

# CRS Report for Congress

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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 Reports RS21411 and RS21419 describe space shuttle funding, and provide excerpts from recent reports and hearings on shuttle safety, respectively. 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).

NASA Administrator Sean O'Keefe immediately appointed an internal "Mishap Investigation Board," and also an external group, the "Columbia Accident Investigation Board (CAIB)," to investigate the accident. Information on the investigation is available at [<http://www.nasa.gov/columbia>]. The external group is chaired by Retired Navy Admiral Harold Gehman, who co-chaired the independent commission that investigated the attack on the U.S.S. Cole in Yemen. The other original members are: Rear Admiral Stephen Turcotte, Commander, U.S. Naval Safety Center, Norfolk, VA; Major General John L. Barry, Director, Plans and Programs, Headquarters Air Force Materiel Command,

Wright-Patterson Air Force Base, OH; Major General Kenneth W. Hess, Commander, U.S. Air Force Chief of Safety, Kirtland Air Force Base, NM; Dr. James N. Hallock, Aviation Safety Division Chief, U.S. Department of Transportation, Cambridge, MA; Steven B. Wallace, Director of Accident Investigation, Federal Aviation Administration, Washington, DC; Brigadier General Duane Deal, Commander 21<sup>st</sup> Space Wing, Peterson Air Force Base, CO; and G. Scott Hubbard, Director, NASA Ames Research Center. Roger Tetrault, retired from McDermott International, and Dr. Shiela Widnall, former Secretary of the Air Force, later joined the Board. Bryan D. O'Connor, NASA Associate Administrator for Safety and Mission Assurance (and a former astronaut), is an ex officio member; and NASA Chief Engineer Theron Bradley, is the Executive Secretary. NASA has revised the Board's charter three times to clarify its independence from NASA, primarily in response to congressional concerns. Because CAIB was created by NASA, includes NASA representatives, and is largely staffed by NASA employees, concerns still exist, however. 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. Speculation continues to focus, however, on damage that may have been caused to the thermal protection system ("tiles") on the shuttle by objects that apparently fell off the shuttle's External Tank<sup>1</sup> 82 seconds after launch and struck the orbiter in the area of the left wing. The first indications of trouble during *Columbia*'s reentry was the loss of data from sensors on that wing, and other sensors registering rising temperatures. The day after the launch, NASA experts reviewing footage of the launch discerned something hitting the orbiter. Analysis by the Boeing Company initially concluded that one object hit the orbiter, but by January 24, determined that three objects were involved. In the days immediately following the *Columbia* accident, however, NASA officials reported that one 20x16x6 inch piece of insulating foam, weighing 2.67 pounds, was at issue and the Boeing analysis concluded it created no safety of flight issue. Others theories are that ice or a heavier insulating material may have hit the orbiter. Another theory is that it was hit by space debris. On February 13, the CAIB announced that preliminary analysis by NASA indicated the superheated gas (plasma) surrounding the shuttle as it descended through the atmosphere must have reached the interior of the wing to cause the temperature rise detected, rather than the heat being transferred through the structure as could happen with a missing tile. Thus, some theorize that the reinforced carbon-carbon (RCC) along the front (leading edge) of the wing, or the landing gear door or seals around it, may have been penetrated.

If tile damage was the problem, the astronauts could not have repaired the tiles in orbit. Astronauts are trained to 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. NASA officials stated that no changes could have been made to the reentry profile to protect a damaged

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<sup>1</sup> 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.

area of tiles and still ensure the safe return of the crew and orbiter. The *Associated Press* reported on February 7, however, that NASA did change the reentry profile for the space shuttle *Atlantis* in May 2000 (STS-101) when tile damage was suspected on that orbiter.

## 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.

*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 mission that ended tragically on February 1, 2003, STS-107, was *Columbia*'s 28<sup>th</sup> 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" (OMDP) in 1994-1995, and a second OMDP in 1999-2001. Its first flight after the second OMDP was STS-109 in March 2001, a servicing mission to the Hubble Space Telescope. STS-107 was its second flight after the OMDP.

## *Columbia*'s STS-107 Crew<sup>2</sup>

**Commander: Air Force Colonel Rick D. Husband**, b. July 12, 1957, Amarillo, TX. Married, two children. Col. Husband was making his second flight into space, having served as pilot of STS-96 in 1999. He 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. Commander McCool was making his first spaceflight. He 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. Col. Anderson was making his second spaceflight, having served on the crew of STS-89. He 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. Capt. Brown was making his first spaceflight. He 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.

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<sup>2</sup> Biographies taken from NASA official biographies, supplemented by media reports.

**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. She 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. Commander Clark was making her first spaceflight. She 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. Col. Ramon was making his first spaceflight. He received a BS in electronic and computer engineering from the University of Tel Aviv, Israel, in 1987.

### **The STS-107 Mission<sup>3</sup>**

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.

STS-107 carried a SPACEHAB Double Module, built by SPACEHAB Inc., 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.

### **Security Concerns**

In the wake of the September 11, 2001 terrorist attacks in the United States, NASA took additional security precautions to protect space shuttle launches. Among the changes

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

was a decision not to announce the exact time a shuttle would be launched until 24 hours in advance. This practice was followed for STS-107.

Because of the threat of terrorism, and the presence of an Israeli astronaut on the mission, questions have arisen as to whether the loss of *Columbia* could be attributed to terrorism. At this time, government officials have stressed that there is no evidence that the tragedy could have been caused by terrorists. They point out, for example, that surface-to-air missiles cannot reach the altitude where the shuttle broke apart. NASA Administrator O’Keefe stated on February 1 that “We have no indication that the mishap was caused by anything or anyone on the ground.” However, no possibility is being ruled out at this early stage of the investigation.

## **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. A forthcoming CRS report will explore some of these issues in more detail, but the 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 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 foam 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, such as changing the reentry profile or launching a rescue mission with another orbiter?
- Is the *Columbia* Accident Investigation Board the best group to assist NASA in this investigation, or should non-government experts be included? Should the White House establish a "blue-ribbon" commission 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?
- What strategy should guide operation of the International Space Station while the space shuttle system is grounded? 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?

A joint hearing between the Senate Commerce Committee and the House Science Committee was held on February 12, 2003. A House Science Committee hearing on implications of the *Columbia* accident on NASA programs and budget is scheduled for February 27.