line management of the Space Shuttle, is the organizational setting best suited to direct near-term national STS operations.

This partnership provides the flexibility for a far-term transition to a new institutional setting if required.

At least two contractors are studying the possibility of buying and operating Space Shuttle orbiters. One contractor, for example, has offered to buy a fifth orbiter in return for an exclusive agreement to market all nongovernment activity on the Shuttles.

PLANNING ISSUES

The decision facing NASA over the next few years will be whether it remains primarily a research and development organization or increases its role in space operations.

The first STS operational flight was launched in November 1982. There are still unanswered questions.

--How long should NASA continue to operate the Shuttle?

--What are the long-term goals regarding NASA and Shuttle operations?

--Can NASA operate STS and at the same time continue research and development on major programs such as a space station?

CHAPTER 3

WILL NASA DEVELOP EFFECTIVE AND ECONOMICAL LOGISTIC SUPPORT FOR SHUTTLE OPERATIONS?

An integrated logistics support system must be established to provide effective and economical support for the Shuttle throughout its life cycle. The principal logistics processes are maintenance, supply, technical operational documentation, transportation packaging, logistics training, and logistics management information.

During Shuttle development, various NASA centers established and managed the logistics processes for the Shuttle components--Johnson for the orbiter; Marshall for the main engine, solid rocket booster, and external tank; and Kennedy for launch, landing, recovery, and refurbishment projects. However, a May 1978 NASA STS Operations Logistics Plan stated that the Johnson and Marshall developmental phase logistics processes would be transferred to Kennedy for the operational phase. Four years later as NASA begins Shuttle operations, it still has not directed the development centers to transfer Shuttle logistics management responsibilities to Kennedy.

STATUS OF SHUTTLE LOGISTICS CONSOLIDATION

A January 1981 NASA directive showed that plans for transitioning logistics responsibilities to Kennedy were to be developed by December 1981 and the item management system supporting Shuttle operations would be implemented at Kennedy by September 1982. At that time, September 1982 was the scheduled date of STS-5, the first operational flight.

A Kennedy official said that the decision to base Shuttle logistics operations at Kennedy was made so that the personnel who use the parts would control them.

As the logistics manager, Kennedy would oversee the repair, warehousing, transportation, documentation, modification, and configuration management of Shuttle components. Also, Kennedy would control the configuration of each Shuttle component and the budget for spares and technical support.

In October 1981 the STS Program Manager suspended center efforts to develop plans for transferring logistics responsibilities to Kennedy. He said that since the orbiter, external tank, main engine, solid rocket booster, and so forth, are still in production, the organization responsible for production should also be responsible for spares and refurbishment.

A March 1982 NASA study on Shuttle logistics management concluded that an early decision on the NASA management to support operations is needed. It found that specific top level policy guidance on how to proceed with the logistics management transfer is urgently needed. Also, the study made (among others) the following observations:

--NASA still does not have specific organizational assignment for managing Shuttle logistics after the development phase.

--Firm statements have not been issued to transfer Shuttle logistics management responsibilities from the development centers to Kennedy.

--There is no clear and up-to-date policy directive on overall NASA program management structure or center roles.

--Adequate data management systems are not available within NASA for a centralized logistics management operation.

--NASA should decide on its Shuttle operation organization before determining the method for transferring logistic management responsibilities.

The study team made (among others) the following recommendations to NASA officials.

--Establish and publish the centers' roles and responsibilities with respect to Shuttle operational management as soon as possible.

--Issue direction and policy guidance on how to proceed with transfer of logistics management responsibility.

--Establish a NASA/DOD transition working group to review and assess progress, highlight problem areas, and make recommendations.

--Establish logistics management transition milestones in relation to the Shuttle's progress rather than by specific calendar dates.

NASA officials said they have already established a NASA/DOD transition working group as recommended by the study team.

In April 1982 a NASA official said that the centers will probably retain responsibilities for logistics processes for the next several years and that transition planning will be deferred indefinitely. However, Kennedy is continuing to develop a computerized inventory management system to support NASA and DOD Shuttle needs into the 1990s. Kennedy requested proposals for hardware and software for such a system in December 1981 and awarded a contract in September 1982. The system will support about 325,000 items.

In April 1982 the NASA Office of Inspector General issued a report on its audit of the Space Shuttle program that included logistics management. The Inspector General (IG) noted that because of budget reductions, the procurement of many spares had been delayed, production and test assets had been used as a major source of spares, and some logistics tasks had been eliminated or delayed. The IG concluded that these support techniques impaired economical and effective logistics support.

The IG also concluded that NASA had not performed the planning and analysis needed to acquire and manage the orbiter inventory for the operational phase. The IG said that when accomplished, this planning should consider procuring operational spares directly from commercial vendors rather than the prime contractor as this direct procurement method could save $23 million during the period 1982 through 1985.

NASA issued a draft interim logistics support policy on July 8, 1982, that addresses some of the IG's concerns. However, it also states:

> "There will not be a significant transfer of functions, hardware, or responsibilities from the other Space Shuttle projects to the KSC Launch and Landing project during the interim operations period."

It also defines the interim operations period as starting with the STS-4 landing through the date that major organizational and support changes are made to manage and process the Space Shuttle in a fully operational mode. However, no specific date has been established for the end of the interim operations period.

PLANNING ISSUES

An economical and effective logistics system is needed to support the Shuttle during its operational life. For several years NASA has planned to transfer logistics management to Kennedy. NASA's interim logistics support policy further postpones any significant transfer of functions, hardware, or responsibilities to Kennedy. This along with the NASA IG study conclusions raises the question: Are adequate logistic procedures being developed and implemented on a timely basis?

CHAPTER 4

CAN LAUNCH AND MISSION CONTROL OPERATIONS

BE ACCOMPLISHED MORE EFFECTIVELY AND EFFICIENTLY?

The Launch Control Center located at the Kennedy Space Center serves as the management and operations control center during Shuttle servicing and launch countdown. The Launch Control Center at Vandenberg Air Force Base will provide similar functions when that launch site becomes operational in 1985. These sites perform all prelaunch and launch ground support activities until solid rocket boosters are ignited.

The Mission Control Center located at Johnson Space Center is responsible for preflight operations planning, defining and developing mission control support facilities, and preparing and conducting onboard and ground-support flight activities. Before launch, this organization designs the Shuttle flight, plans the crew's activity, prepares the flight data files, establishes flight support communication links, conducts prelaunch readiness checks, and so forth. During Shuttle operations, mission control directs the Shuttle flight beginning with solid rocket booster ignition and concluding when the orbiter stops on the runway. This function includes providing abort advisories to the crew, providing solid rocket booster impact predictions, and directing reentry and landing.

Two minutes after launch the solid rocket boosters separate from the orbiter and external tank and parachute into a recovery area about 120 to 170 miles off the Florida coast. Beginning in July 1983 the Department of the Interior plans to issue 10-year leases for oil and mineral deposits exploration in part of this area.

There are questions as to whether (1) NASA's mission control operations at Johnson Space Center should be transferred to the Kennedy launch site, (2) the Johnson Mission Control Center should be upgraded, and (3) proposed oil and mineral exploration will affect Kennedy launch operations.

PROPOSED TRANSFER OF MISSION CONTROL OPERATIONS TO LAUNCH SITES

The Kennedy Space Center employs systems and engineering personnel who analyze Shuttle systems until lift-off (launch control) and the Johnson Space Center employs a similar group of personnel who assume full responsibility for Shuttle operations after lift-off (mission control). Each organization must coordinate with each other's actions.

However, an August 1981 NASA planning document stated that mission control should be transferred from Johnson to Kennedy and Vandenberg (when that facility becomes operational) to increase operations efficiency and reduce costs. The document further stated that Johnson should phase out of the operational mission during the next 3 years. Consistent with these statements, NASA Headquarters officials reportedly believe that a consolidation of launch and mission control activities at Kennedy must be examined over the next 2 years and that a mid-1980s goal for consolidation at Kennedy is appropriate.

The mission control function for U.S. manned spaceflight has been based at Johnson for nearly 20 years, and transferring this function to Kennedy and Vandenberg would have a substantial impact. Some Johnson officials, for example, believe that a near-term transfer is unlikely because of the costs involved and the current investment in new facilities at Johnson. However, other Johnson officials believed that mission control operations should have been placed at Kennedy with launch operations in the 1960s.

Implicit in any transfer of mission control from Johnson to Kennedy are issues relating to whether such a transfer would include moving the astronaut training and mission simulator activities to Kennedy. These activities are closely integrated with mission control.

PROPOSED UPGRADE OF JOHNSON MISSION CONTROL TO PROVIDE MULTIPLE MISSION CAPABILITY AND OTHER IMPROVEMENTS

The Johnson Space Center plans to spend $85 million to upgrade the Mission Control Center for multiple flight capability, provide an interim secure control facility for DOD flights, develop a payload operations control center to support spacelab flights, and obtain a spacelab simulator. The control facility for DOD flights is an interim capability which would be used from November 1983 to 1987 when the DOD Consolidated Space Operations Center in Colorado is ready for use.

The multiple flight capability is scheduled to be available in 1984. This capability was planned to support 14 launches during 1984 with an increase to 24 launches during 1986. However, current plans call for only 5 flights in 1984 with an increase to 13 flights by 1986.

If operations were consolidated at Kennedy by 1986, then the multiple mission capability planned for the Johnson Mission Control Center may not be required. Also, it would seem reasonable to believe that the $85 million mission control upgrading project may only be an interim step since a NASA planning document stated Johnson should phase out of the operational mission during the next 3 years.

NASA officials said there is no indication that a decision to consolidate Johnson Space Center and Kennedy Space Center will be made in the near future. Therefore, it is highly improbable that any consolidation can be implemented before the fiscal years 1987-88 time frame when the flight rate will be in the twenties.

OIL AND MINERALS EXPLORATIONS COULD AFFECT THE SOLID ROCKET BOOSTER RECOVERY AREA

The solid rocket boosters provide thrust during the first 2 minutes of the Shuttle launch. The boosters are then separated from the orbiter's external tank and parachute into the ocean some 150 nautical miles downrange for recovery and reuse. The solid rocket booster recovery area for Kennedy launches extends about 120 to 170 nautical miles off the Florida coast into the Atlantic Ocean. However, the Department of the Interior plans to lease part of this area beginning in July 1983 for oil and mineral deposits exploration. The leases will run for 10 years, and activity can begin at any time.

The Commander, Air Force Eastern Test Range, is responsible for range safety for Kennedy launches. A March 1982 report prepared by the Eastern Space and Missile Center in conjunction with Kennedy Space Center on vehicle flight safety examined the potential impact that the oil and minerals exploration could have on the Space Shuttle launches. NASA and the Air Force believe the oil and minerals exploration in this area will increase Shuttle launch costs or range safety risks because returning solid rocket boosters could be damaged, launches could be delayed, and the choice of launch azimuths could be restricted. Also, it will require additional helicopter and ship support to clear the hazard area and additional personnel for range safety support. There is also increased range safety risks if the launch is aborted.

We met with NASA Headquarters officials in late October. They said they have been working on this problem with the Department of the Interior to prevent the above concerns from becoming a reality.

PLANNING ISSUES

The plans to upgrade the Mission Control Center may only be an interim step fulfilling a reduced requirement for multiple mission capabilities in view of the reduced number of flights planned for the early STS operational time frame and the potential phase out of Johnson's operational mission. This issue along with the issue of oil and minerals exploration in the solid rocket booster recovery area at Kennedy Space Center raises several questions concerning launch and mission control operations:

--Is the total $85 million needed to upgrade the multiple mission control capability at Johnson Space Center in view of the reduced number of flights in the early years of STS operations?

--How long will the mission control capability be needed at Johnson Space Center?

--Will additional construction be needed at Kennedy to provide the mission control capability? If so, when is it needed, what is needed, and how much is it estimated to cost?

--Will the offshore oil and minerals exploration in the solid rocket booster recovery area at the Kennedy launch site affect the U.S. space program and space goals?

--What are the specific risks and hazards to NASA/Air Force personnel and their facilities and equipment that will be created by the proposed July 1983 leases?

--What are the specific risks and hazards to the leasee's personnel, facilities, and equipment?

--What specific actions has NASA taken in cooperation with the Department of the Interior to lessen these risks and hazards and to address the concerns in the March 1982 Air Force and NASA report?

--Will the lease revenues and the contribution of the leases toward meeting our national resource goals be of greater significance than the impact on the space program?

CHAPTER 5

CAN NASA'S ASTRONAUT RECRUITMENT AND TRAINING PROCEDURES BE IMPROVED?

A typical Space Shuttle crew will include two pilots and one or more mission specialists. The pilots and mission specialists are the trained astronaut corps. The command pilot and copilot fly the orbiter. Mission specialists are spacecraft-proficient crew members who will normally operate the remote manipulator systems and perform extravehicular activity to service instruments or satellites deployed on Shuttle missions. They will also be skilled in payload operations and function as the payload specialist, whose primary function it is to operate the scientific experiments in space. When a specialist or expert in a given scientific field is not available within the astronaut corps, a nonastronaut will be selected to perform the payload specialist duties and given a limited amount of training on how to function in space.

In 1977 NASA projected that about 40 pilots and 40 mission specialists would be needed to support 487 flights during the first 12 years of Shuttle operations.

As of February 1982 NASA had 77 astronauts about evenly divided between pilots and mission specialists. However, since 1977 the number of planned missions has decreased from 487 to 234 and the expected maximum annual launch rate decreased from an estimated 55 launches per year to 24 launches per year. Thus, while the astronaut requirements have remained constant since 1977 the flight requirements have been reduced more than 50 percent.

THE ASTRONAUT CORPS MAY BE UNDERUTILIZED

Initial projections for the astronaut corps were based on pilots flying about three missions a year and mission specialists once a year or less. With the reduced launch rate NASA estimates the pilots will only fly every 8 to 12 months. Until NASA builds up to the 24 per year launch rate, it is likely that astronauts will be flying even less. It will certainly be difficult to use the pilots effectively and efficiently without additional flights.

NASA believes it can better use its mission specialists by having them serve as payload specialists. Beginning with Spacelab 3, investigators will be required to use mission specialists as payload specialists unless they can show a need for a specialist or expert in a given scientific field not available within the astronaut corps. However, with this change in policy, scientists are concerned they will lose the opportunity to operate their experiments in space, an option originally planned for the spacelab.

DIFFICULTIES IN PLANNING ASTRONAUT CORPS LEVELS TO MEET MISSION REQUIREMENTS

NASA recruited a total of 54 new astronauts in 1978 and 1980. They did not recruit any astronauts in 1979. The 54 astronauts consisted of 33 military and 21 civilian astronauts. NASA astronauts must train for 3 years. This means that 54 astronauts will complete training and be ready to fly during the 1981-83 time frame when NASA will just be starting to build up its launch rate. This situation is further complicated because military astronauts serve for a period of 5 to 7 years. With the 3-year training requirement, this leaves a maximum of 4 years flight service for military astronauts. Thus, the military astronauts recruited in 1978 will complete their astronaut service no later than 1985 and those selected in 1980 no later than 1987.

Civilian astronauts may leave at any time although there is an unwritten understanding that they will remain with NASA at least 5 years. Only operational experience will show the expected length of civilian astronaut service.

PLANNING ISSUES

The size of NASA's astronaut corps seems somewhat inflexible to changing mission requirements. As NASA begins the Shuttle operations era, there is one primary planning issue: Are there alternative recruitment and training procedures that could better provide for NASA's astronaut requirements?

CHAPTER 6

WILL NASA'S ACCOUNTING SYSTEM ADEQUATELY

IDENTIFY COSTS FOR SHUTTLE LAUNCHES AND SERVICES?

NASA's past efforts primarily have involved research, development, and production of a few large technological systems and periodic launches of expendable vehicles. Managing Space Shuttle operations will represent a new era for NASA. It will support frequent launch, operation, and recovery of the Shuttle for a variety of users including NASA, DOD, and commercial organizations. Unlike prior standard launch operations, users may now obtain optional or special services.

For Shuttle launches, NASA has established a fixed price for standard launch services and separate fixed prices for each optional service. To ensure that the fixed price will equitably recover appropriate expenses, NASA will have to accumulate costs in such a manner that the cost of a standard launch and each optional service can be determined. Such information should also assist center managers in keeping expenditures at recoverable levels.

NASA'S ACCOUNTING SYSTEMS WILL NOT ACCUMULATE COSTS BY INDIVIDUAL MISSION

Kennedy, Marshall, and Johnson's cost accounting systems do not provide for accumulating costs by individual launch, type of service provided, or user. This potential problem was recognized as early as 1977 when a NASA study of financial systems pointed out that costs will have to be recorded in a manner that relates directly to the way services are priced. The report further stated that whether special services desired by some users are provided on a cost incurred or fixed-price basis, the cost accounting system should be able to support either method. The 1977 study further noted that the NASA commitment to a fixed-price policy placed a much heavier emphasis on cost management than did previous programs. It also predicted that cost management will need as much attention as performance management to ensure that costs are held to recoverable levels.

NASA centers operate under the standard NASA budget and accounting guidance which provides for accumulating cost by unique project number--a number under which funds are budgeted and controlled. Contractor costs--which comprise most of the Shuttle operations costs--are accumulated by contract and by unique project number. NASA center officials said that the cost per flight would be determined annually by totaling the Shuttle operations cost for all locations and dividing by the total number of missions for the year.

ACTUAL MISSION COSTS MAY VARY SIGNIFICANTLY

The actual mission costs may vary significantly depending upon the mission's length, optional services required, and the user.

A standard launch on the Shuttle consists of 1 day of operation by a 3-member crew. It includes on-orbit payload handling and deployment of a free flying spacecraft at a 160-nautical mile orbit. A recent NASA paper on Shuttle cargo operations states that when performance above the standard level is required it must be negotiated with the user on a case-by-case basis.

Optional services will be required for many flights. Available optional services include using a spacelab, using upper stages to boost a payload beyond low-Earth orbit, staying in orbit more than 1 day, requiring more than three crew-members, adding flight kits, or performing optional payload related services such as extravehicular activities.

Costs of NASA launches for DOD may cost more or less than the standard launch service provided to other users. For example, NASA's cost to support a DOD mission is not the same as for other users because the Air Force verifies the electrical compatability of DOD payloads with the orbiter and performs mission control functions. Other users do not perform these functions.

PLANNING ISSUES

NASA's accounting system must provide adequate information for pricing Shuttle flights. This point was emphasized in NASA's 1977 study. We also reported in 1977 1/ that NASA had not established accounting procedures to accumulate Shuttle operations costs. NASA officials said then that they had placed their priority on establishing a preliminary user charge policy and had not yet established the necessary accounting policies and procedures to implement this policy. The overall question is: What changes need to be made to NASA's current accounting system and procedures to provide adequate data for NASA to manage STS and carryout its STS pricing policy?

1/"Space Transportation System: Past, Present, and Future" (PSAD-77-113, May 27, 1977).

CHAPTER 7

ARE LAUNCH, LANDING, AND AUXILARY FACILITIES ADEQUATE FOR STS OPERATIONS?

When STS was approved for development in 1972, NASA and DOD agreed that for the program to be fully operational it would require two launch sites--Kennedy Space Center in Florida and Vandenberg Air Force Base in California.

Kennedy is the primary launch, landing, and orbiter refurbishment site. NASA's approach was to maximize use of the facilities of the completed Apollo program by taking existing major facilities, such as the vehicle assembly building, mobile launchers, and launch pads, and modify them to support Shuttle requirements. New construction included an orbiter processing facility and a landing runway. Kennedy began actual STS operations in November 1982 with facilities for processing two orbiters concurrently.

The second site, Vandenberg, is being funded by DOD and it is responsible for developing and operating Shuttle launch and landing facilities there, as well as special DOD facilities needed at Cape Canaveral Air Force Station in Florida and NASA's Kennedy and Johnson Space Centers. DOD used existing facilities left from the canceled Manned Orbiting Laboratory program where possible. The Vandenberg launch and landing site is to become operational in October 1985.

The Kennedy and Vandenberg facilities provide different modes of operation. At Kennedy, the Shuttle assembly, payload checkout, and installation take place in facilities remotely located from the launch pad, and the Shuttle is then transported to the pad. At Vandenberg these functions are performed on the launch pad.

LONGER SHUTTLE TURNAROUND TIME MAY REQUIRE ADDITIONAL FACILITIES AND EQUIPMENT

NASA's May 1982 Shuttle turnaround time estimate exceeds NASA's design goal by 4-1/2 times. Shuttle turnaround time is the period between orbiter landing at the launch site and its next launch. NASA's initial operational design goal was for Shuttle turnaround time not to exceed 160 working hours covering a span of 14 calendar days based on a 5-day, 2-shift workweek. As of May 1982 NASA estimated it will attain a Shuttle turnaround time of 888 hours by its 26th operational launch.

NASA personnel estimate that with this turnaround time its maximum annual flight capability is 15.6 flights. If a third mobile launcher platform is added, the annual flight capability, as shown on the next page, is 23.4 flights.

Annual Flight Capabilities

Major facilities and equipment	Quantity of facilities and equipment 1	2	3	4
	------(Not	limiting)	-----	
Crawler-transporter				
Launch pad	13.6	27.2	-	-
Orbiter processing facility/ high bay	18.6	37.2	-	-
Vehicle assembly building/ high bay	14.3	28.6	-	-
Mobile launcher platform	7.8	15.6	23.4	-

The current traffic model for four orbiters shows that the Kennedy Space Center is expected to launch 18 flights per year by 1988, and this could increase to 30 flights per year with a fifth orbiter. As noted in the above table, the mobile launcher platform, vehicle assembly building, and launch pad constraints indicate that 30 launches per year are unlikely unless the turnaround time is drastically reduced or the facility constraints eliminated by buying additional facilities. NASA officials said that NASA has included in its fiscal year 1983 and 1984 budgets facility and equipment funding requirements to reach a launch rate of 24 per year.

DOD SECURITY REQUIREMENTS

DOD has developed a classification guide that is applicable to almost all facilities and tracking, telemetry, and communications equipment. The controlled mode, the term used for DOD's ability to conduct classified missions using the STS and NASA facilities, has required modifications at Kennedy, Johnson, and Goddard and to the Tracking and Data Relay Satellite system. Estimated costs to secure DOD operations have increased and are estimated at about $100 million just for Kennedy and Johnson. DOD is funding these costs.

In February 1977 the STS Program Manager disbanded a NASA/ DOD requirements coordinating group only to form a new NASA Security Review Team by December 1978. Yet, in 1980 the NASA Administrator asked the Shuttle Program Director to find out what DOD's security requirements really were. There are also indications that NASA was reluctant to accept DOD's security requirements at NASA installations because they provided DOD too much control over Shuttle operations.

PLANNING ISSUES

NASA's initial design goal was for Shuttle turnaround time not to exceed 160 hours. NASA's most recent estimate was for an 888 hour Shuttle turnaround time by its 26th operational launch. As the turnaround time increases, more facilities are needed to maintain the Shuttle launch rate. The questions are:

--What will these facilities cost?

--What will the effect of these facilities' costs be on NASA's budgets?

--What are the costs of DOD's security requirements at these facilities?

--What effect will the DOD security requirements have on NASA's normal STS operations?

CHAPTER 8

ARE ADDITIONAL ORBITERS AND/OR EXPENDABLE LAUNCH VEHICLES NEEDED FOR STS?

The Space Shuttle was approved on the premise that NASA and DOD would phase out expendable launch vehicles. This concept continued at least through the 1970s. The NASA phaseout was to be completed 3 years after the first operational flight (launched in November 1982), and the DOD phaseout was to be completed 1 year after initial operational capability at Vandenberg (now scheduled for October 1985).

By late 1981 both NASA and DOD had serious doubts that either could be totally dependent on the Shuttle. The NASA Deputy Administrator, for example, stated "it is now generally agreed that unmanned launch vehicles will not be phased out completely once the shuttle is operational." Also, DOD officials and studies have recently reiterated the need for DOD to continue using expendable launch vehicles.

In August 1982 NASA published its analysis of policy issues including the question of a mixed fleet and future launch vehicle needs. For all cases and conditions evaluated, it was concluded that an all-STS fleet is more cost effective than a combined STS and expendable launch vehicle fleet. Also, they concluded that a fifth orbiter should be available as soon as possible after 1986 and a sixth orbiter should be delivered no later than the 1990-1991 time frame. Further, they suggested that a seventh orbiter will be needed in 1991. The final conclusion was that the national STS fleet should consist of both expendable launch vehicles and reusable Space Shuttles until the capability of STS is sufficient to permit the phase out of the expendable launch vehicles.

MISSION MODEL VERSUS PAYLOAD REQUIREMENTS

NASA has used a number of traffic and mission models for STS planning and justification. In October 1973 NASA presented to the Congress a 725 flight mission model covering the period 1980 through 1991. This model would have required the acquisition of seven orbiters. However, NASA's planned STS program actually presented to the Congress was more conservative and only provided for five orbiters.

Since 1973 there has been a continuing reduction in NASA's mission model because the STS capability has not measured up to design requirements and because in 1978 a decision was made to request only four orbiters. NASA now projects that the most probable mission model is for 234 flights through 1994.

Essentially, the mission model is only a planning estimate based more on Shuttle capability rather than on approved payload plans. Despite this, the mission model has been used to justify the orbiter fleet size. There is some question now as to when and if NASA and DOD will phase out their expendable launch vehicles. There appear to be conflicting opinions on this matter.

NASA currently has viable operating systems for Delta and Atlas launches. There are 48 Delta launches scheduled from January 1982 through March 1987 of which 40 are reimbursable commercial payloads. All of the Delta reimbursable payloads are communications satellites destined for geosynchronous orbit and all are compatible with the STS and the French Ariane.

NASA officials and recent market surveys indicate that the next two major areas requiring launching services will be remote sensing satellites and materials processing. The private operation of remote sensing and meteorological satellites and the availability to industry of remote sensing output from DOD satellites are still being debated. The number of expendable launch vehicles or STS launches needed to serve this market has not been established.

It is also very evident that space systems have become important elements in U.S. military force structure and dependence on them has increased in response to their unique capabilities, worldwide coverage, reductions in overseas land bases, and phase-out of nonspace alternatives. Military payloads now include communications, weather, navigation, nuclear detection, remote sensing, reconnaissance, and classified intelligence collection satellites. Other military payloads could be added in the future.

Regardless of what NASA and DOD decide, there are private sources within the United States who are developing an expendable launch vehicle that could prove to be an alternative to Shuttle launches, particularly for smaller payloads. Also, foreign capabilities, including the French Ariane, also exist.

FUTURE LAUNCH CONCEPTS AND/OR SHUTTLE IMPROVEMENTS COULD PROVIDE VIABLE ALTERNATIVES

NASA and DOD have a number of ongoing contractor studies to develop alternative launch vehicles and concepts. Some examples are:

- --A horizontal take-off rocket powered aircraft called the Reusable Aerodynamics Space Vehicle.

- --Advanced propulsion concepts for a military space sortie system that would provide a fast response Earth-to-orbit capability.

--Technology requirements for Shuttle derived vehicles--the so called heavy lift or super Shuttle.

--An unmanned launch vehicle derived from the Shuttle's recoverable solid rocket boosters. The vehicle is called the SRB-X and would supplement the Shuttle.

PLANNING ISSUES

Although NASA takes the position that an all-orbiter fleet is the most cost effective, it still does not know when the expendable launch vehicles can or will be phased out. Some of the more apparent planning issues are:

--What are the short- and long-term space launch requirements for U.S. government and commercial users and for foreign government and commercial users?

--Based on current U.S. space policy, what part of the space launch market will NASA try to reach?

--Based on a four orbiter fleet, what portion of the space launch requirements can NASA fulfill?

--What are the alternatives to a four orbiter fleet to provide additional launch services and what are the pros and cons of each alternative?

--What is the government's responsibility to meet the demand for launch services? Should the government increase the launch capability to meet demand?

CHAPTER 9

WILL STS ACHIEVE ITS DESIGN GOALS AND

WHAT ARE NASA'S PLANS TO ENHANCE ITS OPERATION?

STS is being designed to place payloads weighing up to 65,000 pounds into a 150-nautical mile, due-east orbit from Kennedy and up to 32,000 pounds into a specified 100-nautical mile near-polar (north-south) orbit from Vandenberg. It was also to be designed to retrieve payloads in orbit for refurbishment and reuse.

STS became operational in November 1982. However, STS currently cannot perform at its designed level nor will it have the operational capability to routinely retrieve and/or repair satellites on orbit for some time. However, NASA is working toward these goals.

MAJOR STS COMPONENTS STILL UNDER DEVELOPMENT AND TESTING

NASA began STS operations with a 39,000-pound launch capability--26,000 pounds short of its design goal. However, NASA is taking steps to improve the Shuttle lift capability by developing lighter weight external tanks, solid rocket boosters, and orbiters. Also, NASA plans to introduce a higher performance motor for the solid rocket booster and increase the performance of the orbiter's main engines. With these changes NASA expects to achieve its 65,000-pound lift capability for selected orbiters by 1984.

NASA officials recognize that not every user can be assigned to fly in the high performance orbiters. Also, because higher engine performance reduces engine life, engines should be operated at minimum levels when appropriate. This and other economic considerations will result, for most users, in reduced performance to about 57,000 pounds in a 150-nautical mile orbit at a 28.5 degree inclination. When performance above this level is required, it must be negotiated with NASA on a case-by-case basis.

Other development efforts or solutions may be required. For example, the auxiliary power units, brakes, tires and wheels, remote manipulator arm, fuel cell, thermal protection system, toilet, radio, and so forth, showed evidence of less than optimum performance while other capabilities such as crosswind landings have not yet been tested.

SATELLITE SERVICES EQUIPMENT UNDER DEVELOPMENT AND ORBITAL TRANSFER VEHICLES BEING PLANNED

Satellite services is a catchall program for a group of projects NASA is defining to enhance the Shuttle's capabilities in the area of satellite retrieval, return, refurbishment, and reuse; satellite on-orbit maintenance and repair; unsteady satellite stabilization; space debris removal; and satellite and Shuttle inspection.

The satellite services projects are apparently in support of activity in near-Earth orbit. One element in satellite services is the teleoperator maneuvering system defined in 1970 which is necessary for positioning and maintenance of the space telescope due to be launched in January 1985. However, the teleoperator maneuvering system may not be operational until 1986 or 1987.

The space tug was dropped from the STS program in about 1977. It was to deliver 6,000-8,000 pounds to geosynchronous orbit and retrieve 3,000-4,000 pounds from this orbit. By 1979 NASA had initiated a new study and definition effort leading to the development and operation of another reusable upper stage to extend the capabilities of STS up to geosynchronous orbit. This time it is called the Orbital Transfer Vehicle.

NASA is planning an evolutionary development program that will provide a manned orbital transfer vehicle by the mid-1990s. Although the development approach is not firmly defined, NASA may develop an interim orbital transfer vehicle, then a reusable unmanned vehicle, and ultimately a fully reusable manned vehicle. Early thinking on this renewed space tug project was that the Orbital Transfer Vehicle would be space based, serviced by the Shuttle, and periodically returned to Earth for refurbishment.

PLANNING ISSUES

NASA plans to continue STS development to achieve design requirements and fund Shuttle enhancements to achieve payload savings through satellite retrieval, on orbit maintenance, or return to Earth for refurbishment. The questions are:

--Will the Shuttle enhancements provide sufficient capability to permit NASA to achieve its design requirements?

--Will satellite services equipment and the orbital transfer vehicles being developed by NASA provide sufficient on-orbit capability to meet user requirements in a timely manner?

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