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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 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 often.

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. NASA has a Web site where many of the materials it is releasing to the public can be obtained [http://www.nasa.gov/Columbia].

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]. Biographical information on Adm. Gehman and the other members of the Board are available at that site. 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. NASA transitioned responsibility for the investigation to the CAIB on February 6. There is no time limit on the Board's investigation.

NASA and the CAIB are working through a "fault tree" of possibilities of what may have happened to *Columbia*, and no conclusion has been reached. The Board initially focused on data from sensors in *Columbia*'s left wing in the minutes prior to the orbiter's break up. The first indications of trouble were the loss of data from sensors in that wing, and other sensors registering rising temperatures. NASA analysis indicates that the superheated gas surrounding the shuttle as it descended through the atmosphere must have reached the interior of the wing to account for those readings. Some theorize that reinforced carbon-carbon (RCC) panels along the front (leading edge) of the wing may have been breached. On March 21, debris searchers in Texas found a flight data recorder (the Orbiter Experiment Support System, or OEX) from the shuttle in remarkably good condition. Data are now being recovered from the OEX, which was recording readings during launch and reentry from sensors located throughout *Columbia*, including on the left wing. The sensor readings are in addition to those originally available, which were transmitted to the ground during reentry. These were stored on magnetic tape for analysis after the shuttle landed. Initial analysis of the OEX data supports the theory that a breach occurred in the left wing leading edge area.

How and precisely where the breach occurred still is unclear. One theory is that the left wing may have been damaged by objects that fell off the shuttle's External Tank[1] 82 seconds after launch and struck the orbiter in that area. The day after the launch, NASA experts reviewing footage of the launch discerned something hitting the orbiter. Analysis by the Boeing Company initially focused on one object, believed to be foam insulation, but by January 24, Boeing's presentation slides indicated that three objects were involved. The Boeing analysis concluded the debris created no safety of flight issue. The concern was that the objects might have damaged protective tiles that form part of the shuttle's thermal protection system. It does not appear that the analysis assessed potential damage to the RCC panels. E-mail exchanges among NASA and contractor employees during STS-107's flight continued discussion of theoretical scenarios stemming from damaged tiles until the day before the landing. Other theories are that ice or a heavier insulating material hit the orbiter during launch, that space debris hit it while it was in orbit, or that the RCC system failed due to aging. Some shuttle engineers reportedly requested that NASA ask the Department of Defense to image the shuttle while it was in orbit with

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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.

ground-based telescopes or satellites to gather more data about the extent of damage. NASA officials declined to do so because the Boeing analysis indicated there was no safety of flight issue, and such images taken on earlier flights were unhelpful. NASA reached agreement with the National Imagery and Mapping Agency (NIMA, see CRS Report RL31369) on March 25 that NIMA will image the shuttle on a routine "targets of opportunity" basis, and upon specific request from NASA in an emergency.

If tiles had been damaged, the astronauts could not have repaired them in orbit. Astronauts can make emergency spacewalks into the shuttle's cargo bay, but cannot maneuver around to the belly of the orbiter where the tiles are located, and there is no method to repair a damaged tile on orbit, according to NASA. It is not clear what, if anything, the crew could have done to repair an RCC panel. 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[2]

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[3]

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

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[2] Biographies taken from NASA official biographies, supplemented by media reports.

[3] Summarized from NASA's Press Kit for the STS-107 mission available at [http://spaceflight.nasa.gov] and news accounts.

had been delayed for a variety of reasons since the summer of 2001. 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, so some of the crew's scientific research did survive them. 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

As the causes of the *Columbia* tragedy are investigated, Congress and the Bush Administration are facing a number of issues. Following is a brief list of questions likely to frame the debate. A key factor in evaluating many of these questions is how long the shuttle system may be grounded. That will not be known until the cause of the accident is determined and remedial steps identified.

- 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 RS 21419) 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 establish 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) rely on Russian Soyuz and Progress spacecraft to bring crews and cargo to space station?
- If the decision is made to rely on Russian Soyuz and Progress spacecraft beyond those that Russian already has agreed to provide at no cost to the other partners, who will pay for them? In this context, it is important to recall that 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 to Congress 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?
- What changes are needed to NASA's recently revised Integrated Space Transportation Plan? Should efforts to develop an Orbital Space Plane, announced in that plan, 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?

The following hearings have been held: joint hearing between the Senate Commerce Committee and the House Science Committee, February 12, 2003; and House Science Committee hearing on implications of the *Columbia* accident on NASA programs and budget, February 27. A Senate Commerce Committee hearing on the *Columbia* investigation and future space policy, planned for March 20, was postponed to May 14.