

# CRS Report for Congress

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## NASA's Space Shuttle Program: Issues for Congress Related to The Columbia Tragedy and "Return to Flight"

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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. A synopsis is provided in CRS Report RS21606. This report summarizes the *Columbia* tragedy and the investigation board's report, and discusses issues for Congress including the "Return to Flight" (RTF) effort, and the future of the shuttle. NASA currently hopes RTF will occur during a July 13-31, 2005 launch window. More information on the space shuttle is available in CRS Issue Brief IB93062. 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).

Then-NASA Administrator Sean O'Keefe immediately appointed an internal "Mishap Investigation Board" (MIB) and 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. NASA's *Columbia* website is [<http://www.nasa.gov/columbia/home/index.html>]. CAIB is disbanded, but its website [<http://www.caib.us>] was still active as of the date of this report.

## 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, but is jettisoned as the orbiter reaches Earth orbit, and disintegrates as it falls into the Indian Ocean. At the beginning of 2003, all planned shuttle launches, other than STS-107 and two missions to the Hubble Space Telescope, were scheduled to support assembly and operation of the International Space Station (see CRS Issue Brief IB93017).

*Columbia* was one of four spaceflight-worthy reusable space shuttle orbiters in NASA's fleet. The remaining orbiters 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 28<sup>th</sup> 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)**

Then-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, 2003. Chaired by **Adm. (Ret.) Harold Gehman**, former NATO Supreme Allied Commander, Atlantic, CAIB had 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, included NASA representatives, and the Board members were appointed by the NASA Administrator, so concerns about its independence continued. CAIB released the results of its investigation on August 26, 2003 in Vol.1 of its report; Volumes II-VI were released in October 2003. All are available at CAIB's website. Board member Brig. Gen. Duane Deal wrote a 10-page supplement, which is published in Vol. 2, providing additional recommendations and viewpoints that he felt were 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, of which 23 are technical and six are organizational. CRS Report RS21606 provides a synopsis of them. Of the 29 recommendations, the Board specified 15 that must be completed before the shuttle returns to flight status, including that NASA should do the following:

- 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

**Return to Flight.** NASA and its contractors are working to resume shuttle launches. NASA has slipped the date for "Return to Flight" (RTF) several times. The current target is a launch window between July 13-31, 2005. The *Discovery* orbiter will be used for the RTF mission, designated STS-114. NASA will have a second shuttle, *Atlantis*, ready to launch on short notice in case a rescue mission is needed. NASA's "Return to Flight Implementation Plan," which is routinely updated, is at [<http://www.nasa.gov/news/highlights/returntoflight.html>].

**Cost.** NASA's most recent public estimate of the total cost for RTF (FY2003-2009) was released in July 2004. RTF costs are in addition to regular shuttle funding, although some of the RTF money has been taken from other shuttle-related activities (e.g. upgrades). The July 2004 estimate was \$2.2 billion, double the previous estimate of \$1.1 billion. For FY2005, NASA requested \$4.3 billion for the shuttle program. In November 2004, NASA informed Congress it needed \$762 million more than expected for FY2005. In the FY2005 Consolidated Appropriations Act (P.L. 108-447), Congress approved the \$4.3 billion, subject to an across-the-board 0.80% rescission. Conferees stated (H.Rept. 108-792) that NASA could submit a request for supplemental appropriations, or reprogram funds from other NASA programs. Congress also appropriated \$126 million to NASA in an FY2005 emergency supplemental for hurricane relief (P.L. 108-324).

According to a May 10, 2005 update to its FY2005 operating plan, NASA is reprogramming the following funds into RTF: \$55 million from the Science Mission Directorate (\$20 million from space science, \$35 million from earth science); \$375.8 million from the Exploration Systems Mission Directorate (\$73 million from biological and physical research, \$204 million from human and robotic technology, and \$98 million from transportation systems); and \$331.2 million from the Space Operations Mission Directorate (\$160 million from the space station, \$170 million from space shuttle upgrades, and \$1.2 million from space flight support).

Whether the shuttle program overall is receiving adequate funding continues to be a question. The CAIB noted that long term budget constraints were a factor in the *Columbia* tragedy. NASA's FY2006 shuttle budget request is \$4.5 billion, with a projection that it will decline to \$2.4 billion by FY2010. NASA plans to retire the shuttle

in 2010. Whether the agency can accomplish the remaining required shuttle launches (see below) within such a declining shuttle budget remains to be seen.

**Oversight of Compliance with CAIB Recommendations.** NASA created a task group chaired by two former astronauts — Thomas Stafford and Richard Covey — to assess NASA’s implementation of the 15 CAIB recommendations related to Return to Flight. It is not addressing organizational or cultural issues. The Stafford/Covey Task Group [<http://returntoflight.org>] has issued three interim reports, in January and May 2004, and January 2005. On February 17, 2005, the Task Group announced that it has closed out (i.e., approved NASA’s implementation of) seven of the 15 recommendations, and conditionally closed one more. Seven of the CAIB recommendations remain open, as well as another that the task group added to its responsibilities — the ability to use the space station as a “safe haven” for shuttle crews.

Cultural issues were addressed by an internal NASA study led by then-NASA Goddard Space Flight Center Director Al Diaz (currently Associate Administrator for Science at NASA Headquarters). NASA also hired an outside consulting firm, BST, to assess NASA culture and make recommendations about what changes are needed. BST’s most recent report (February 5, 2005) concluded that while there is improvement, a significant number of people at NASA’s field centers do not yet perceive change.

Then-NASA Administrator O’Keefe said that not only would NASA comply with the CAIB recommendations, but would “raise the bar” to ensure the shuttle is as safe as possible. Some view NASA’s repeated RTF slips positively as an indication that NASA is taking every possible step to minimize shuttle risks. Others worry that NASA is proceeding too cautiously. Striking a balance between raising the bar high enough to minimize risk, but not so high that the goal cannot be achieved, is a challenge.

Dr. Michael Griffin became NASA Administrator in April 2005. At an April 18 press conference, he said he will listen carefully to advice, such as that of the Stafford/Covey group, but that NASA and contractor personnel are those responsible and accountable for determining if and when the shuttle is ready for RTF. He would not commit to meeting every CAIB recommendation.

**The Shuttle’s Future and the “Vision for Space Exploration.”** The CAIB hoped that the *Columbia* tragedy would stimulate a national debate about future goals for the U.S. human spaceflight program, leading to a vision that would place the shuttle program, and the risks of human space flight, in context. President Bush announced a new “Vision for Space Exploration” in January 2004, directing NASA to return astronauts to the Moon by 2020 and someday send them to Mars and “worlds beyond” (see CRS Report RS21720). Under the plan, the shuttle — at least in its current form — would be terminated in 2010 when construction of the space station is expected to be completed, primarily so that its funding can be redirected towards achieving other aspects of the Vision. The decision raises a number of issues.

First is whether the United States wants to place itself in the position of being dependent on Russia for human access to space. The President directed NASA to develop a new “Crew Exploration Vehicle” (CEV) to take astronauts to and from the Moon, with an Earth-orbital capability by 2014. That would leave a multi-year gap during which the United States would not have any ability to launch astronauts. (Assuming the last date the

shuttle could fly is December 31, 2010, and that the CEV is available on January 1, 2014, it would be a 3-year gap. If the CEV were not available until the end of 2014, it would be a 4-year gap.) Russia is the only other ISS partner with the ability to launch people into space, and is currently providing crew transportation services to NASA at no cost under a 1996 agreement. That agreement will be fulfilled in April 2006. No additional agreements have been reached, and Russia has made clear that it expects to be paid for any future arrangements. NASA currently is not permitted to pay Russia for such services unless Russia abides by the Iran Nonproliferation Act, however (see CRS Report RS22072 for a discussion of the ISS-INA linkage). Dr. Griffin has made accelerating the availability of the CEV a priority in order to reduce the gap as much as possible.

Next is whether the decision places undue schedule pressure on the shuttle program similar to what existed prior to the *Columbia* accident. NASA is reassessing how many shuttle flights are needed to complete ISS construction; the number appears to be between 18 and 28. If the shuttle returns to flight in July 2005, that many flights would have to be accomplished in 5 ½ years. That flight rate is within the program's experience (as many as eight have been conducted in a year, although NASA had four orbiters then, instead of three), but the CAIB cited schedule pressure as a factor in the *Columbia* tragedy. Mr. O'Keefe was then stressing that a phase of construction ("U.S. Core Complete") be finished by February 2004. Some are concerned that similar pressure is being exerted now to meet another somewhat arbitrary, budget-driven date.

The effect on utilization of the ISS by NASA and its partners (Russia, Europe, Canada, and Japan) is another issue. ISS was designed to be serviced by the shuttle, which can carry larger crews than the Russian Soyuz spacecraft, and larger and heavier cargo than the Russian Progress cargo spacecraft. In addition, the shuttle is the only cargo spacecraft that can return large amounts of material to Earth (Russia's Progress burns up as it reenters the atmosphere). Without the shuttle, the results of scientific experiments, equipment needing repair, and other items could only be returned if they fit within the small confines of the Soyuz capsule along with whatever crew members were returning to Earth. How NASA can ensure that the shuttle system will remain safe as workers and vendors move on to other projects as the shuttle program comes to an end is also being discussed. A 2005 GAO report (GAO-05-230) concluded that NASA needs to better position itself to address future shuttle workforce needs. (NASA is considering development of a "shuttle-derived" launch vehicle where the orbiter would be replaced with a cargo pod. Such a program could mitigate some of the expected shuttle workforce displacements. See CRS Issue Brief IB93062 for more information.)

**Terminating Hubble Servicing Missions.** The Hubble Space Telescope was designed to be serviced by astronauts aboard the space shuttle. NASA also planned to return Hubble to Earth at the end of its mission lifetime using the shuttle. Two days after President Bush's Vision speech, however, Mr. O'Keefe announced that no more shuttle flights would be made to Hubble, citing, *inter alia*, crew safety concerns. The new NASA Administrator, Dr. Griffin, said during his Senate confirmation hearing that, after RTF, he would reassess the question of whether the shuttle should be used to service Hubble. For more information on Hubble, see CRS Report RS21767.