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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 discussion of issues for Congress, particularly those related to NASA's "Return to Flight" effort. 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).

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.

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 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 Volume 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. The current target for the shuttle's "Return to Flight" (RTF) is May 2005. The *Discovery* orbiter will be used for the RTF mission, designated STS-114, and 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].

In July 2004, NASA updated the cost estimate for RTF. The total estimate for FY2003-2009 rose from $1.1 billion to $2.2 billion. For FY2004, the amount is $450 million instead of $265 million, and for FY2005, $350-650 million instead of $238 million. NASA anticipates covering the additional FY2004 costs from available resources, but is not certain about FY2005, and cautions that RTF costs remain uncertain. In its version of the FY2005 VA-HUD-IA appropriations bill (H.R. 5041, H.Rept. 108-674), the House Appropriations Committee fully funded the $4.3 billion request for the shuttle program. However, NASA's total request of $16.2 billion was cut by $1.1 billion. (NASA received $4 billion for the shuttle program in FY2004, out of a total budget of $15.4 billion.) The Senate Appropriations Committee (S. 2825, S.Rept. 108-353) approved the full shuttle request, and added $500 million in emergency spending for meeting the CAIB recommendations and other RTF activities. Its recommended total for NASA is $16.4 billion. Congress appropriated $126 million to NASA in an FY2005 emergency supplemental appropriations act (P.L. 108-324) to repair facilities at Kennedy Space Center, FL, damaged by hurricanes. The hurricane damage was cited as a factor in NASA's October 1, 2004 decision to slip RTF from March-April to May.

Questions on which Congress is focusing regarding RTF include the following.

- Should the shuttle return to flight, and, if so, for how long? Some Members have expressed concern that the shuttle is unsafe and should not fly again. Others are questioning the shuttle's cost, and whether the program should be terminated as soon as possible, instead of waiting until 2010 as proposed in President Bush's new exploration initiative (discussed below). The President wants to retain the shuttle until 2010 so it can be used to complete construction of the space station. The shuttle was also intended to be used to service the station during its operational phase, so others want to continue the shuttle until a new U.S. spacecraft is available for taking people into space so that U.S. astronauts do not have to rely on Russia for access to the space station.

- If the shuttle is to resume operations, when should that occur? NASA has delayed RTF several times. Some view this positively as an indication that NASA is taking every possible step to ensure that shuttle safety risks are minimized. Others worry that NASA is proceeding too cautiously. NASA says that not only will it comply with the CAIB recommendations, but will "raise the bar" in terms of ensuring the shuttle is as safe as possible. If the shuttle is to fly again, how can a balance be struck between raising the bar high enough to minimize risk, but not so high that the goal cannot be achieved?

- In terms of minimizing risk, what technical issues exist within the shuttle program today that may not be sufficiently understood by NASA and its contractors, just as the potential consequences of foam striking the orbiter were not fully appreciated? For example, NASA discovered that gears that deploy speed brakes on the orbiters — called rudder speed brake actuators — were installed incorrectly when the orbiters were built. In the succeeding years, they apparently were never inspected, even though, if they failed, a catastrophic accident could have resulted. NASA is attempting to determine how the error could have gone undetected for so long.

Oversight of Compliance with CAIB Recommendations. Some have questioned 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 — to assess NASA's implementation of the CAIB recommendations as they relate to the next shuttle flight (STS-114), but it is not addressing organizational or cultural issues. The task group [http://returntoflight.org]) has issued two interim reports, in January and May 2004. The May report conditionally closed out three of the 15 CAIB recommendations, but also determined that the ability to use ISS as a shelter for shuttle crews is becoming increasingly important as a RTF issue, and it has added that capability to its oversight responsibilities. The report also expressed concern about whether the shuttle program has sufficient personnel to complete the RTF activities.

Cultural issues were addressed by an internal NASA study led by then-NASA Goddard Space Flight Center Director Al Diaz. NASA also hired an outside consulting firm, BST, to assess NASA culture and make recommendations about what changes are needed. The two reports are at [http://www.nasa.gov/home/index.html].

Questions that are arising regarding NASA's compliance with CAIB 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 mechanism, if any, is needed to oversee NASA's compliance with the other CAIB recommendations, such as organizational and cultural issues. Are the Diaz and BST reports sufficient? Should CAIB be reconvened periodically? Should another group be created, and, if so, by whom — Congress, the White House, or NASA? H.R. 3219 would create a panel of the National Academies of Science and

Engineering to provide that oversight. S. 1821 would create a permanent National Space Commission to do that and other tasks.

Impact of President Bush's New Exploration Initiative. 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. That national debate has yet to take place, but President Bush announced a new vision for NASA in a January 14, 2004 speech. The President called for the United States, together with international partners, to return humans to the Moon by 2020 and someday travel to Mars and "worlds beyond" (see CRS Report RS21720 and CRS Report RS21744). Under the plan, the shuttle would be terminated in 2010 after construction of the space station is expected to be completed, primarily so that funding now allocated to the shuttle can be redirected towards achieving the new goals. In terms of the Return to Flight effort, the following questions may arise:

- Does the President's initiative, which assumes space station construction will be completed by 2010, followed by retirement of the shuttle, create schedule and funding pressure on the shuttle program similar to that prior to *Columbia*?

- How can NASA 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?

- What impact will projected budget cuts to the shuttle program in the FY2008-2009 period (presented in the FY2005 NASA budget request) have on shuttle safety?

- What impact will anticipated reductions in investments in shuttle upgrades — now that the shuttle will be terminated in 2010 — have on shuttle safety?

- If the completion of space station construction slips beyond 2010 by a year or two, must the shuttle be recertified in 2010 anyway, as recommended by CAIB? To what extent does the current RTF effort constitute "recertification" and who should make that determination? If further recertification is needed, how long would it take and how much would it cost?

Terminating Hubble Servicing Missions. NASA Administrator O'Keefe announced two days after the President's speech that no more servicing flights will be made to the Hubble Space Telescope. Among the reasons cited was that meeting CAIB's requirement that shuttle missions to orbital destinations other than the space station have an autonomous inspection and repair capability would not have application other than the Hubble servicing mission, making the expense questionable. The Hubble decision is discussed in more detail in CRS Report RS21767. Among the questions being asked is:

- Why did the Administrator conclude that the investment in an autonomous inspection and repair capability would not have application except to the Hubble mission? The CAIB recommendation states that the ultimate objective is to develop such a capability for space station-related missions too, in case the shuttle develops problems before or after docking with ISS.