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NASA's Space Shuttle Columbia: Quick Facts and Issues for Congress

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Summary

On February 1, 2003, NASA's Space Shuttle *Columbia* broke apart while returning to Earth from a 16-day science mission in orbit. All seven astronauts—six Americans and one Israeli—were killed. An investigation board issued its report on the accident on August 26, 2003, which is available at [http://www.caib.us]. A synopsis is provided in CRS Report RS21606. This report provides quick facts about *Columbia,* an overview of the investigation board's report, and a brief discussion of issues for Congress. More information on the space shuttle is available in CRS Issue Brief IB93062, CRS Report RS21411, and CRS Report RS21419. This report is updated regularly.

The Loss of the Space Shuttle *Columbia*

The space shuttle *Columbia* was launched on its STS-107 mission on January 16, 2003. After completing a 16-day scientific research mission, *Columbia* started its descent to Earth on the morning of February 1, 2003. As it descended from orbit, approximately 16 minutes before its scheduled landing at Kennedy Space Center, FL, *Columbia* broke apart over northeastern Texas. All seven astronauts aboard were killed. They were Commander Rick Husband; Pilot William McCool; Mission Specialists Michael P. Anderson, David M. Brown, Kalpana Chawla, and Laurel Clark; and payload specialist Ilan Ramon, an Israeli. The last communication with *Columbia* was at about 09:00 EST. The shuttle was at an altitude of 207,135 feet, traveling at a speed of Mach 18.3 (about 13,000 miles per hour).

NASA Administrator Sean O'Keefe immediately appointed an internal "Mishap Investigation Board," (MIB) and also an external group, the "*Columbia* Accident Investigation Board" (CAIB), to investigate the accident. MIB was replaced by the NASA Accident Investigation Team (NAIT) on March 21, 2003. Much of the information NASA is releasing to the public can be obtained at [http://www.nasa.gov/columbia/]. The CAIB is discussed below. It has its own Web site [http://www.caib.us.].

The Space Shuttle *Columbia* and the STS-107 Mission

The Space Transportation System (STS)—the space shuttle—consists of an airplane-like orbiter, two Solid Rocket Boosters (SRBs) on either side, and a large cylindrical External Tank that holds the fuel for the orbiter's main engines. The SRBs detach from the orbiter 2 ½ minutes after launch when their fuel is spent, fall into the ocean, and are recovered for refurbishment and reuse. The External Tank is not reused. It is jettisoned as the orbiter reaches Earth orbit, and disintegrates as it falls into the Indian Ocean.

Columbia was one of four flightworthy reusable space shuttle orbiters in NASA's fleet. The others are *Discovery*, *Atlantis*, and *Endeavour*. A fifth orbiter, *Challenger*, was lost in a 1986 accident. Another orbiter, *Enterprise*, was used for approach and landing tests in the 1970s and was not designed to travel in space. *Enterprise* now belongs to the Smithsonian's National Air and Space Museum.

Columbia was the first spaceflight-worthy orbiter built for NASA by Rockwell International (the space division of Rockwell, which built the orbiters, was later bought by Boeing). It was used for the very first shuttle flight on April 12, 1981. The STS-107 mission was *Columbia*'s 28th flight. Although *Columbia* was the oldest orbiter, *Discovery* has been used for more flights (30). NASA has conducted a total of 113 shuttle launches to date. Orbiters are periodically taken out of service for maintenance and overhaul. *Columbia* last underwent such an "orbiter major modification" (OMM) period in 1999-2001. STS-107 was *Columbia*'s second flight after the OMM. It was a scientific research mission that, unlike most current shuttle launches, was not related to the International Space Station (ISS) program (see CRS Issue Brief IB93017). The crew conducted a research program involving 59 separate investigations. Some of the research required analysis of specimens and data sets after the shuttle returned to Earth, and most were destroyed along with the crew and orbiter. Other data, however, were transmitted to ground-based researchers during the flight, and a few specimens were retrieved among the debris, so some of the research survived. Quantifying the amount is difficult.

Previous Spaceflight-Related Crew Fatalities

The United States has suffered two other spaceflight-related accidents that caused astronaut fatalities. On January 27, 1967, the crew of the first Apollo mission—Virgil "Gus" Grissom, Edward White, and Roger Chaffee—died when electrical arcing in spacecraft wiring caused a fire in their Apollo command module during a pre-launch test. Apollo flights resumed after 21 months. On January 28, 1986, the space shuttle *Challenger* (STS 51-L) exploded 73 seconds after launch, killing all seven astronauts aboard: Francis "Dick" Scobee, Michael Smith, Judith Resnik, Ellison Onizuka, Ronald McNair, Gregory Jarvis (a payload specialist from Hughes Aircraft), and schoolteacher Christa McAuliffe. A presidentially-created commission, chaired by former Secretary of State William Rogers, determined that cold weather at the launch site caused a rubber "O-ring" in one of the SRBs to fail, allowing gases to escape, resulting in a catastrophic explosion. The shuttle system was grounded for 32 months.

Four Soviet cosmonauts also died during spaceflights. Cosmonaut Vladimir Komarov died during the first Soyuz flight on April 24, 1967. The spacecraft's parachutes did not function properly and it struck the ground with great force, killing

Colonel Komarov. Soviet human spaceflights were suspended for 18 months. Three cosmonauts died on Soyuz 11 on June 29, 1971 when an improperly sealed valve allowed the spacecraft's atmosphere to vent into space. The cosmonauts—Georgiy Dobrovolskiy, Vladislav Volkov, and Viktor Patsayev—were not wearing spacesuits, and were asphyxiated. There were no Soviet human spaceflights for 27 months.

The *Columbia* Accident Investigation Board (CAIB)

NASA Administrator O'Keefe established the *Columbia* Accident Investigation Board (CAIB) within hours of the tragedy, and transitioned responsibility for the investigation to it on February 6. Chaired by **Adm. (Ret.) Harold Gehman**, former NATO Supreme Allied Commander, Atlantic, CAIB has 12 other members (see [http://www.caib.us]. All were appointed by Mr. O'Keefe, although some were added to the initial roster upon the recommendation of Adm. Gehman. NASA revised the Board's charter three times to clarify its independence from NASA, primarily in response to congressional concerns. However, the CAIB was created by NASA, includes NASA representatives, and the Board members were appointed by the NASA Administrator, so concerns about its independence remain. CAIB released the results of its investigation on August 26, 2003. The report is available at its Web site. Additional volumes are planned for publication later. Board member Brig. Gen. Duane Deal wrote a 10-page "supplement" to the report that will be published in Vol. 2. It provides additional recommendations and viewpoints that Gen. Deal felt important to convey.

The Cause of the Accident. The Board concluded that the tragedy was caused by both technical and organizational failures. The technical cause was damage to *Columbia*'s left wing by a 1.7 pound piece of insulating foam that separated from the External Tank's left "bipod ramp" and struck the orbiter's left wing 81.9 seconds after launch. The foam strike created a hole in a Reinforced Carbon-Carbon (RCC) panel on the leading edge of the wing, allowing superheated air (perhaps exceeding 5,000°F) to enter the wing during reentry. The extreme heat caused the wing to fail structurally, creating aerodynamic forces that led to the disintegration of the orbiter. Organizationally, the Board pointed to detrimental cultural traits and organizational practices that developed over the institutional history of the program. Adm. Gehman cited a loss of "checks and balances" in the program's management that should have led to a recognition of the danger posed by "foam shedding" from the External Tank, which had occurred on previous shuttle missions. The Board also cited long term budget constraints as a factor.

CAIB's Recommendations. The CAIB made 29 recommendations, five of which were issued prior to the report's release. Of those 29, 23 are technical and six are organizational. The complete set is listed in Chapter 11 of the report; it is too lengthy to reproduce here. Of the 29 recommendations, the Board specified 15 that must be completed before the shuttle returns to flight status, including that NASA should:

- develop and implement a comprehensive inspection plan to assess the structural integrity of the RCC panels, supporting structure, and attaching hardware;
- ensure that on-orbit imaging of each shuttle flight by Department of Defense satellites is a standard requirement;
- develop a practical capability to inspect and effect emergency repairs to the orbiter's thermal protection system both when near the International Space Station and when operating away from it;

- augment the ability to image the shuttle during its ascent to orbit;
- obtain and downlink high resolution images of the External Tank after it separates from the orbiter, and of certain orbiter thermal protection systems;
- initiate an aggressive program to eliminate all External Tank foam shedding;
- initiate a program to increase the orbiter's ability to sustain minor debris damage;
- test and qualify "bolt catchers" used on the shuttle;
- adopt and maintain a shuttle flight schedule that is consistent with available resources;
- implement an expanded training program for the Mission Management Team; and
- prepare a plan for creating an independent Technical Engineering Authority, independent safety program, and reorganized space shuttle integration office.

Issues for Congress

Congressional hearings are expected to focus not only on the shuttle program, but more broadly on the nation's human spaceflight goals and implications for NASA's budget. Among the many questions likely to be addressed are the following.

Future of the Shuttle and the U.S. Human Spaceflight Program. A fundamental question is whether the benefits of human spaceflight are worth its risks and costs. CAIB hopes that the *Columbia* tragedy stimulates a national debate about future goals for the U.S. human spaceflight program. As the public and policy makers consider what goals, if any, are sufficiently compelling to warrant exposing crews to the risks inherent in human spaceflight, and the expenditures needed to achieve them, debate is likely to focus on whether the nation should commit itself to a goal of sending humans back to the Moon or to Mars, or to rely more heavily on robotic spacecraft to explore the solar system. In the near-term, decisions will be needed about the future of the existing human spaceflight program. Several options are available, each with its own pros and cons, which are discussed in CRS testimony to the Senate Commerce Committee, April 2, 2003, at [http://commerce.senate.gov] (click on the PDF version of the testimony):

- Terminate the U.S. human spaceflight program, including the space shuttle, U.S. participation in the International Space Station (ISS) program, and plans to develop an Orbital Space Plane.
- Terminate the shuttle and Orbital Space Plane programs, but continue participation in the ISS program, relying on Russian vehicles for taking U.S. astronauts to and from space when possible.
- Terminate the shuttle program, but continue participation in the ISS program and continue to develop the Orbital Space Plane or another replacement for the shuttle.
- Continue the shuttle program, but with fewer missions—perhaps limiting it to space station visits—and as few crew as possible.
- Resume the human spaceflight program, including shuttle flights, as planned.

Based on past experience and current polls, many expect the last option to be chosen. Therefore, debate may focus on how to reduce the risk of an accident, and increase the likelihood of crew survivability if an accident occurs. A USA Today/CNN/Gallup poll found that 43% of those polled were willing to accept one fatal shuttle accident every 100 missions, 19% every 50 missions, 7% every 20 missions, 6% every 10 missions, and 17% none (USA Today, August 19, 2003, A 1). Those numbers suggest that a large percentage

of the public is willing to accept the risks inherent in human spaceflight, but within limits. Questions that may arise include:

- Should NASA invest more money in developing crew escape systems to help assure the crew's survival if an accident occurs?
- What would be required to modify the shuttle to operate autonomously, or with fewer crew?
- Should efforts to develop a vehicle to replace or complement the shuttle—such as the Orbital Space Plane now being designed—be accelerated? Is the nation willing to invest the resources needed to develop a new vehicle during a time of record budget deficits and substantial budget demands for other national priorities?

Timing of "Return to Flight". Assuming that the decision is made to continue the shuttle program, the question arises as to when it will be ready to return to flight status. NASA established a "Return to Flight" (RTF) team soon after the tragedy to ensure the agency was ready to resume flights at the earliest opportunity. The current target date is March/April 2004. NASA officials refer to a "sense of urgency" to resume shuttle launches, but insist the RTF process will be deliberate and cautious. Adm. Gehman states that he sees no reason NASA could not resume flights in that time frame, and the CAIB supports RTF at the "earliest date consistent with the overriding objective of safety." The Board separated its recommendations into those that must be completed before RTF, and others that are "continuing to fly" recommendations if the shuttle is to be used for years to come. Although the Board cited both technical and organizational failures as causes of the accident, it concluded that many of the organizational changes would take a long time to fix and need not delay RTF. As noted, it took 21 months after the 1967 Apollo fire and 32 months after the 1986 *Challenger* explosion for the U.S. human spaceflight program to resume. Thus, some are surprised that NASA and the Board believe the shuttle can return to flight in such a comparatively short period of time. The urgency to return to flight apparently stems from a desire to proceed expeditiously with construction of the International Space Station. Questions that may arise include:

- To what extent should space station construction drive the schedule for returning the shuttle to flight status? Russian Soyuz and Progress spacecraft can be used to rotate crews and resupply the station as long as funds are available to construct them. If funds are not available, the station could be destaffed, although there is concern that a technical malfunction could imperil the station if it could not be solved remotely by sending commands from the ground. Schedule delays also would increase the program's costs. Those concerns would have to be weighed against the repercussions if the shuttle returns to flight too hurriedly and suffers a major failure.
- Could schedule pressure cause NASA to take shortcuts in fixing the shuttle? The CAIB report cites space station schedule pressure as a factor in the *Columbia* accident. How will a similar result be avoided now?

Causes of the *Columbia* Accident. The CAIB report details technical and organizational failures, and budgetary constraints, that led to the accident. Questions on which Congress may focus include:

- To what extent was the accident caused by inadequate funding? What funding will be required in the future to ensure that the shuttle is as safe as possible? Is the nation willing to invest those resources?

- Why did NASA and its contractors not consider foam striking the shuttle to be a safety-of-flight concern? What other technical issues exist with the shuttle today that similarly may not be sufficiently appreciated?
- What "cultural" changes are needed at the agency to ensure that future shuttle launches do not involve unnecessary risk? Some personnel already have been removed from their positions; are other personnel changes needed to ensure the agency and the shuttle program have the leadership necessary to effect such changes?

Oversight of NASA's Response to CAIB. Questions are arising about what group should oversee NASA's compliance with the CAIB recommendations. NASA created a task group chaired by two former astronauts—Thomas Stafford and Richard Covey—with a 2-year charter to assess NASA's implementation of the CAIB recommendations "as they relate to the safety and operational readiness of STS-114," the next shuttle flight (see[http://www.nasa.gov/news/highlights/returntoflight.html]). Col. Covey has stated that the group plans to complete its work one month before RTF, however, and its charter does not include addressing many of the organizational and cultural issues raised by the CAIB report. Questions that may arise include:

- Is the NASA-created Stafford/Covey Task Group the best mechanism for overseeing NASA's compliance regarding technical fixes, or should an independent committee, separate from NASA, be established, as was done following the *Challenger* accident? In that case, the Rogers Commission directed that the National Research Council oversee NASA's redesign of the solid rocket boosters.
- What group should oversee NASA's compliance with the other CAIB recommendations, such as needed organizational and cultural changes? Should CAIB be reconvened periodically? Should another group be created, and, if so, by whom—Congress, the White House, or NASA?

Budget Implications. Mr. O'Keefe states that he does not know how much it will cost to fix the shuttle. Congress is currently considering NASA's FY2004 budget request as part of the VA-HUD-IA appropriations bill (H.R. 2861). That request, formulated prior to the tragedy, includes $3.968 billion for the shuttle program. For FY2003, Congress approved NASA's full request for the shuttle and added $50 million for the *Columbia* investigation and remedial actions (see CRS Report RL31347). The Bush Administration requested another $50 million in the second FY2003 emergency supplemental request. Although it was not included in the supplemental that cleared Congress (see CRS Report RL31999), it is in the Senate-passed version of the Legislative Branch Appropriations bill (H.R. 2657), awaiting conference. NASA estimates that, in FY2003, it will need $152.5 million for Recovery and Investigation, and $40 million for initial activities related to Return to Flight. NASA expects to save $30 million in FY2003 because the shuttle fleet is grounded. That would leave $62.5 million to be found from other sources for FY2003 if the supplemental is approved. An estimate for FY2004 and beyond is not available. At the same time, costs for the space station program may increase because of schedule delays, and NASA wants to accelerate development of the Orbital Space Plane. Thus, the budget implications in FY2004 and beyond could be significant. Additional resources might be needed if new human spaceflight goals emerge from a national policy debate about the future of the space program.