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

Marcia S. Smith
Specialist in Aerospace and Telecommunications Policy
Resources, Science, and Industry Division

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 is underway. This report provides quick facts about *Columbia*, her crew, the STS-107 mission, the status of the investigation, and a brief discussion of issues for Congress. Additional information on the space shuttle program is available in CRS Issue Brief IB93062, CRS Report RS21411, and CRS Report RS21419. This report will be 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).

Accident Investigation

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 can be obtained at [http://www.nasa.gov/columbia/home/index.html].

The CAIB is chaired by **Adm. (Ret.) Harold Gehman**, former NATO Supreme Allied Commander, Atlantic, and has its own Web site [http://www.caib.us]. NASA transitioned responsibility for the investigation to the CAIB on February 6. There is no time limit on the Board's investigation. 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 new Board members must be appointed by the NASA Administrator, so concerns about its independence continue. Another criticism is that the members of the Board who were not government employees at the time they were chosen were then hired as Special Government Employees. Since that means that all the Board members now are government employees, the Board is not subject to the Federal Advisory Committee Act (FACA), thereby restricting public access to meetings and records. Furthermore, the Board members are being paid with NASA funds, which critics contend may influence their judgment. Adm. Gehman insists that NASA is merely a conduit for the funds, which were appropriated by Congress specifically for the *Columbia* investigation and which he oversees as Board chairman. Another controversy is that the Board has conducted interviews with NASA and contractor employees on a confidential basis, and the Board did not want the results of those interviews disclosed to Congress or the public. Adm. Gehman since has indicated that an agreement is being developed whereby certain Members of Congress will have access to that documentation.

On May 6, the CAIB released a "Working Scenario" (available at http://www.caib.us) that represents the Board's and NASA's current understanding of events leading to *Columbia*'s breakup. It is based on sensor readings, still and video photography, testing, and forensic analysis of recovered debris. The working scenario is that the shuttle began its reentry into Earth's atmosphere with "unknown damage" to a reinforced carbon-carbon (RCC) panel along the front (leading edge) of the left wing, or to a "T-seal" connecting two RCC panels. A breach occurred in the wing soon after "entry interface" (when the shuttle first encounters the atmosphere), and as the shuttle continued its descent, the increasingly superheated air surrounding the shuttle entered the wing through the breach, burning through the wing's structure. As the wing failed, its shape deformed, causing exterior materials (such as tiles) to detach and changing the aerodynamics of the shuttle. The orbiter's maneuvering engines fired to compensate for increased drag on the left side, but could not control the orbiter as damage progressed. The vehicle ultimately broke apart due to aerodynamic forces. Adm. Gehman stressed that this scenario is being used to focus the investigation and may change at any time based on additional analysis.

Precisely how the breach occurred remains uncertain, though many believe that the left wing was damaged by an object that fell off the shuttle's External Tank[1] 82 seconds after launch and struck the orbiter. The day after the launch, NASA experts reviewing footage of the launch discerned something hitting the orbiter. During *Columbia*'s mission,

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[1] The Space Transportation System (STS) — the space shuttle — consists of an airplane-like orbiter, two Solid Rocket Boosters (SRBs) on either side of the orbiter, and a large cylindrical External Tank that holds the fuel for the orbiter's main engines. The SRBs detach from the orbiter about 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.

Boeing analyzed what damage might have been caused by the object, thought to be insulating foam, to protective tiles that form part of the shuttle's thermal protection. Boeing concluded that the impact of the debris created no safety of flight issue. The analysis did not assess potential damage to the RCC panels. Other theories are that ice or a heavier insulating material hit the orbiter during launch. Although the Board knows that debris impacted the orbiter during ascent, it has not concluded that the damage to the left wing was caused by that event. Other possibilities include that the shuttle was struck by space debris, or the RCC panels failed due to aging. Tests are underway to determine the effect of debris striking the leading edge. On May 30, the CAIB reported that initial testing on fiberglass (not RCC) caused a T-seal to shift its position and create a 22 inch long opening. The Board still has not reached any definitive conclusions, however.

Some shuttle engineers requested that NASA ask the Department of Defense to image the shuttle while it was in orbit with ground-based telescopes or satellites to gather more data about the extent of damage. NASA officials declined to do so reportedly because the Boeing analysis indicated there was no safety of flight issue, and such images taken on earlier flights were unhelpful. NASA now has an agreement with the National Imagery and Mapping Agency (NIMA) that NIMA will image the shuttle on a routine "targets of opportunity" basis, and, in an emergency, upon specific request from NASA.

NASA and the Board are assessing what could have been done if a determination had been made that the tiles or RCC panels were damaged. Originally, NASA officials stated that nothing could have been done since the astronauts could not have repaired them in orbit. NASA Administrator O'Keefe emphasizes that if they had known of any safety of flight issue, NASA would have done everything possible to save *Columbia*.

Because of the threat of terrorism, and the presence of an Israeli astronaut on the mission, questions arose as to whether the loss of *Columbia* could be attributed to terrorism. Government officials stress that there is no evidence that the tragedy could have been caused by terrorists.

CAIB Recommendations

On April 17, 2003, the CAIB issued two preliminary recommendations. The Board found that current inspection techniques are not adequate to assess the structural integrity of the RCC panels, supporting structure, and attaching hardware. Therefore, it recommended that NASA develop and implement a comprehensive inspection plan prior to the shuttle's return to flight. Second, the Board found that the full capabilities of the United States to image *Columbia* during its flight were not utilized. It recommended that NASA modify the arrangement it recently reached with NIMA (discussed above) to make on-orbit imaging of each shuttle flight a standard requirement.

Space Shuttle *Columbia*

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 that ended tragically on February 1, 2003 was *Columbia*'s 28th flight. Although *Columbia* is the oldest orbiter, *Discovery* has been used for more flights (30). Orbiters are periodically taken out of service for maintenance and overhaul. *Columbia* underwent an inspection and retrofit program from August 1991-February 1992, was in an "orbiter maintenance down period" in 1994-1995, and an "orbiter major modification" (OMM) period in 1999-2001. STS-107 was its second flight after the OMM.

Columbia's STS-107 Crew

Commander: **Air Force Colonel Rick D. Husband**, b. July 12, 1957, Amarillo, TX. Married, two children. This was his second flight into space, having piloted STS-96 in 1999. Received a BS in mechanical engineering from Texas Tech University in 1980 and a MS in mechanical engineering from California State University-Fresno in 1990.

Pilot: Navy Commander William "Willie" McCool, b. September 23, 1961, San Diego, CA. Married, three children. This was his first spaceflight. Received a BS in applied science from the U.S. Naval Academy in 1983, an MS in Computer Science from the University of Maryland in 1985, and an MS in aeronautical engineering from the U.S. Naval Postgraduate School in 1992.

Payload Commander/Mission Specialist 3: Air Force Lieutenant Colonel Michael P. Anderson, b. December 25, 1959, Plattsburgh, NY. Married. two children. This was his second spaceflight, having flown on STS-89. Received a BS in physics/astronomy from the University of Washington in 1981 and an MS in physics from Creighton University in 1990.

Mission Specialist 1: Navy Captain David M. Brown, b. April 16, 1956, Arlington, VA. Single. This was his first spaceflight. Received a BS in biology from the College of William and Mary in 1978 and a doctorate in medicine from Eastern Virginia Medical School in 1982.

Mission Specialist 2: Dr. Kalpana Chawla, b. July 1, 1961, Karnal, India. Married. Dr. Chawla is a naturalized U.S. citizen, and was making her second spaceflight. Received a BS in aeronautical engineering from Punjab Engineering College, India, in 1982; an MS in aerospace engineering from the University of Texas in 1984; and a PhD in aerospace engineering from the University of Colorado in 1988.

Mission Specialist 4: Navy Commander (captain-select) Laurel Blair Salton Clark, b. March 10, 1961, Ames, Iowa, but considered Racine, WI as her hometown. Married, one child. STS-107 was her first spaceflight. Received a BS in zoology from the University of Wisconsin-Madison in 1983 and a doctorate in medicine from the same school in 1987.

Payload Specialist: Colonel, Israeli Air Force, Ilan Ramon, b. June 20, 1954, Tel Aviv, Israel. Married, four children. STS-107 was his first spaceflight. Received BS in electronic and computer engineering from the University of Tel Aviv, Israel, in 1987.

The STS-107 Mission

STS-107 was a scientific research mission that, unlike most current shuttle launches, was not related to the International Space Station (ISS) program. The launch of STS-107 had been delayed for a variety of reasons since the summer of 2001. According to NASA's STS-107 press kit [http://spaceflight.nasa.gov] and news accounts, STS-107 carried a SPACEHAB Double Module in the shuttle's cargo bay, which allows astronauts to conduct scientific experiments in a "shirt-sleeve" environment. The crew, working round-the-clock, conducted a research program involving 32 payloads, with 59 separate investigations. SPACEHAB marketed 18% of the module's capacity to international and industry commercial users, while NASA experiments made up the remaining 82%. Students from six schools in Australia, China, Israel, Japan, Liechtenstein, and the United States probed the effects of spaceflight on spiders, silkworms, inorganic crystals, fish, bees, and ants, respectively. Other experiments were attached to the outside of the SPACEHAB Double Module, or on a bridge-like structure mounted across *Columbia's* payload bay. The latter, called Fast Reaction Experiments Enabling Science, Technology, Applications and Research (FREESTAR), included the Mediterranean Israeli Dust Experiment which involved observations of Israel from space. Some of the research required analysis of specimens and data sets after the shuttle returned to Earth, and they 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 Crew Fatalities During Space Missions

The United States has suffered two other spaceflight-related accidents that caused astronaut fatalities. On January 27, 1967, the three-man crew of the first Apollo mission died when a fire erupted in their Apollo command module during a pre-launch test. The three astronauts were Virgil "Gus" Grissom, Edward White, and Roger Chaffee. A NASA investigation determined that electrical arcing in spacecraft wiring caused the fire. Modifications were made to the Apollo design and test procedures before Apollo flights resumed 21 months later.

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. President Reagan appointed a special commission to investigate the accident, chaired by former Secretary of State William Rogers. The Rogers Commission determined that cold weather at the launch site caused a rubber "O-ring" in one of the Solid Rocket Boosters (SRBs) to fail, allowing gases to escape, resulting in a catastrophic explosion. The shuttle system was grounded for 32 months while NASA redesigned the SRBs. The shuttle returned to flight in September 1988. Congress appropriated $2.1 billion to build a replacement for *Challenger*. The new orbiter, *Endeavour*, made its first flight in May 1992.

Four Soviet cosmonauts also died during spaceflights. Cosmonaut Vladimir Komarov died during the first Soyuz flight on April 24, 1969. The spacecraft's parachute tangled during descent and it struck the ground with great force, killing Colonel Komarov. Soviet human spaceflights were suspended for 18 months while the Soviets investigated

and remedied the problem. 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 while modifications were made to the spacecraft.

Issues for Congress

Following is a brief list of questions framing the debate over *Columbia* and the future of the human space flight program. A key factor in evaluating many of these questions is how long the shuttle system may be grounded, but that is not yet known.

- Was funding for the shuttle program adequate to ensure shuttle safety?
- Did NASA adequately respond to concerns expressed over the past several years by the Aerospace Safety Advisory Panel and others (see CRS Report RS21419) that the shuttle program was under stress due to funding and workforce constraints?
- Did NASA adequately investigate damage that might have been caused to *Columbia*'s heat resistant tiles by objects that fell from the External Tank during launch? If *Columbia* had been damaged, was there anything NASA could have done to ensure the safe return of *Columbia*'s crew?
- Is the *Columbia* Accident Investigation Board the best group to assist NASA in this investigation, or should the White House have established a "blue-ribbon" commission independent of NASA as was done following the *Challenger* tragedy in 1986?
- What are the funding implications of the *Columbia* accident for the space shuttle program, and for the space station program, which relies on the shuttle for assembly and operation?
- Should permanent occupancy of the space station be suspended until the shuttle system is operating again, or should the space station partners (the United States, Russia, Europe, Japan, and Canada) indefinitely rely on Russian Soyuz and Progress spacecraft to bring crews and cargo to space station? (See CRS Issue Brief 93017.)
- If the decision is made to rely indefinitely on Russian spacecraft beyond those that Russian already has agreed to provide at no cost to the other partners, who will pay for them? The Iran Nonproliferation Act (P.L. 106-178) prohibits NASA from making payments to Russia, in cash or in kind, in connection with the space station program unless the President certifies that Russia is not proliferating nuclear or missile technologies to Iran.
- Should a replacement orbiter be built? If so, how much will it cost and how long will it take? If not, can NASA service the Hubble Space Telescope and continue assembly and operation of the space station with only three orbiters?
- Should efforts to develop an Orbital Space Plane be accelerated instead of building a replacement for *Columbia*? To what extent *can* those plans be accelerated?
- Are the benefits of human spaceflight worth the risks and costs?

Three congressional hearings have been held to date: February 12 (joint hearing Senate Commerce Committee/ House Science Committee); February 27 (House Science Committee); and May 14 (Senate Commerce Committee).