Engine Troubles Delay the Space Shuttle

All of the Challenger's engines have been removed for repair, and the delay will probably affect Spacelab

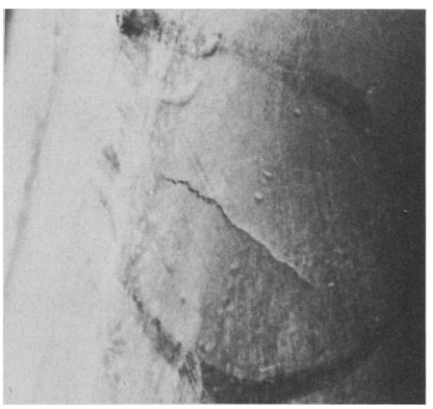
A series of unforeseen problems with the engines of the space shuttle is threatening to delay several key missions this year, including the launch of two communications satellites and the initial flight of Spacelab, a unique scientific laboratory developed by the European Space Agency (ESA). Spacelab is now scheduled for launch on 30 September, and officials of the National Aeronautics and Space Administration (NASA) in Washington say that they will do everything possible to prevent a postponement. But others within the agency insist that the flight schedule between now and then is so unrealistic that Spacelab could be delayed up to 5 months, at a cost as high as $12 million.

"The people in Europe are very unhappy," says Wilfred Mellors, the director of ESA's Washington office. Shuttle development troubles have already delayed the laboratory's initial launch four times, a circumstance that is considered the primary cause of its 40 percent cost overrun. "ESA's member states funded the last overrun only after a year's hard negotiation—one of the most difficult experiences the agency has ever had. It would be quite impossible to persuade the member states to find any more money," says Mellors.

Although delay is an old feature of the shuttle program, some of NASA's clients assumed that its troubles were behind it when the shuttle Columbia completed its fifth test flight successfully last November. Since then, the agency has been working feverishly to ready a second shuttle, the Challenger, for a maiden flight that was originally scheduled for last month. Having benefited from painful experiences with the first shuttle, NASA was expected to have an easier time with production and operation of the second. Given the depth of its current problems, this seems increasingly unlikely. The agency's management, however, is clinging publicly to highly optimistic schedules, hoping to placate clients and to provide an added incentive for its own work force. The most probable result is additional disappointment and additional labor to accommodate the inevitable schedule changes.

The chief vexations at present are the engines, the most technically advanced machinery on board. Each costs $30 million, and three are installed in each shuttle. The engines have a long history of design troubles, many of which have been corrected. The latest difficulties have been traced to poor workmanship, of the sort that can easily recur.

According to NASA officials, it all began in December 1981 at a plant operated by Rocketdyne, a subsidiary of Rockwell International, in Canoga Park, California. A worker at the plant was



This is the crack that delayed the satellites, putting Spacelab data in jeopardy.

preparing to make a small repair in the main combustion chamber for an engine when an improbable series of accidents occurred. A clamp on the lathe he was operating slipped, distracting his attention while the lathe was turning. Simultaneously, according to Rocketdyne, the clutch on the machine slipped, permitting the engine chamber to rotate farther on the lathe than it should have. An 8-inch pipe attached to the chamber tore loose when it struck the machine.

Rocketdyne, in consultation with NASA, elected to reattach the pipe through hand welding. The alternative, machine welding combined with heat treating for hardening and stress relief, would have forced a delay of several months in the program and cost thousands of dollars. Rocketdyne officials thought that the weld would hold, and it did—through hundreds of subsequent tests. Only after installation of the engine on the Challenger at Kennedy Space Center in Florida did the weld begin to crack. A leak of volatile hydrogen was detected last December during an engine test-firing on the launching pad. Because the weld was in a relatively inaccessible spot, the location of the leak was not determined until a few weeks ago, after a second test. If it had gone undetected, the leak could have resulted in a devastating explosion, between 1 and 2 minutes after the Challenger had lifted off.

NASA officials shipped a spare engine from their test facility in Mississippi to Florida. On its arrival, technicians discovered that it too had a small welding crack, in a portion of the engine that circulates liquid oxygen as a coolant. Had the leak not been discovered, the oxygen would have escaped into an area filled with hydrogen, creating "a blowtorch in a critical area," according to Lt. General James Abrahamson, the shuttle program director.

A third engine, originally intended as a replacement on the first shuttle, was shipped to Florida last week; if problems develop in that one, NASA will have no choice but to install one of the used engines from the first shuttle. NASA originally planned to tear all those engines apart and rebuild them before reuse. Meanwhile, leaks were discovered in hydrogen lines on the remaining engines already installed on the Challenger. They were removed last week and a special welding machine was shipped in from California to make the appropriate repairs.

As a result of these misfortunes, the sixth flight of the space shuttle has been delayed until late March; the seventh flight has been delayed from April to late May; and the eighth flight has been delayed from June until late July. Abrahamson says that if every mission is launched on time, no delay will occur in the ninth mission, which carries Spacelab.

Skepticism within the agency abounds, and contingency planning is under way in Washington and at the Marshall Space Flight Center in Huntsville, Alabama. A timely launch of the sixth and eighth missions is essential to Spacelab's success, because each mission will transport into space a tracking and data relay satellite, necessary for the

transmission of Spacelab's data to earth. Without one or both satellites, much of the scientific data will be lost. "The bytes will just fall off the end of the table and onto the floor," says Richard Chappell, a Spacelab mission scientist.

NASA and ESA have several options if both satellites are not up and running by 30 September. One is to delay Spacelab's flight by as much as a month, a choice that ESA likes because it might result in only minor data loss. But NASA is concerned that such a delay will crowd the tenth flight of the shuttle, now scheduled for November, which has a payload constructed by the Defense Department. National security comes before science under the Reagan Administration space policy.

A second option is to fly in September with only one satellite available. Chappell says that under this option "a majority of the 77 experiments on Spacelab will lose some data." No one yet knows which ones and how much. But certain experiments require more live data transmission than others to ensure their success. Included in this category are experiments in x-ray spectroscopy, measurements of deuterium and of the solar constant, microwave remote sensing, an investigation of motion sickness, and a $30-million experiment involving active generation of charged particle beams. "If the experimental time line is redone and extra recording tapes are stored on board, perhaps 90 percent of the data could be retained," Mellors says.

A third option is to delay the flight until February, when the winter solstice has ended and there is sufficient light for the experiments requiring earth observations. The chief disadvantages are the added expense, and the need to revise the schedule of experiments so as to take into account intervening celestial movement.

Mellors says that if the delay winds up costing a lot of money, ESA might have to pull back from its contractual commitment for engineering support during the second Spacelab flight sometime later next year. "We want to avoid this if possible," he says. "But if we do have another hiccup, we may well have to invoke the contract clause that says 'subject to the availability of funds.' "

NASA is earnestly attempting to avoid any delay. Recently, for example, it decided not to test-fire all the shuttle engines together after repairs are completed, because it would require 3 weeks of preparation. Abrahamson says that four shifts are now working around the clock and on weekends to smooth out the troubles at the launch site. No one at the agency seems certain how much this will cost, but most estimates are in the tens of millions of dollars.

Unlike some previous shuttle program managers, Abrahamson is candid about the agency's role in the present mess. For years, the agency cut back on testing and the production of spare parts in an attempt to control costs and give the program as low a political profile as possible. The agency's technical problems were manipulated, not solved. Difficult work was put off until the first shuttle was so far along that Congress could not scrap it. The object, Abrahamson says, was to get the first flight off quickly, and to do it without exceeding the tight fiscal constraints. "We just didn't have much spare hardware," which meant that if something went wrong unexpectedly, it required a long time to fix. "We didn't catch the problems we would like to have caught earlier," Abrahamson says.

The existing engine problems are the legacy of this management style. Few engine parts are available for repairs. The first shuttle must now be cannibalized so that the second can fly. Abrahamson is trying to improve the situation, but spare parts ordered today will not be available for several years. The agency, meanwhile, finds itself under increasing pressure to meet its commitments, from the White House, the Congress, the Pentagon, and its commercial clients. Consequently, it continues to exude optimism.

—R. JEFFREY SMITH

Vietnam's Herbicide Legacy

Recent studies in Vietnam have found long-term environmental damage and a possible rise in birth defects from U.S. spraying

A major epidemiological study conducted by Vietnamese scientists has turned up evidence of an increase in the incidence of congenital abnormalities among children whose fathers were exposed to herbicides during the Vietnam War. Several Western scientists who examined reports of the research at a recent conference in Ho Chi Minh City called the study "impressive," but cautioned that the findings are suggestive rather than conclusive.

Nevertheless, the study is likely to influence debate in the United States over the long-term impact of the spraying on American troops who served in Vietnam. Some veterans have claimed that exposure to Agent Orange—the most widely used herbicide—caused birth defects in their children. But the evidence is anecdotal and comes from a self-selected group. The Vietnamese study "is the first reported scientific investigation. . . . We have to pay attention to it," says Maureen Hatch, a reproductive epidemiologist from Columbia University who attended the conference.

The conference provided the first opportunity for scientists from outside Vietnam to review research on the long-term environmental and health effects of Operation Ranch Hand, the U.S. military operation that dumped some 72 million liters of herbicides and defoliants on southern Vietnam between 1961 and 1971. In addition to the preliminary findings on birth defects, several reports indicated that the spraying inflicted some lasting scars on Vietnam's environment.

The most striking evidence linking exposure to herbicides with reproductive problems comes from a survey of some 40,000 families in northern Vietnam. Because all the spraying took place in the south, women in the northern villages were not exposed to herbicides or defoliants. The survey found that women whose husbands fought in the south—and who were therefore potentially exposed to the spraying—had a higher incidence of pregnancies resulting in stillbirths and congenitally abnormal offspring than women whose husbands had remained in the north. An independent follow-up study indicated that the risk factor was about 3.5.

The survey and the statistical analysis were apparently well conducted, according to those who examined the methodology. "We had no control over whether