

GAO

Report to the Chairman, Subcommittee
on Investigations and Oversight,
Committee on Science, Space, and
Technology, House of Representatives

July 1994

SPACE SHUTTLE

NASA's Plans for Repairing or Replacing a Damaged or Destroyed Orbiter





United States
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National Security and
International Affairs Division

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The Honorable James A. Hayes
Chairman, Subcommittee on
Investigations and Oversight
Committee on Science, Space,
and Technology
House of Representatives

Dear Mr. Chairman:

This letter responds to your request for information on the National Aeronautics and Space Administration's (NASA) (1) contingency plans should an accident occur that destroys or seriously damages a space shuttle orbiter, (2) plans for maintaining critical manufacturing skills in the shuttle work force, and (3) facilities that will be essential to maintain the shuttle orbiters over their expected lifetime.

Background

The space shuttle system consists of a reusable orbiter with three main engines, two partially reusable solid rocket boosters, and an expendable external fuel tank. The shuttle has operated for over 10 years and will be required for at least another 12 to 15 years. It is the nation's only launch system that can carry humans. Production of shuttle orbiters ended with delivery of the Endeavour on April 21, 1992. There are currently four orbiters in the shuttle fleet—Columbia, Discovery, Atlantis, and Endeavour.

After Endeavour was completed, NASA planned to buy a complete set of structural spares—airframe components such as wings and the vertical stabilizer—in the event that another orbiter was needed. However, the fiscal year 1994 Appropriations Conference Committee eliminated most of the funding NASA requested for the structural spares program and NASA is in the process of terminating the program.

Orbiter production facilities consisted primarily of two plants located in Southern California. Downey, which is primarily an engineering and production plant, was used for manufacturing orbiter structural components. The Palmdale plant, which is owned by the Air Force, was used as the final orbiter assembly plant and for installing major modifications to the Columbia and Atlantis orbiters.

The NASA Administrator established a National Facilities Study Team in November 1992 to develop a comprehensive and integrated long-range plan for future aerospace facilities. The study team issued its report in April 1994.¹

Results in Brief

NASA has not established contingency plans to replace an orbiter in the event of a catastrophic accident or to repair an orbiter seriously damaged in an accident because national policy is not to produce any additional orbiters. The agency also is terminating its structural spares program. According to orbiter project officials, should the need arise for an additional orbiter or a structural component, the capability to produce it could be obtained from the commercial sector. However, production would take longer than if spare structural components and critical manufacturing skills were readily available.

Terminating the structural spares program will result in the loss of some critical manufacturing skills that would be needed to produce another orbiter, such as the skills required for making payload bay door skins. However, NASA does not believe that terminating the structural spares program, with its associated loss of manufacturing skills, will significantly increase risk to the shuttle because those skills could be reacquired if another orbiter is needed.

The plants at Downey and Palmdale will be required to support the shuttle at least until modifications for flights to Mir² and the international space station are completed. The Downey facility will be used to provide engineering support for the orbiters, payload integration, and manufacturing capability. The Palmdale facility will be needed for making major modifications to the orbiters as well as performing scheduled structural inspections and maintenance. The National Facilities Study Team recommended that NASA consider consolidating production activities of the Downey and Palmdale plants after it completes major modifications to the orbiters. We agree that a decision will be needed on the use of these plants when the modification program is completed since excess capacity will exist.

¹See National Facilities Study Summary Report (Apr. 29, 1994).

²Mir is the Russian space station that is currently in orbit. NASA has made a commitment to fly up to 10 missions to Mir.

NASA Has Not Established Contingency Plans for Replacing an Orbiter

NASA has no contingency plans for producing another shuttle orbiter because national policy is not to produce another one. NASA could produce a new orbiter if needed, but it would take longer than it did to produce Endeavour because the agency is terminating production of structural spares, which could be used to shorten production time.

Replacement Orbiter May Not Be Needed

The National Space Council³ issued the national space launch strategy in July 1991. The strategy provides for continued use of the space shuttle, but states that no additional orbiters will be produced. Accordingly, NASA currently has no plans to produce another orbiter even if one of the four vehicles is destroyed or seriously damaged. NASA plans to fly from six to eight shuttle missions a year for the foreseeable future and according to a NASA official, it could support that flight rate with only three orbiters. For example, NASA conducted six flights in 1990 and 1991 with only three orbiters.

NASA Is Terminating Its Structural Spares Program

After the Endeavour was completed, NASA planned to produce a complete set of structural spares in the event another orbiter was needed. However, to meet budget constraints in fiscal year 1993, NASA restructured the structural spares program to concentrate on producing only high-risk structural parts—those considered most likely to sustain damage during normal operations. NASA planned to spend about \$35 million annually, starting in fiscal year 1993 through fiscal year 1996, on this effort. The fiscal year 1994 VA, HUD, and Independent Agencies Appropriations Conference Committee report eliminated \$30 million of the \$35 million requested for structural spares and NASA decided to terminate the program.

When a termination agreement is reached with the contractor, parts that are 85 percent or more complete will be finished and placed in storage. Those that are less than 85 percent complete, along with any raw materials on hand, will be sold or scrapped. Tooling will be dismantled and placed in storage. NASA is evaluating a termination proposal from Rockwell International, the prime contractor for structural spares, and estimates that total termination costs will be about \$20 million. Thus, an additional \$15 million above the \$5 million the Congress provided in fiscal year 1994 may be required to terminate the program. According to NASA officials, this amount will be funded from orbiter contingency reserves and prior year appropriations for structural spares that have not been spent.

³The National Space Council was established by president Bush to advise and assist the president on national space policy and strategy, including establishing long-range goals and developing a strategy for national space activities.

NASA officials do not believe that terminating the program will substantially increase risk associated with operating the shuttle. To date, NASA has flown the shuttle about 60 times, and except for the Challenger incident, no structural component has been seriously damaged. The orbiter assistant project manager told us that the orbiters are handled very carefully and that the probability of damaging one is minimal.

However, if policy changes and another orbiter is needed, not having structural spares on hand would mean that it would take longer to build it. At termination, the only completed spares will be a set of landing gear doors, external tank doors, elevons, and mid-fuselage truss tubes. Thus, according to the assistant project manager, it would take 6 to 7 years to manufacture another orbiter. Endeavour—the Challenger replacement—took only about 4 years because a complete set of structural spares was available and was used to construct that vehicle.

NASA Will Lose Some Critical Manufacturing Skills

Terminating the structural spares program will also mean that there will be no active commercial source for some manufacturing skills that would be required to produce another orbiter. Highly skilled artisans are needed to manufacture skins for payload bay doors and the orbital maneuvering system, and that production capability will no longer be active. The skins are a nonmetallic epoxy material that require very precise mixtures and special manufacturing techniques.

Some manufacturing skills will still be available to NASA, at least for a while, because a limited manufacturing capability will be maintained through other projects. For example, air locks are being manufactured for missions to the Russian Mir and the international space station. Also, orbiter performance capability enhancements required for the shuttle to launch the international space station at its planned orbit inclination will require some manufacturing capability.

NASA officials do not believe that the loss of manufacturing skills that will result from terminating the structural spares program will substantially increase operational risk to the shuttle system because the skills could be reacquired if needed. For example, most of the orbiter structure is based on aircraft industry standards and the required skills could be obtained from that industry. The required highly specialized skills could be developed as they were for initial production of the orbiters.

NASA Needs Production Facilities for Major Modifications

At one time, NASA considered closing the Downey and Palmdale plants. However, after the decisions to fly up to 10 shuttle missions to Mir and to place the international space station in a 51.6-degree orbit, NASA decided to keep both plants open, at least for the present time. These decisions will necessitate major modifications to shuttle orbiters. The national facilities study recommended that NASA study the consolidation of activities at these plants after the major modifications are completed.

NASA Decided to Retain Downey Plant for Manufacturing Major Modifications and Orbiter Engineering Support

NASA's Inspector General recommended in September 1992 that the agency evaluate the need for the Downey plant and cancel planned facility improvements.⁴ NASA agreed to suspend plans for facility improvements until an absolute need could be determined and initiated an evaluation of future need for the plant.

After the Inspector General's report, the United States and Russia negotiated a cooperative agreement under which the shuttle will be used for up to 10 flights to Mir, which will require modifying 2 orbiters to dock with Mir. Also, Russia became a partner in the international space station program and the partners decided to assemble the station in a 51.6-degree orbit, which also will require modifying some orbiters to help increase the shuttle's lift capability.

Downey will be the manufacturing plant for hardware needed for these modifications. For example, the hardware to modify orbiter Atlantis to dock with the Mir was manufactured at Downey. The hardware to modify the orbiter Discovery for missions to Mir will also be manufactured at Downey.

The Downey plant also is used for system engineering support to the orbiters and payload integration activities. Orbiter project officials studied moving these functions from Downey to Johnson Space Center, Texas. NASA estimated that such a move would cost about \$105 million and would result in recurring savings of \$10 to \$18 million annually. According to NASA's analysis, it would take 6 to 11 years to recover the \$105 million up-front cost of the move. Moving the engineering activity to Johnson could also result in a temporary loss of some expertise because some Downey employees might be unwilling to move to Texas, according to NASA officials. Rockwell International, the orbiter prime contractor, currently employs about 3,000 people at Downey for orbiter engineering

⁴NASA Office of Inspector General Audit of Orbiter Production Phasedown Activities (A-JS-91-008), Sept. 30, 1992.

support services. The assistant orbiter project manager told us that moving engineering support activities at this time also could interrupt support to the ongoing manufacturing effort. According to this official, NASA will consider relocating the engineering services activity when the manufacturing work at Downey is completed.

While we did not perform a detailed analysis of NASA's cost estimate, our limited review of the estimate showed that NASA considered appropriate cost factors such as employee moving expenses, facility acquisitions, and skill losses. According to the assistant project manager, the estimated recurring savings would result from factors such as lower labor rates in Texas, reduced insurance and workmen compensation premiums, and lower facility occupancy costs.

Although NASA has not closed the Downey facility, it is reducing shuttle costs at that location. According to NASA officials, Rockwell moved some of its other activities, such as satellite manufacturing, to Downey and closed some of the warehouses at the Downey plant. This effort provided a broader business base for spreading overhead and should result in a more efficient operation. NASA officials estimate that shuttle occupancy costs at Downey will be reduced from about \$50 million to about \$27 million annually beginning in fiscal year 1995.

NASA Decided to Continue Major Modification Installation at Palmdale Plant

Orbiters are taken out of service for detailed inspection and maintenance about every 3 years. Any needed major modifications are also performed while an orbiter is out of service.

NASA had planned to close the Palmdale plant and move the inspection, maintenance, and modification work to Kennedy Space Center. The decision to close Palmdale was made before NASA knew about the major modifications needed to support flights to Mir and the international space station. In March 1994, the Program Director decided to keep the Palmdale plant open and continue performing the periodic inspection, maintenance, and modification work at that plant.

Because shuttle flights are not scheduled evenly throughout the year, all three orbiter processing facility bays are needed at times to support shuttle processing at Kennedy. However, one of the three bays would also be needed for most of the year for the periodic inspection and maintenance and for installation of major modifications, if that work were moved to Kennedy. Moving the major modification work to Kennedy

would mean that orbiters would have to be shifted from one bay to another during processing, causing inefficiencies and possibly jeopardizing launch schedules. According to the Program Director, retaining major modification work at Palmdale and continuing to concentrate the Kennedy workforce on vehicle processing will help to streamline shuttle processing and maintain safe launch and landing operations.

Performing the inspection, maintenance, and major modification work at Palmdale will cost about \$20 million a year more than if the work is performed at Kennedy. The additional cost results because labor rates are higher in California than in Florida and the orbiters will have to be transported from Kennedy to Palmdale and returned to Kennedy once work is completed. However, according to the Program Director, limiting Kennedy's specialized workforce to shuttle processing should help identify ways to improve processing efficiency and produce offsetting savings. While a specialized launch processing workforce may result in efficiencies, there is no data available to analyze the magnitude of any cost savings.

**National Facilities Study
Recommends NASA
Consider Consolidation**

In November 1992, the NASA Administrator chartered a multiagency task force to develop a comprehensive and integrated long-term plan for facilities that meet current and projected needs for commercial and government aeronautical and space research, development, and operations. The task force catalogued government and industry facilities and studied current and future requirements to identify shortfalls in existing capabilities; project new facility requirements; and propose needed upgrades, consolidation, and phase out of facilities.

The task force recognized that NASA needed both the Downey and Palmdale plants to manufacture and install the major orbiter modifications. However, they recommended that NASA study consolidating activities at one of the two plants after the major modifications are completed. According to the task force report, after major orbiter modifications are completed, NASA may be able to realize personnel efficiencies by consolidating hardware manufacturing and assembly requirements at a single facility. The task force recommended that NASA complete the consolidation study by the end of fiscal year 1995. We agree that the study is needed because there will be excess capacity when the modifications are completed.

Agency Comments

NASA agreed that this report accurately reflects current plans for replacing a damaged or destroyed orbiter and future plans for manufacturing facilities late in this decade.

Methodology

To obtain information on NASA's plans for producing another orbiter in the event of loss or major damage to a vehicle, maintaining critical manufacturing skills, and phasing down production facilities, we analyzed program and budget documents, a report by NASA's Inspector General, and the national facilities study summary report. We also discussed contingency planning with Johnson Space Center and NASA headquarters officials. We did not perform an in-depth analysis of NASA cost estimates mentioned in this report. Our review was limited to determining whether NASA appeared to have considered all relevant factors in preparing the estimates.

We conducted our review from January through May 1994 in accordance with generally accepted government auditing standards.

Unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from its issue date. At that time, we will send copies to other interested congressional committees, the Administrator of NASA, and the Director of the Office of Management and Budget. We will also provide copies to others upon request.

Please contact me on (202) 512-8412 or Lee Edwards, Acting Assistant Director, on (205) 650-1411 if you or your staff have questions concerning this report. The major contributors to this report are listed in appendix I.

Sincerely yours,



Donna M. Heivilin, Director
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