Satellite Accident May Delay Shuttle Flights

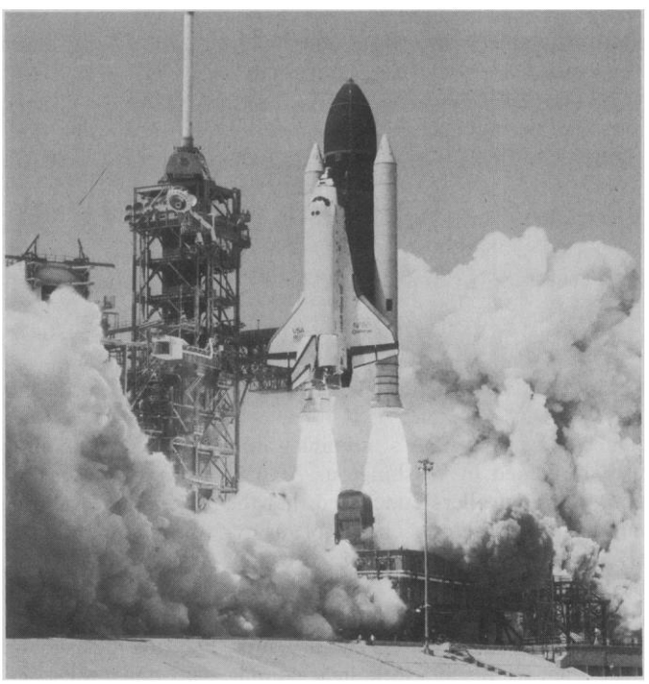
A malfunction of the satellite's booster could lead to costly repairs and delays in the next few launches

Johnson Space Center, Texas. On the morning of 5 April, the National Aeronautics and Space Administration (NASA) lost contact with a critical communications satellite shortly after it was launched during the maiden flight of the space shuttle Challenger. Agency employees around the globe worked feverishly in an attempt to determine what had gone wrong. Three hours later, when contact was reestablished, the satellite was operating normally, but it was wildly off course and had sustained some minor damage that seriously complicated rescue plans.

The accident seemed to be caused by an engine or equipment malfunction in the rocket that was to ferry the satellite into a permanent orbit 22,350 miles above the earth. A similar rocket is scheduled to transport a similar satellite into orbit during the eighth shuttle flight in July. Both satellites are needed to obtain data from the scientific experiments aboard Spacelab, which is now scheduled for launch on 30 September. NASA officials and contractors privately predict that the accident will lead to delays in the operation of both satellites, and to either a curtailment of Spacelab's experiments or a delay in its launch. Either circumstance will create bad feelings at the European Space Agency, which is responsible for Spacelab and anxious to have it launched on time (*Science*, 11 March, p. 1195).

Dale Carpenter, an assistant program manager at TRW Inc., where the satellites were designed, says that "it will probably take several months to determine exactly what happened." Edward Smylie, NASA's associate administrator for tracking and data systems, told *Science* that "it is hard to imagine anything so mundane that it won't cause a delay." Nevertheless, he predicts that the agency will hew publicly to the existing schedule. "If you don't continue pressing down the optimistic road, then everybody relaxes," he says.

Although the accident can hardly be considered small, it was virtually the only flaw in the Challenger's maiden flight. Its launch had been repeatedly delayed by engine troubles, and as a NASA official told ABC-TV, "we were all a little antsy . . . a little nervous about making it all the way to orbit." The flight schedule demanded that launch occur within a few minutes of 1:30 p.m. on 4 April, and it was only 0.08 second late. Billowing clouds of white smoke preceded flames as bright as a welder's arc. The rumble and roar were undiminished by modifications that make Challenger nearly 21,500 pounds lighter than Columbia, the first shuttle. Minutes later, Jay Greene, the ascent flight director, said "We have a good vehicle on our hands."



NASA was able to reduce the Challenger's weight by redesigning the large rust-colored external fuel tank and by constructing the two boosters with thinner motor casings. The weight reduction, in combination with more powerful engines, will enable the orbiter to transport heavier payloads into space.

The crew's first major assignment was deployment of the satellite, which is designed to relay tracking and communications data from the shuttle, Spacelab, Landsat 4, and the Space Telescope to a ground station in White Sands, New Mexico. The arrangement is designed to handle more information, more quickly than the existing NASA ground stations and to facilitate almost continuous transmissions. Before the mission, Paul Weitz, the shuttle commander, said that the crew's principal reason for flying was to deliver the satellite and its upper-stage rocket "in attitude on time. And once we get that done, as far as I'm concerned, the mission is a success." The satellite was constructed by TRW under contract to NASA, and the rocket was constructed by Boeing United Technologies and TRW under contract to the Air Force.

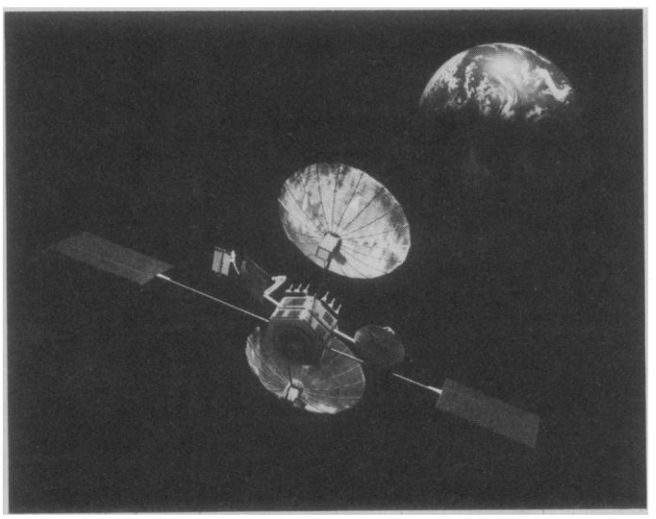
Once the shuttle had maneuvered a safe distance away, the motor of the rocket's first stage fired for 151 seconds, longer than any other solid-fueled engine. This moved the satellite from the shuttle's roughly circular orbit at an altitude of 155 miles to an elliptical orbit with an apogee of 21,850 miles. At apogee, a second-stage engine was to fire for 103 seconds, making the orbit circular.

At about 4:30 a.m. (C.S.T.), between 70 and 80 seconds into the burn of the second-stage motor, communications with the $77-million rocket and the $416-million satellite were abruptly cut off. At the controls inside a small, windowless room at the Johnson Space Center were Robert Aller, a satellite manager from NASA headquarters, Dean Carpenter, and Lieutenant Colonel Ralph Tourino, a rocket manager from the Air Force Space Division.

The first indication of malfunction was the satellite's tardiness in arriving at its expected station. The ground controllers deduced from intermittent signals that the satellite-rocket combination was

tumbling out of control at 30 revolutions per minute. Not knowing how to stabilize the two together, the controllers commanded the rocket to separate by severing some connecting bolts. But the signal failed to penetrate the tumble. As time passed, the controllers became concerned that the batteries powering the boltcutters had been drained, dooming the satellite to lug the rocket through space forever. "We commanded separation in the blind, constantly," reports Smylie. This was not without risks. If separation was not swift or sure, the satellite could be damaged through impact with the rocket.

At 5:50, Aller noted that "we're fast running out of time to do anything."



The tracking and data relay satellite pictured in this TRW simulation consists of two solar arrays and seven antennas for communications in the S-band, the C-band, and the K-band.

James Beggs, NASA's administrator, was awakened in Washington. At 6:57 a.m., the controllers concluded that the mission had a 5 percent chance of survival. Steps were taken to seal records and begin an investigation.

"It was sickening to think that we'd lost the total mission," says Carpenter. "But then we'd see a little light coming out." By 7:30, the satellite's tumble had slowed, and at 8 a.m., contact was reestablished. Separation occurred shortly thereafter, even though the rocket batteries were thought to be dead. The satellite deployed its enormous solar panels, and then its antennas. But serious problems remain. Its orbit is 21,850 miles by 13,800 miles, well short of a useful altitude. It is drifting to the east, not the west as planned. And one of the thrusters on the satellite is locked shut, possibly from impact with the rocket during separation.

NASA originally planned to raise the satellite's orbit right away, using surplus hydrazine fuel, which fortuitously is stored on board because of the agency's troubled management of the satellite and shuttle programs. When the satellite was first designed, it was supposed to serve commercial as well as federal clients, and the fuel was needed to maintain a precise orbit for commercial communications. Because of delays in the satellite's launch, as well as increased costs and some pressure from the Defense Department to exclude commercial clients, a partnership with Western Union has been dissolved, and the government will pick up a $2.5-billion tab for the whole program. The orbital tolerance for government communications is much greater, so much less fuel is required.

NASA's latest estimate is that almost all of the extra fuel will be needed for the ascent operation, leaving little room for mistake. The effort will require 14 days. If it is successful, the satellite must be examined for roughly 90 days before it begins full tracking and data relay operation. NASA delayed the start of the ascent so that it could study the thruster malfunction. "We do need roll control during the ascent maneuver," says Smylie, and if the same problem should befall one or two similar thrusters, the agency will be out of luck and the satellite will be lost. "We have a long way to go and it's going to take probably a month or so to get [to the correct orbit]," Aller said on 7 April. "I believe in the situation we're in I wouldn't want to try to assure anybody of anything. We have been through a critical emergency. We've come out of it in pretty good shape."

On 9 April, NASA revealed that sensitive Air Force cameras, located in Socorro, New Mexico, had captured a sharp change of course by the satellite booster at the moment telemetry was lost. This could have been caused by a malfunction of either the engines or the guidance system. At the time the satellite was deployed, two of the five gyroscopes aboard the rocket were inoperative for mysterious reasons. Ground controllers decided to deploy the satellite anyway, in a belief that a correct orbit could still be achieved.

There is also speculation that the rocket's design is somehow flawed. In October 1982, when a similar rocket transported two defense communications satellites into geosynchronous orbit, the telemetry failed in mid-deployment. Air Force and Boeing engineers say that they redesigned some switches and replaced some cables in the rocket carried by the space shuttle. But the program's entire history is somewhat checkered, with problems in both propellants and electronics, and a 60 percent growth in costs.

A final possibility, judged least likely by agency officials, is that the rocket was somehow damaged when it was transferred from one payload bay to another before the flight. "There was a handling incident," says J. J. Conwell, a NASA payload officer, "but I think 'dropped' is too strong a word. The first reports came out that it was dropped, and after we looked at it, the determination was that it settled."

In a news conference on 9 April, NASA associate administrator James Abrahamson said that "we will not fly a second satellite on the eighth shuttle until we understand what went wrong on this flight. . . . We're convinced that we will understand . . . but it will be a very tight schedule indeed to make everything work on time."

Certainly no delays are expected from the Challenger itself. Only minor problems developed with the shuttle's heaters, flight recorders, thermal protection blankets, and computers. A spacewalk by astronauts Story Musgrave and Donald Peterson occurred without incident. The shuttle's exterior was largely unaffected by reentry and landing, which occurred on 9 April at 1:53 p.m. (E.S.T.), only 42 seconds late. "I just can't get over how clean the ship is," says James Harrington, the manager of ground operations.

The Challenger's astounding success demonstrates the soundness of Abrahamson's decision to delay the flight until the engine bugs were eliminated. "We have stubbed our toe, but we have not broken our leg," he said of the delay before the launch. "The price that we're paying . . . is small compared to the real gain in efficiency and operational capability that we'll have later on when we'll be operating at high launch rates." The Air Force would be well served by a similar approach.—**R. JEFFREY SMITH**