# SPACE SHUTTLE

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## ISSUE DEFINITION

The National Aeronautics and Space Administration's major manned program of the post-Apollo era is the development of a space transportation system (STS) based on a reusable space shuttle launch vehicle. Funded since FY71, the shuttle program is coming to fruition: the space shuttle successfully completed its series of four test flights on July 4, 1982. The first operational flight was successfully completed in November 1982. The next shuttle flight has been delayed because of leaks in one of the orbiter's main engines. NASA hopes to be ready for launch on Apr. 4, 1983.

Total estimated costs for research, development, test, and evaluation of the shuttle are expected to be $18.030 billion in FY83 dollars. The original estimate for the shuttle program was $5.15 billion in 1971 dollars. If deescalated to 1971 dollars, the current estimated cost of the shuttle program is $6.748 billion, an increase of 31%.

Although the shuttle is being developed by NASA, the Defense Department has played a role in designing the shuttle since the beginning of the program because it will be a prime shuttle user. In addition to providing input to the shuttle's design, DOD is developing the inertial upper stage (IUS) for the shuttle, and constructing shuttle launch facilities at Vandenberg Air Force Base.

Major shuttle issues before the Congress include: cost overruns, schedule slippages, and NASA shuttle program management; the Centaur vs. the IUS as an upper stage; transition from expendable launch vehicles to the shuttle; how many shuttle orbiters to build; who should ultimately own and operate the shuttle; and shuttle pricing policy.

## BACKGROUND AND POLICY ANALYSIS

This section of the issue brief is divided as follows:

Shuttle Upper Stage -- IUS or Centaur
Continuing Need for Expendable Launch Vehicles
Shuttle Pricing Policy

## SPACE SHUTTLE PROGRAM

### The Space Transportation System

The concept of a reusable space vehicle has existed at least since the 1940s. However, this concept was shelved during the 1950s and 1960s because the early development of the space program was closely linked to the military ballistic rocket program and the pressure of the "space race" did not permit a redirection in basic concepts. The climate of public opinion with regard to the space program cooled drastically after the successful moon landing in 1969, and since that time cost has been a primary consideration in future space planning. In this changed climate, NASA's long-range plans have been sharply scaled down, and ambitious projects such as manned Mars expeditions and permanent space stations have been indefinitely postponed. The space shuttle emerged as the chief hope for maintaining a meaningful space program because of the savings it promised in the cost of space operations and most future space activities are predicated on the availability of a space transport vehicle which can deliver payloads into Earth orbit.

The term "space transportation system" (STS) has come to be used interchangeably with the term "space shuttle," although the shuttle is only one element of the system. As originally envisioned, STS would have involved a fully reusable space shuttle, units such as Spacelab which are carried in the shuttle cargo bay, a variety of reusable and expendable upper stages to take payloads into orbits higher than those which the shuttle can access directly, and auxiliary power supplies to permit the shuttle to remain in orbit for longer periods of time and to provide electrical power for experiments. During the early phase of STS discussions, plans also existed for building a permanent earth orbiting space station which would be serviced by the shuttle.

As budget constraints within NASA increased, however, the scope of STS diminished to where it is now only the shuttle (and units like Spacelab which fit into it) and a variety of expendable upper stages. The fully reusable shuttle concept was dropped in 1971 because of budget concerns, and a partially reusable system (described below) was substituted. President Nixon gave the go-ahead for the current shuttle system in January 1972.

The remaining STS elements may be developed in the future, but this depends upon budgets and needs. Without auxiliary power supplies, the shuttle can only remain in orbit for 7-10 days, and limits are placed on the number and kind of experiments that can be conducted (materials processing experiments, for example, require large supplies of electrical power). Although space station plans were deferred during the 1970s, NASA is now strongly recommending that such a program be the Nation's next major space goal. Availability of a space station could decrease the need for auxiliary shuttle power sources.

Plans have also been deferred for developing reusable upper stages such as the Space Tug and Orbital Transfer Vehicle, and for units such as a remotely controlled Teleoperator Retrieval System. If a strong need is perceived for such capabilities, NASA, DOD, or private industry may develop them.

Description of the Space Shuttle

The partially reusable shuttle consists of a manned orbiter vehicle, an expendable propellant tank (referred to as the external tank), and two recoverable solid-fueled booster rockets. The shuttle is launched by use of the solid-fueled rockets together with liquid-fueled engines on the orbiter, which are fed from the external tank. The solid rocket casings are parachuted back to Earth and land in the ocean to be recovered and reused. The empty external tank, when released, breaks up and is partially destroyed by heat as it re-enters the atmosphere. The remaining pieces fall into the Indian Ocean (after a launch from the Kennedy Space Center) or the South Pacific Ocean (for launches from Vandenberg Air Force Base).

The Orbiter. The orbiter, which resembles an airplane, is designed to carry up to 65,000 pounds (29,545 kilograms) into Earth orbit (185-1110 Km or 100-600 nautical miles). The shuttle will routinely carry a crew of three to seven persons (although the first four missions had a crew of two), plus a payload such as a satellite to be placed in Earth orbit. For some missions, the payload will include a pressurized space laboratory, "Spacelab," which has been developed by ten European nations at their expense and will be used to conduct experiments in the orbiter payload bay. When the mission of the shuttle is completed, the orbiter returns to Earth and lands horizontally like an airplane, bringing back to Earth the Spacelab or other payloads in its cargo bay. The shuttle is designed to stay in orbit for 7-10 days, although there are adequate supplies to provide for contingencies which might force a mission to be extended.

NASA has been authorized to construct four flight-worthy space shuttle orbiters (Orbiter 101 will not be used for space flights). Debate over whether a fifth shuttle orbiter will be needed to accommodate all potential shuttle users through the rest of this decade has continued for many years, and has yet to be resolved. The authorized shuttle orbiters have both numbers and names as follows: Orbiter 101 (Enterprise); Orbiter 102 (Columbia); Orbiter 099 (Challenger); Orbiter 103 (Discovery); and Orbiter 104 (Atlantis). Rockwell International is the prime contractor for the orbiters.

Orbiter 101 was used for the approach and landing tests described below, but will not be used for space flights because it is overweight; reconfiguration for flight appears to be prohibitively expensive. Orbiter 101 is currently at Rockwell's Palmdale, California, facility where the orbiters are constructed, and it is being used for spare parts for Orbiters 103 and 104. It may also be used to test the launch facilities an Vandenberg AFB.

Orbiter 102 was used for the four orbital test flights and the first operational flight. It is now being refurbished and slightly modified for future flights.

Orbiter 099, formerly designated the Structural Test Article, was originally designed solely for ground testing. It has been converted to flight configuration, and will be the second orbiter into space. Challenger was delivered to NASA's Kennedy Space Center on July 5, 1982, and will make its first spaceflight in 1983.

Production of long lead items for Orbiters 103 and 104 has started, with plans currently calling for these orbiters to be ready in 1984 and 1985, respectively.

The debate over the need for a fifth shuttle orbiter is discussed under the ISSUES section below.

Launch and Landing Sites. Two launch and landing sites are planned for the space transportation system: Kennedy Space Center (KSC) at Cape Canaveral, Florida, for launches into an easterly orbit and the Vandenberg Air Force Base (VAFB) in California for launches into polar or sun-synchronous orbits. KSC has been used for all launches to date, and landings are expected to begin at KSC in 1983 (instead of at Edwards AFB, California). VAFB is scheduled to begin shuttle operations in October 1985.

## Approach and Landing Tests

The first series of suborbital flight tests (known as the ALT or Approach and Landing Tests) for the space shuttle orbiter 101 (the Enterprise) were held during February and March 1977 at Edwards Air Force Base (AFB), Calif. In these tests, the orbiter was unmanned, with the systems inert, and mounted on a Boeing 747 which was specially modified to be the shuttle carrier aircraft. The second series of flight tests, during which the orbiter was manned and its systems were active (while attached to the Boeing 747), took place in June and July 1977. The third series of flight tests was successfully initiated in August 1977 with the first free flight and landing of the orbiter Enterprise. Five successful free flights were carried out in this last series of approach and landing tests, with the last test in October 1977.

## Orbital Flight Tests

The first four shuttle flights, referred to as Orbital Flight Tests (OFTs), were designed to test shuttle capabilities and systems. All OFTs were carried out by Orbiter 102 (the Columbia), were launched from NASA's Kennedy Space Center at Cape Canaveral, Florida, and landed at Edwards Air Force Base, California (except for STS-3 which landed at White Sands, N.M. because of weather problems).

STS 1. The first orbital test flight, designated STS-1 (for Space Transportation System 1), was successfully launched at 0700 EST on Apr. 12, 1981. Launch had been delayed for two days because of problems with computer software. STS-1 was commanded by John Young, a veteran of four previous space flights, and piloted by Robert Crippen, on his first space flight. All test objectives were met on the 54 hour 21 minute mission, and Columbia performed as planned. After landing at Edwards AFB at 1321 EST on Apr. 14, the Columbia was flown atop the shuttle carrier aircraft back to Kennedy Space Center for refurbishment for the next shuttle mission.

STS 2. The second shuttle test flight, STS-2, was successfully launched on Nov. 12, 1981. Commanded by Joe Engle and piloted by Dick Truly, the flight was originally planned to last for 5 days and 4 hours, but was curtailed when problems developed with one of the three fuel cells which provide electricity for the spacecraft. The shuttle landed at Edwards AFB, California on Nov. 14 after 2 days and 6 hours in space. Although the mission was shortened considerably, NASA states that 90% of the mission objectives were met, including testing of the Remote Manipulator System (built by Canada) which will be used on subsequent flights to deploy and retrieve satellites. STS-2 also carried a payload designated OSTA-1 (for NASA's Office of Space and Terrestrial Applications). The experiments in the payload concerned remote sensing of land resources, atmospheric phenomena, and ocean conditions, including 1) a Shuttle Imaging Radar (SIR-A) to test techniques for mapping geological structures important in oil and gas exploration; 2) a Multispectral Infrared Radiometer (SMIRR) to measure solar reflectance of mineral-bearing rock formations; 3) a Feature Identification and Location Experiment (FILE) to discriminate between water, bare ground, vegetation, snow, or clouds in order to collect only wanted data; 4) a Measurement of Air Pollution from Satellites (MAPS) experiment to measure the distribution of carbon monoxide in the troposphere; 5) an Ocean Color Experiment (OCE) to map algae concentrations; 6) a night and day optical survey of lightning storms (NOSL); and 7) a Heflex Bioengineering Test (HBT) to determine the relationship between plant growth and moisture content in the space environment.

Two attempts to launch STS-2 on Nov. 4 failed because of problems with the lubricant for two of the three auxiliary power units (APUs) used for launching and landing the shuttle. The APUs provide power for hydraulic systems which rotate the shuttle main engines during launch and drive the landing gear and aerodynamic control surfaces (rudder, elevons, etc.) during reentry. The problem was caused by dirty filters which prevented the lubricating oil from reaching the hydraulic lines.

STS 3. The third OFT mission, STS-3, was successfully launched at 1100 EST on Mar. 22, 1982, and landed at 1105 EST on Mar. 30. Because of inclement weather at the prime landing site (Edwards AFB, California), the shuttle landed at the White Sands Missile Range in New Mexico. Launch was delayed by one hour because of difficulties encountered during fueling the external tank. Landing was delayed by one day because of high winds at the landing site.

The mission was commanded by Jack Lousma, on his second spaceflight, and piloted by Gordon Fullerton, on his first. The crew spent eight days in orbit performing a wide variety of engineering and scientific experiments. One major goal of STS-3 was to determine the heating effects on the shuttle from the Sun while in orbit. The shuttle passed all these tests, although the payload bay doors would not close after prolonged exposure to the cold, and had to be warmed in order to shut. In addition, STS-3 carried the OSS-1 payload (Office of Space Science 1), which included experiments related to astronomy and space plasma physics. The crew continued tests of the Remote Manipulator System begun on STS-2, but two of the cameras required for operating the RMS failed (one on the RMS itself, the other in the shuttle cargo bay), so one of the two tests had to be cancelled. Among the scientific experiments on STS-3 was a small greenhouse, about the size of a file cabinet drawer. The greenhouse contained 96 plants (oat and mung bean seeds and young slash pine seedlings) to test the effects of weightlessness on the formation of lignin in these plants. Lignin allows plants on Earth to grow upward against the pull of gravity, gives them their characteristic shapes, and supports the organs which carry food and chemicals. Another experiment tested the processing of the drug urokinase, which is used to dissolve bloodclots. On Earth, it is difficult to produce the drug because of the force of gravity; it is hoped that by producing it in space, the cost of the drug can be reduced (a single dose now costs $3,000).

STS 4. The last shuttle test flight, STS-4, was successfully launched at 1100 EDT from Cape Canaveral on June 27, 1982. This was the first on-time launch of the shuttle. Commanded by Thomas (Ken) Mattingly and piloted by

Henry Hartsfield, the mission ended at 1210 EDT on July 4 at Edwards AFB on a concrete runway. This was the first shuttle landing on a hard surface.

STS-4 carried a variety of civil and military experiments. Included in the civil category were an electrophoresis experiment sponsored by the McDonnell-Douglas Corporation in collaboration with Johnson and Johnson, and the first "get-away special" involving experiments developed by college students in Utah. Although the military experiments were classified, it is known that one experiment involved testing a new space sextant, while another tested an advanced surveillance sensor called CIRRIS (Cryogenic Infrared Radiance Instrumentation Sensor).

### Operational Shuttle Flights

The first operational flight of the space shuttle, STS-5, was successfully launched at 0719 EST on Nov. 11 and landed at 0933 EST on Nov. 16, 1982. This was the first shuttle mission to carry a crew of four -- two pilots (Vance Brand and Robert Overmeyer) and two mission specialists (Joseph Allen and William Lenoir). The main mission for STS-5 was to deploy two communication satellites: Telesat-E for Canada and SBS-C for the American company Satellite Business Systems. In addition, Allen and Lenoir planned to perform extravehicular activity in the cargo bay of the shuttle, but the exercise was cancelled when both spacesuits malfunctioned.

Next Shuttle Launch. The next launch of the space shuttle, STS-6, will use the orbiter Challenger rather than Columbia. Launch was originally scheduled for January 20, but a leak was detected in one of Challenger's main engines. NASA decided to replace the faulty engine with a spare, but during testing, a leak was discovered in the spare as well. Subsequently, a storm at Cape Canaveral blew dust into the satellite installed inside Challenger, which then had to be removed, cleaned, and reinstalled. Launch is scheduled for April 4. The STS-6 crew (Paul Weitz, Karol Bobko, Donald Peterson, and Story Musgrave) will deploy the first of three Tracking and Data Relay Satellites.

## MILITARY IMPLICATIONS OF THE SHUTTLE

Once it is fully operational, the space shuttle will be the national space transportation system and will be used for both civilian and military missions. The Department of Defense (DOD) has been intimately involved in designing the shuttle since the beginning of the program to ensure that it would meet requirements for military payloads. DOD is expected to be the single largest user of the shuttle and may require as many as a third of all shuttle launches during the 1980s. Of the 311 missions listed on the most recent shuttle manifest for the years FY83-FY94, 114 (37%) will be for DOD, compared to 93 (30%) for NASA, 38 (12%) for U.S. commercial users, 38 (12%) for foreign countries, 18 (6%) for reflight opportunities, and 10 (3%) for U.S. civil government agencies other than NASA. Although NASA is responsible for funding shuttle research, development, and production, DOD has agreed to fund the following shuttle-related items: (1) development and production of the inertial upper stage (IUS) which will be used to take payloads from the relatively low Earth orbit accessible directly by the shuttle to higher orbits or into deep space trajectories; (2) development and construction of shuttle-related facilities at Vandenberg Air Force Base, California, which will serve as the west coast launch site for the shuttle; (3) operation of the Vandenberg facilities for all users (military and civilian); and (4) funding of whatever shuttle facilities are necessary for DOD operations at Kennedy Space Center and Johnson Space Center (including secure operations or "controlled mode"). In return, DOD will be charged a lower rate per flight than other users.

DOD involvement in the shuttle program has prompted a perception of the shuttle as primarily a military vehicle rather than both military and civilian. The military is expected to use the shuttle to launch payloads into space and possibly for other purposes such as photographic reconnaissance, though such alternatives have not been openly discussed by DOD. It should be noted that Western experts have reported that the Soviet Union uses its manned Salyut space stations for military reconnaissance purposes.

The shuttle is not, in itself, a weapon. During talks between the Soviet Union and the United States on limiting the development of antisatellite devices (see issue brief 81123, Antisatellites (Killer Satellites)), the Soviets reportedly claimed that the shuttle was related to weapons systems and therefore should be banned along with other space weapons; the United States rejected this contention. However, the shuttle may carry experiments which might eventually have application to space weapons (such as space-based lasers).

## SOVIET REACTION TO THE SHUTTLE

The Soviet Union has an active manned space program and there has been considerable speculation for many years that the Soviets are developing a reusable spacecraft. Currently, they rely on the Soyuz and Progress spacecraft, which can only be used once, for ferrying crews and supplies to the orbiting Salyut space stations. The Salyut 6 space station hosted 18 crews during its four and a half years of life (from 1977 to 1982), and the Salyut 7 station, launched in April 1982, has hosted three crews. Thus, a reusable spacecraft would obviously be of great utility in the Soviet space program. The question is in what timeframe such a vehicle would be introduced.

In its March 1983 edition of Soviet Military Power, the U.S. Department of Defense stated that the Soviets are developing two reusable spacecraft: one similar to the U.S. shuttle, and a second, smaller "spaceplane." A drawing of the Soviet shuttle was included in the report. The report stated that orbital tests of the smaller spaceplane have already been conducted, a possible reference to the 1982 Kosmos 1374 mission which was widely speculated as having been a test flight of a prototype scale-model Soviet reusable spacecraft. A similar mission was flown in March 1983 (Kosmos 1445), and was identified in hearings before Congress by Dr. Robert Cooper, head of DARPA, as being a test flight of a soviet spaceplane.

The Soviet Union has expressed great concern about the potential military implications of the U.S. space shuttle. As noted above, for example, during discussions between the United States and the Soviet Union concerning limiting the development of weapons in space the Soviets claimed that the shuttle is a weapons system. In addition, the Soviet Union submitted a draft treaty to the United Nations in the fall of 1981 which is designed ostensibly to ban the stationing of weapons in space. Included in the draft treaty is language obviously referring to the space shuttle: "The member states undertake not to put into orbit around the earth objects with weapons of any kind, not to install such weapons on celestial bodies and not to deploy such weapons in outer space in any other way, including also on piloted space vessels of multiple use..." (emphasis added).

The U.S. International Communication Agency has issued a report (see REFERENCES) concerning how the Soviet Union views U.S. technology, and according to the report, the Soviets were overwhelmed with the shuttle launch. "The U.S. space shuttle, in particular, seems to have left Soviets, including some at the highest levels, almost speechless....Many believe that they are incapable of doing what the U.S. has done with the shuttle" (page 17).

## NASA FUNDING

NASA appropriations for the space shuttle program grew from $78.5 million in FY71 (used exclusively for shuttle R&D) to approximately $3.5 billion in FY83 for R&D, procurement, and operations. In recent years, the major points of controversy in shuttle funding have been: how many shuttle orbiters to procure, how much DOD should be charged for its shuttle launches, and what type of upper stage to develop for placing satellites into higher orbits than can be reached by the shuttle alone.

### FY83

The total NASA FY83 appropriation level is $6.807 billion, an increase of $196 million over the request, and $36 million more than was authorized. Additional information on the NASA budget is contained in IB82118, Space Funding and Policy: NASA and Civilian Space Programs.

The FY83 NASA authorization bill (P.L. 97-324) provided $85 million for procurement of a fifth shuttle orbiter. The Senate had recommended $90 million for this purpose, while the House had not included any funding. The appropriation bill (P.L. 97-252) does not provide funding for a fifth orbiter, however. Both the House and Senate versions of the appropriation bill included language stating that NASA must obtain their approval before initiating procurement of a fifth orbiter.

Regarding how much DOD should be charged for its shuttle launches, the problem centers on a decision made in the 1970s that DOD would be charged about two-thirds of the price other users are charged for the first 6 years of shuttle operations because DOD would be providing a west coast launch site for the shuttle and the inertial upper stage. During consideration of the FY83 funding bills, however, the Senate expressed the opinion that DOD should pay the same price as other users beginning in FY83.

The Senate-passed versions of the authorization and appropriation bills therefore reduced NASA's funding for shuttle operations by $409 million (the additional amount the Senate felt should be reimbursed to NASA for FY83 by DOD) and most of it was redistributed to other NASA programs. The House did not make a similar recommendation. In conference on the authorization bill, the two Houses agreed to direct NASA to charge DOD "such prices as necessary to recover the fair value" of launches beginning in FY84. No dollar amount was stipulated, but NASA's budget for shuttle operations was reduced by $128 million. In the appropriations bill, the only language relating to this issue stated that NASA's appropriation level will be reduced in subsequent years by whatever amount is transferred to NASA as payment for shuttle launches.

A particularly troublesome issue during the FY83 budget deliberations was deciding whether to support the continued development of the inertial upper stage (IUS) or Centaur (see ISSUES). The House Science and Technology Committee supported the IUS in its report on the NASA authorization bill (H.Rept. 97-502), and the House agreed when it passed the bill on May 5, 1982. The Senate version of the authorization bill supported Centaur, however (S.Rept. 97-449, passed Senate June 9). Conference action on the bill was delayed for several months, during which time Congress took two actions which affected the outcome of this issue. First, the FY82 Urgent Supplemental bill was passed (P.L. 97-216) which directed NASA to procure two Centaur stages for upcoming NASA planetary missions. Then the House and Senate appropriations committees completed work on the FY83 HUD-Independent Agencies bill, which includes NASA, and in consonance with the Urgent Supplemental, supported Centaur. During House floor debate on the appropriations bill, Congressman Flippo (chairman of the House Science and Technology Subcommittee on Space Science and Applications) introduced an amendment to support IUS instead of Centaur, but the amendment was defeated. Thus, the final version of the appropriation bill supported Centaur. Subsequently, the conference on the authorization bill was held and the Senate position, in support of Centaur, was adopted. As enacted, the authorization bill provides $120 million for Centaur while the appropriation bill provides $140 million.

FY84

For FY84, NASA is requesting a total of $7,106.5 million, of which $3,448 million (48.5%) is for the space transportation system. This includes shuttle production and operations, development of upper stages, advanced programs, Spacelab, and development of a Tethered Satellite which will be suspended from the shuttle into the upper atmosphere by a long (60-mile) tether line in order to make scientific measurements. No funding is requested for a procurement of a fifth orbiter, although $100 million is designated for buying structural spares to enable repair of any orbiter that might break down. NASA has not made a decision on whether to accept the SpaceTran offer to buy the fifth orbiter for NASA in exchange for marketing rights.

## DOD FUNDING

Through FY82, the DOD had spent a total of about $2.6 billion on the STS program. This includes funding for development of the IUS, construction of a shuttle launch facility at Vandenberg AFB, and modifications needed to launch DOD payloads via shuttle instead of conventional launch vehicles.

FY83 DOD Authorization. For FY83, DOD requested $581 million for shuttle-related activities, including Vandenberg operations, two shuttle flights, and procurement and operations related to the Inertial Upper Stage. Neither the House nor Senate Armed Services Committees made changes in the requested amount for the procurement, research, development, testing and evaluation (H.Rept. 97-482 and S.Rept. 97-330, both issued on April 13). The Senate passed the DOD authorization bill on May 13. The House passed the bill on July 29 after adding an amendment that limits the funds that can be transferred from DOD to NASA for shuttle activities to amounts required by laws in effect as of July 1, 1982. The conference report (H.Rept. 97-750) retained the wording, and was passed by the Senate on Aug. 17 and the House on Aug. 18. The bill was signed into law on Sept. 8.

FY83 DOD Appropriation. The Senate Appropriations Committee reported out the FY83 DOD appropriation bill on Sept. 23 (S.Rept. 97-580). The committee added $50 million to the Air Force budget "to permit the Air force to pay a greater share of the cost of operating the space shuttle," adding that the Air Force is "capable of absorbing a greater share of these costs." The House Appropriations Committee report on the bill (H.Rept. 97-843, Dec. 2) did not include this funding increase.

Action on the DOD appropriation bill was not completed by the end of the 97th Congress, so funding was provided through the continuing appropriation bills (P.L. 97-276 and P.L. 97-377). The additional $50 million was not included in the continuing appropriation bill.

FY83 Military Construction Authorization. The House Armed Services Committee decreased the requested amount in the military construction bill (H.Rept. 97-525) for facilities modifications at Vandenberg AFB for the shuttle from $26.5 million to $14.8 million. The Senate Committee followed the House's action when it reported the bill on May 27. The Senate passed the bill on June 30; the House on Aug. 11. The conference report was filed on Sept. 28 (H.Rept. 97-880) and passed the Senate that day and the House Sept. 28. The bill was signed into law Oct. 15 (P.L. 97-321).

FY83 Military Construction Appropriation. The House Appropriations Committee reported out the FY83 military construction appropriation bill on Aug. 11 (H.Rept. 97-726). The committee expressed concern about construction of the shuttle launch site at Vandenberg AFB, noting that costs may rise from the initial estimate of $252 million to $882 million. The committee said it was "particularly concerned" that the money already spent would not result in a "usable facility," but that there was probably no alternative to completing the project, and thus advocated a number of steps to monitor more closely costs and construction. The committee reduced the request for STS facility modifications from $26.5 million to $10.5 million ($4.3 million less than had been recommended by the authorizing committee), and although it approved the full $40 million for the STS Vertical Assembly Environmental Shelter at Vandenberg, the committee noted that it did so contingent upon a review of the final plans and costs for the project. The House passed the bill on Aug. 19.

The Senate Appropriations Committee reported the bill on Sept. 22 (S.Rept. 97-572). The committee reduced the request for STS facility modifications to $14.8 million, but approved the full $40 million for the STS environmental shelter at Vandenberg. The conference report was filed on Sept. 30 (H.Rept. 97-913) and adopted a compromise level for STS facility modifications of $12.65 million. The report was approved by the House and Senate on Oct. 1 and signed into law on Oct. 15 (P.L. 97-323).

## ISSUES FOR CONCERN IN THE 98TH CONGRESS

A large number of issues concerning the space shuttle program will come before Congress for discussion in this and subsequent sessions. The following is a list of selected issues which appear most likely to be of interest to the 98th Congress specifically. Other issues are discussed in the report "United States Civilian Space Programs: 1958-1978" prepared by the Science Policy Research Division of the Congressional Research Service for the House Committee on Science and Technology.

## 1. Cost Overruns/Schedule Slippages/NASA Program Management

The space shuttle program has encountered a number of schedule slippages, resulting in cost overruns and questions about NASA's ability to manage the project. The orbital test flights began more than two years later than originally planned, and the shuttle program is now expected to cost $9.91 real year dollars (through the end of the four test flights). This is equivalent to $6.65 billion in FY71 dollars, a cost increase of 29% over the initial 1971 estimate of $5.15 billion.

In February and March 1979, NASA testified before the Congress as to the necessity for a supplemental appropriation of $185 million to keep the shuttle development program on schedule. NASA stated that the cost increases in the FY79 budget resulted from deferred work left uncompleted on Orbiter 102, which had to be completed at KSC, and on additional engineering and manufacturing efforts in all elements of the shuttle program, especially main engine testing, installation of thermal protection on the orbiter and external tank, and qualification testing of orbiter systems. The Congress agreed to the additional funding.

In April and May 1979, it became evident that despite the $185 million supplemental, there was going to be a cost overrun of perhaps up to $600 million in the shuttle program. In addition, the first orbital flight would slip into late 1980, a schedule lag of over a year from the originally planned target launch date in March 1979. In the spring of 1979 NASA submitted, and the Congress approved, a $220 million budget amendment for FY80 in order that the schedule for Orbiters 103 and 104, essential for priority national defense missions, not slip further. In January 1980, NASA requested a $300 million supplemental for FY80 for shuttle development. A supplemental of $285 million was approved. In addition, the FY81 request, at $1.873 billion, was about $800 million more than NASA had anticipated it would need for FY81. Thus in FY80 and FY81, as well as FY79, shuttle development efforts required a higher rate of expenditure than earlier anticipated. This was due primarily to problems with the thermal protection system and the main engine.

The cost overruns for the shuttle have led many Members to question NASA's management of the shuttle program. In 1979 the Senate Commerce Committee requested that NASA prepare a thorough review of the situation and submit a report to the Committee. In addition, the House Committee on Science and Technology, NASA, and independent consultants studied NASA's management of the shuttle program and made a number of recommendations. NASA considered all the recommendations of the different reviewers and implemented a number of changes to expedite efficient shuttle program management and keep costs under control.

Vandenberg AFB Preparations. The launch facilities construction at VAFB has also shown cost overruns caused by inflation and by the rapidly increasing costs for certain construction materials. The initial operational capability date has already slipped to October 1985 (from August 1984). Factors impacting on the readiness of the launch facility include: (1)

design problems relating to the buildup of ice on the external tank in the humid climate at VAFB; (2) inability of Martin Marietta (the Air Force shuttle contractor) to induce a sufficient number of engineers to move to the area to work at VAFB; (3) construction problems; (4) concurrency of work at VAFB and Kennedy Space Center (originally operations at KSC were to have been proved by this time, thus making VAFB preparations easier); and (5) increased funding requirements caused by the aforementioned problems. In reporting out the FY83 military construction appropriation bill, the House Appropriations Committee noted that costs may rise from the initial estimate of $252 million to $882 million, and that it was "particularly concerned" that the money already spent would not result in the "usable facility."

## 2. Number of Orbiters

When the shuttle program was initiated, NASA planned for a 5-orbiter fleet to carry out an estimated 560 missions during the 12-year period from 1980-1991. During the past decade, the expected number of shuttle missions in the 12-year shuttle operational period has decreased -- first to 487 missions, then to 311 missions (the current estimate). As a result, debate developed over whether five orbiters would be required or if four would be sufficient (this does not include orbiter 101, the Enterprise, which is not spaceflight-worthy).

In 1978, President Carter decided that production of a fifth orbiter should not be initiated. Subsequent NASA budget requests to Congress have not included funding for production of a fifth orbiter, although funding has been provided (sometimes at the initiation of the Administration, other times because of congressional insistence) for long-lead items associated with a fifth orbiter in case a decision is made at a later time to procure it. Proponents of a 5-orbiter fleet argue that even though the need for 5 orbiters may not be apparent now, it may develop in the future (especially if NASA is given permission to build a space station), and the orbiter would be more costly to procure if the production lines shut down after the fourth orbiter is completed.

NASA and DOD have consistently expressed the opinion in congressional hearings (most recently in June 1982) that at least 5 orbiters will be needed. The problem now is that subcontractors are already running out of work, so a decision on whether or not to proceed with a fifth orbiter must be made soon if production lines are to remain open. No funding for a fifth orbiter was included in NASA's FY84 budget request, although $100 million has been requested for structural spares to repair the other four orbiters as needed. NASA stated that a reassessment of projected launch demands in light of competition from other launch services such as ESA's Ariane led the Administration to conclude that a fifth orbiter may not be required after all.

One option has been presented by a private firm, Space Transportation Company (SpaceTran), which has offered to purchase the fifth orbiter and give it to NASA in return for exclusive marketing rights to payloads flown on that orbiter. NASA has been considering the proposal since the spring of 1982, but no decision has been made and 80% of SpaceTran was recently acquired by Federal Express so the offer is now being reviewed by the new management.

## 3. Ownership and Operation of the Space Shuttle

An issue which will assume increasing importance as the shuttle progresses from research and development into operations is who should own and operate it. NASA is a research and devlopment agency and does not operate space systems once they have completed the R&D phase. For example, weather satellites are operated by the National Oceanic and Atmospheric Administration (NOAA, part of the Department of Commerce), an agency which was also given operational authority over remote sensing satellites in 1979 (see issue brief 82066, LANDSAT--Earth Resources Satellite System). Communication satellites are operated by private industry.

The shuttle presents unique problems because of its role in U.S. military programs. As a result, suggestions have been made that two shuttle fleets be developed: a "white" fleet for civilian and commercial users, and a "blue" fleet for the Air Force. Thus, DOD could operate its own shuttles as it does other military hardware, and the white fleet could eventually be handled by an entity other than NASA.

Discussions over how and when to transfer the shuttle out of NASA and into some other government, quasi-government, or non-government entity have been going on for many years without resolution. The issues include whether a private sector entity would be required to reimburse the Government for R&D funding spent on the shuttle (which may reach $15 billion); whether NASA would continue to perform R&D related to the existing shuttle system and possible shuttle follow-ons if the private sector takes over shuttle operations; and what regulations would need to be developed to cover private sector operation of the system. The underlying question in connection with private sector ownership of the shuttle is when and if the shuttle will become profitable.

The Subcommittee on Science, Technology, and Space of the Senate Commerce, Science, and Transportation Committee held hearings on Dec. 9, 1981, to begin addressing these issues.

## 4. Shuttle Upper Stage -- IUS or Centaur

Cost overruns in the Air Force's inertial upper stage (IUS) program prompted NASA to decide in January 1981 to cease its support for developing a three-stage IUS for sending spacecraft into deep space trajectories (Air Force development of the two-stage IUS was not directly affected by this decision). Instead, NASA decided to proceed with development of a high energy upper stage called Centaur (in fact, it is a modification of the Centaur upper stage that has been used for many years). In January 1982, NASA reversed itself and said that it would stay with IUS.

NASA's 1981 decision to develop Centaur rather than IUS led to considerable controversy for two reasons. First, there is only one currently approved NASA mission which would require the Centaur capability (the Galileo mission to Jupiter), and one European mission which NASA has promised to launch (the International Solar Polar Mission). The Air Force has not identified any specific missions for which it would need Centaur either, although both NASA and DOD have told Congress that they would like to have the Centaur capability available for missions which might develop in the future.

Second, NASA decided to use sole source procurement for Centaur, rather than allowing companies to bid for the contract (NASA chose General Dynamics which builds the Centaur upper stage now in use). As a result of the dispute over the need for Centaur and the method NASA was using to procure the vehicles, both the House Science and Technology Committee and the Senate Commerce, Science, and Transportation Committee held hearings on this issue in March 1981. In reporting NASA's FY82 authorization bill, both committees requested the agency to "reassess the national requirements for a new upper stage, review the ability of a modified Centaur and alternate launch systems to meet these requirements, and reconsider the sole source procurement approach." The bill (P.L. 97-96) prohibited NASA from spending any money for sole source procurement of Centaur and stated that NASA should make a commitment to the Galileo mission before making a commitment to Centaur.

NASA's 1982 decision to reverse itself on this issue also generated controversy. Reports in the trade press in the fall of 1981 and the beginning of 1982 had suggested that NASA and the Air Force were making arrangements to develop a version of Centaur which would meet the requirements of both agencies. When it appeared NASA would not have the funding available to proceed with Centaur in FY83, it was thought that the Air Force might develop Centaur on its own. The Air Force subsequently decided not to develop Centaur because it had no mission requirements for it until 1987.

When NASA reported its decision not to proceed with Centaur to Congress, the agency was sharply criticized on the basis that it had argued the previous year that Centaur was desperately needed to support the planetary program. Without Centaur, the Galileo mission to Jupiter would have to have been placed into a different trajectory with the less capable IUS, and the transit time to Jupiter would have doubled from two to four years. In addition, the orbiter would not have been able to make as many orbits of Jupiter, and the science acquired by the mission would have been reduced by 15-20%, according to NASA. The agency explained that with only two planetary missions to use Centaur, it simply could not justify the expense of development. The issue was complicated further when NASA provided cost figures to Congress showing that the total development cost for Centaur would be approximately $230 million, while IUS development is expected to be $650-700 million. Individual Centaur units would cost $35-40 million, while each IUS would cost $50-60 million. In addition, Centaur has over twice the payload capability of IUS: Centaur can take a 10,600 pound payload from low earth orbit to higher orbits, while the IUS can carry only 5,000 pounds. The arguments in favor of IUS were that it is well along in development and would be ready by 1985 when the Galileo and ISPM missions are planned for launch, and most of the development money has already been spent.

In its report on the FY83 NASA authorization bill (H.Rept. 97-502), the House Science and Technology Committee accepted the position that a high energy upper stage is required, but stated that NASA should be the procuring agency for such a vehicle and it should accommodate future modifications for reusability; $5 million was included to complete Phase B definition studies leading to a competitive procurement of such an orbital transfer vehicle in FY84. The Senate Commerce, Science, and Transportation Committee, conversely, supported development of Centaur via a sole source procurement award in its markup of the bill on May 11. The committee allocated $150 million in FY83 for this purpose.

The FY82 Urgent Supplemental Appropriations bill (P.L. 97-216) contained language directing NASA to procure Centaur upper stages, on a sole source basis, for use with those two missions, although NASA may use IUS for other launches. In its report on the FY83 HUD-Independent Agencies bill (H.Rept. 97-720), the Appropriations Committee added $140 million for Centaur in accordance with the language in the Urgent Supplemental. After defeating an amendment that would have supported IUS instead of Centaur, the House passed the bill on Sept. 15. The final version of NASA's FY83 appropriation bill (P.L. 97-272) contains this amount.

Under the existing arrangement, two versions of Centaur will be developed: a "short" version for use by NASA and DOD for earth orbital missions, and a "long" version for use by NASA for planetary missions. NASA and DOD will split the costs for the short version, while NASA will pay for the long version.

## 5. Continuing Need for Expendable Launch Vehicles

When the space shuttle was originally approved for development by President Nixon, it was expected eventually to replace all the expendable launch vehicles (ELVs) which are now used to place spacecraft in orbit (Atlas, Delta, Titan, etc.). Only the Scout launch vehicle, used for placing very small scientific payloads into orbit, was expected to be retained for use during the shuttle era.

The production of ELVs and their associated upper stages has been systematically scaled down during the past several years, but recently NASA and DOD have begun to reexamine the question of whether ELVs should be retained. As NASA has been forced by budget constraints to reduce the number of shuttle flights between 1981 and 1985, it has not been able to assure shuttle launches to all potential customers (in the summer of 1981, NASA announced a reduction from 48 to 34 shuttle flights through 1985, and press reports indicate that this may soon be reduced by another 10 flights). As a result, some potential shuttle customers are either asking NASA to provide them with an assurance of an ELV launch in lieu of shuttle, or are signing up with the European Space Agency for launches on its Ariane launch vehicle.

DOD has always been concerned about having to rely totally on one launch system in the event there is a sudden need for one or more military launches, and has indicated that it would like to retain its Titan launch capability.

In September 1982, a NASA study was released suggesting that if NASA has only four shuttle orbiters, 84 ELV launches may be required between FY89 and FY94 to meet expected demand. Several companies are now being formed which may market existing ELVs, such as Delta, Atlas-Centaur, and Titan, as NASA withdraws from ELV operations, and two companies are developing their own ELVs.

NASA has issued a stop-work order to contractors who make the Delta launch vehicle so that the Delta capability will end in 1986. Concern has been expressed that the shuttle system has not been proven yet (especially in light of recent problems with the sixth shuttle launch which has caused at least a 2-month delay), and the expendables should not be terminated until NASA is certain that the shuttle can perform as promised.

## 6. Shuttle Pricing Policy

In 1977, NASA established prices for shuttle launches as follows: $18 million for commercial, foreign, and U.S. civil agencies for the first 3 years of operations; and $12.2 million for DOD for the first 6 years of operations (prices are in 1975 dollars). The lower price for DOD was predicated on the fact that DOD is providing a shuttle launch site at Vandenberg AFB and the inertial upper stage. After these fixed periods expire, the price is to be adjusted annually to allow NASA to fully recover its operational expenses. Since 1977, shuttle program costs have risen, and NASA will have to make up the difference between the price it charges and the actual cost to launch the shuttle. In a report prepared by the General Accounting Office in 1982 (see REFERENCES), it was estimated that this would force NASA to pay 80% of shuttle costs through 1985, while flying only 36% of the missions.

GAO recommended that NASA reconsider its pricing policy to establish more equitable prices to all users. In addition, the congressional committees which deal with NASA's authorization have directed that NASA recoup full costs for DOD missions earlier than the six year period specified in the 1977 pricing policy. Specifically, the House Science and Technology Committee directed NASA to recoup full costs from DOD beginning in 1985, while the Senate Commerce, Science, and Transportation Committee directed that full costs be paid by DOD beginning in FY83. The Senate committee decreased NASA's budget $409 million for FY83 on the assumption that DOD would reimburse NASA that amount for the two DOD launches scheduled for FY83. The Senate Appropriations Committee followed the action of the Commerce committee, but House Appropriations did not agree. In conference, the authorization bill was amended to read that NASA should charge DOD whatever prices were necessary to recover the "fair value" of shuttle launches, but no dollar amount was stipulated. The appropriations bill was amended to include language stating only that in future years, NASA's appropriation level would be reduced by whatever amount was transferred to NASA as reimbursement for shuttle flights.

In June 1982, NASA announced a new pricing policy for space shuttle launches which will occur between Oct. 1, 1985, and Sept. 30, 1988. The new cost of an entire shuttle cargo bay is $38 million in 1975 dollars, compared to the previous price of $18 million 1975 dollars. When adjusted for inflation, the cost in 1985 to launch the shuttle is expected to be $90 million. Several satellites can be carried into space at one time by the shuttle, however, and NASA anticipates that the cost to place one satellite into orbit will be $26 million, including required upper stages. NASA expects this cost to be competitive with U.S. and foreign expendable launch vehicles.

Simultaneously, NASA announced that the number of expected flights had dropped from 487 to 312, partially because of longer than expected turn around times for refurbishing the shuttle. Because of the lower launch rate, NASA changed its philosophy regarding shuttle pricing policy. Instead of attempting to recover full costs over the 12 year flight period (1982-1994), NASA will only attempt to recover out-of-pocket expenses for the three year period for which the prices are in effect.

These prices do not apply to DOD. In September 1982, NASA and DOD reached a tentative agreement on higher prices for DOD launches for the period FY84-FY88. Instead of the $12.2 million (FY75 dollars) originally agreed to for the first 6 years, DOD will pay $16 million (FY75 dollars) for launches occurring in FY84 and FY85, and $29.8 million (FY75 dollars) during FY86-FY88.

## LEGISLATION

H.R. 1816 (Price)/S. 720 (Thurmond)
Authorizes appropriations to NASA for FY84. Introduced Mar. 11, 1983; referred to Committee on Science and Technology.

H.R. 2065 (Fuqua et al.)
Authorizes appropriations for military construction for FY84. Referred to House and Senate Armed Services Committees, respectively.

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U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. National Aeronautics and Space Administration Act, 1982; report to accompany S. 1098. May 15, 1981. Washington, U.S. Govt. Print. Off., 1981. (97th Congress, 1st session. Senate. Report no. 97-100)

## CHRONOLOGY OF EVENTS

11/16/82 -- Fifth flight of the space shuttle landed at Edwards AFB at 0933 EST. Astronauts successfully deployed 2 commercial communications satellites, but had to cancel a planned space walk.

11/11/82 -- Fifth shuttle flight launched on-time at 0719 EST. This was the first operational shuttle flight.

07/04/82 -- The fourth shuttle flight landed at 1210 EDT at Edwards AFB. First landing of the shuttle on a hard runway.

06/27/82 -- Fourth and final test flight of the space shuttle began with the first on-time launch at 1100 EDT.

06/15/82 -- House Science and Technology Committee held hearings on the need for the fifth space shuttle orbiter.

06/03/82 -- Soviets launched a spacecraft that appears to have been a test related to development of a manned reusable vehicle.

03/30/82 -- The third shuttle flight landed at White Sands, New Mexico, one day later than planned because of high winds.

03/22/82 -- Third launch of the space shuttle took place.

12/09/81 -- Senate Commerce, Science, and Transportation Committee held hearings on operational management of the shuttle.

11/14/81 -- Second shuttle test flight landed at Edwards AFB after fuel cell problems caused early termination of the mission.

11/12/81 -- Second shuttle test flight was launched successfully.

09/21/81 -- House Science and Technology Committee began three days of hearings on future space programs and policy.

04/14/81 -- Columbia landed at Edwards AFB in California after a nearly perfect mission.

04/12/81 -- First launch of the space shuttle Columbia successfully accomplished.

06/05/80 -- Total test time for the shuttle main engine went over the 80,000 second mark established as the minimum needed to assure the reliability of the shuttle main engine prior to the first flight.

02/13/80 -- Successful completion of the final test firing of the shuttle's solid rocket booster motor.

03/31/80 -- The space shuttle main engine passed a milestone with the first sustained (6 minute) operation of the engine at full power level.

03/00/79 -- Orbiter 102 ferried from Edwards AFB, California, to Kennedy Space Center, Florida, to be readied for orbital flight.

10/26/77 -- Fifth and final orbiter free flight (tail cone off) was successfully completed by astronauts Haise and Fullerton.

08/12/77 -- The first shuttle orbiter free flight was successfully completed by Astronauts Haise and Fullerton. The orbiter was released from the Boeing 747 at an altitude of 6,768 meters above ground level and glided to a landing five minutes 23 seconds later on the dry lake bed runway at NASA's Dryden Flight Research Center at Edwards Air Force Base, California.

06/00/77 -- The second phase of the space shuttle flight test was begun. This phase was successfully completed in July 1977 after three flights from Edwards AFB, Calif., in which the orbiter was manned and attached to the Boeing 747.

03/02/77 -- The first flight test phase of the shuttle orbiter was successfully completed with the fifth captive unmanned flight of the orbiter.

02/18/77 -- The first test flight of the space shuttle orbiter was successfully accomplished at Edwards Air Force Base, Calif. The orbiter was unmanned, and mounted on a Boeing 747 during the entire flight.

09/17/76 -- The first space shuttle Orbiter 101 was completed and "rolled out", marking its readiness for suborbital flight tests.

11/19/73 -- NASA selected Thiokol Chemical Corporation to develop the solid rocket motors for the shuttle (contract worth $106 million).

08/16/73 -- NASA selected Martin Marietta to develop the external tank for the shuttle (contract worth $158 million).

07/26/72 -- NASA selected North American Rockwell (now Rockwell International) for the $3.5 billion shuttle orbiter development contract.

01/05/72 -- President Nixon announced decision to proceed with partially reusable shuttle system.

07/13/71 -- NASA awarded Rocketdyne the $450 million shuttle main engine development contract.

11/00/69 -- NASA proposal for fully reusable shuttle submitted.

09/00/69 -- Space Task Group report outlined ambitious program for 1970s and 1980s.

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